The Forty-seventh General Assembly of the State of Illinois, with a view of conserving the lives of the mine workers and the mineral resources of the State, authorized an investigation of the coal resources and mining practices of Illinois by the Department of Mining Engineering of the University of Illinois and the State Geological Survey in co-operation with the United States Bureau of Mines. A co-operative agreement was approved by the Secretary of the Interior and by representatives of the State of Illinois.

The direction of this investigation is vested in the Director of the United States Bureau of Mines, the Director of the State Geological Survey, and the Head of the Department of Mining Engineering, University of Illinois, who jointly determine the methods to be employed in the conduct of the work and exercise general editorial supervision over the publication of the results, but each party to the agreement directs the work of its agents in carrying on the investigation thus mutually agreed on.

The reports of the investigation are issued in the form of bulletins, either by the State Geological Survey, the Department of Mining Engineering, University of Illinois, or the United States Bureau of Mines. For copies of the bulletins issued by the State and for information about the work, address Coal Mining Investigations, University of Illinois, Urbana, Ill. For bulletins issued by the United States Bureau of Mines, address Director, United States Bureau of Mines, Washington, D. C.

ILLINOIS
COAL MINING INVESTIGATIONS
CO-OPERATIVE AGREEMENT
Issued bi-monthly

State Geological Survey
Department of Mining Engineering, University of Illinois
U. S. Bureau of Mines

BULLETIN 13

Coal Mining In Illinois

BY

S. O. ANDROS

Urbana
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1915

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COAL MINING IN ILLINOIS

By S. O. Andros

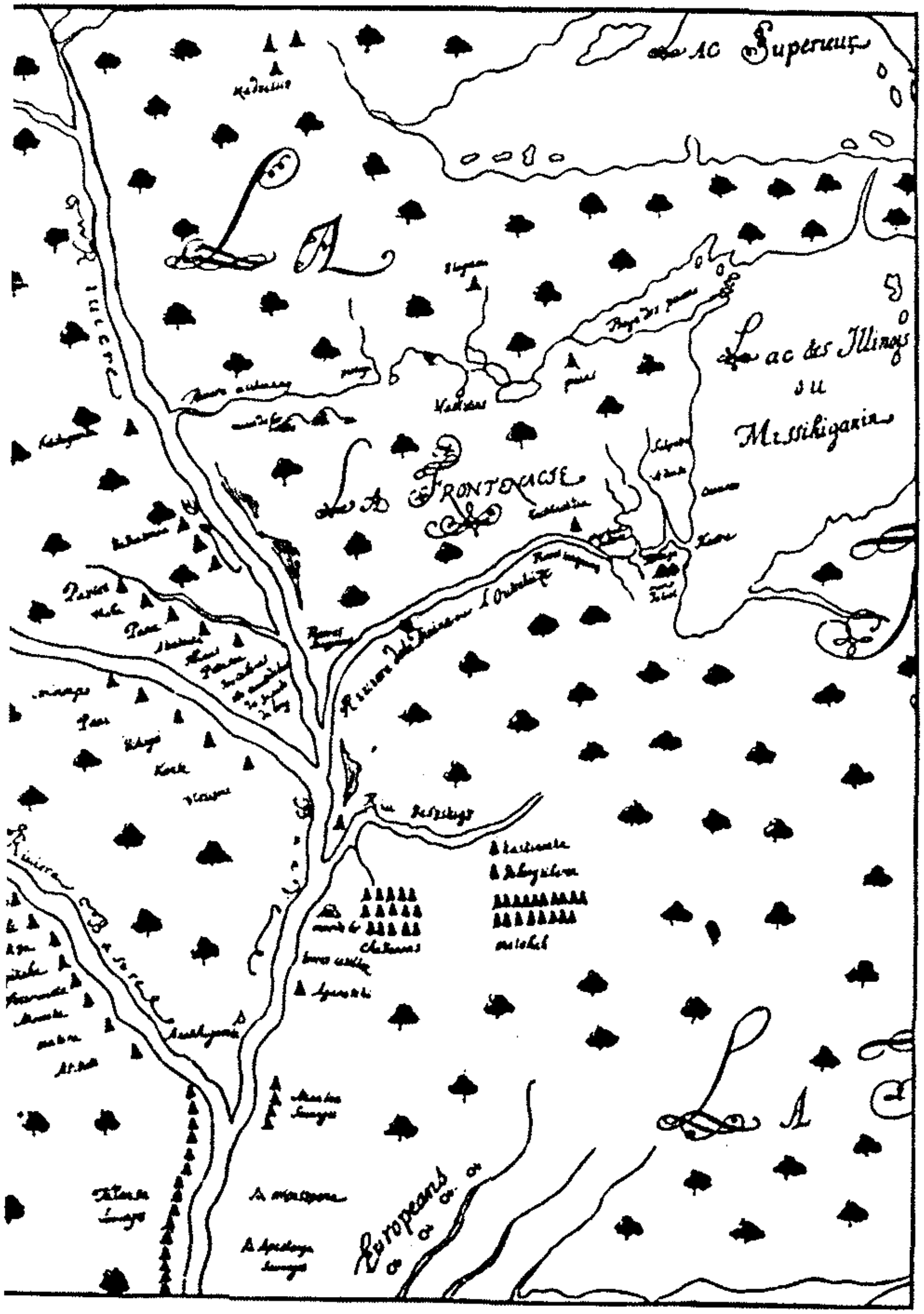
INTRODUCTION

The importance of a nation or a state depends upon its agricultural resources, its coal production, and the extent of its iron manufacture. Coal is indispensable to modern civilization and industrial development and the present industrial prosperity of Illinois is due principally to the large area of its coal fields, 36,125 square miles of its territory being underlain by coal.

The annual coal production of the world is approximately 1,450,000,000 tons, of which amount the United States produces about 40 per cent and the State of Illinois more than 4. Illinois is the third largest producer of coal in the United States, being exceeded in production only by Pennsylvania and West Virginia, and its annual tonnage is about 11 per cent of the output of the country.

Employing 80,000 men who mine annually 60 million tons of coal worth over 70 million dollars, the coal mining industry must be regarded as one of the most important industries in the State and its economic status is of vital interest.

With a desire to be informed about the degree of safety to the miners and the efficiency of mining methods the Forty-seventh General Assembly of the State of Illinois authorized an investigation of the coal resources and mining practices of Illinois by the Department of Mining Engineering of the University of Illinois and the State Geological Survey in co-operation with the United States Bureau of Mines. Each co-operating party to the agreement furnished trained specialists for particular phases of the investigations and the work, begun in 1911, has been continued under annual ratifications of the initial agreement. A general survey of the State has been made by districts and several special problems have been studied in detail and the data thus obtained have been published in bulletins issued from time to time as the work progressed.



THE CENTRAL PORTION OF JOLIET'S MAP, 1674, SHOWING THE MISSISSIPPI AS THE "BAUDE."

FIG. 1. Copy of Joliet's map made in 1674 (From "A History of the Mississippi Valley," by Spears and Clark)

That the work of the Illinois Coal Mining Investigations is answering to a real need is shown by the hundreds of requests for bulletins which have come from many foreign countries, from every State in this country, and from all parts of Illinois.

The object of this bulletin is to abstract and summarize the district reports so as to compare mining practice in the different districts and to make generalizations on the practice of the State as a whole. The need for such a summary bulletin is emphasized by the many requests for earlier district reports which are now out of print.

In order to make the bulletin more valuable to those interested in coal mining in Illinois an historical chapter on the economic development of the industry has been included and a bibliography of the geology, chemistry, and exploitation of the different seams has been appended.

The operators, superintendents, mine managers, and mine workers of the chosen mines and the State Mine Inspectors rendered generous and valuable assistance in the collection of data and acknowledgments have been made to them with particularity in the district reports. Further acknowledgments are due to Mr. F. S. Peabody, Mr. A. J. Moorshead, Mr. C. M. Moderwell, Mr. Horace Clark, Mr. E. T. Bent, Mr. G. W. Traer, Mr. Carl Scholz, Mr. Gordon Buchanan and Mr. D. W. Buchanan for furnishing supplementary cost data, and to Mr. Frank Farrington, President of District 12, United Mine Workers of America, for reviewing the manuscript of this report.

The author is greatly indebted to Professor H. H. Stoek, Head of the Department of Mining Engineering of the University of Illinois for his invaluable assistance in arranging the subject matter of this report.

HISTORY

PERIOD OF EXPLORATION (1673-1810)

Up to the present time the first mention of coal in the country which afterwards became the United States has been erroneously credited to Father Louis Hennepin, who shows on a map published in 1689 the location of a "cole mine" along the Illinois River. The credit for this first mention of coal does not, however, belong to Hennepin for the first discovery of coal in the United States by Europeans was made by Joliet and Marquette in 1673. Margry's account[1] of Joliet's voyage says, "The said M. Joliet adds, That he had set down in his Journal an exact Description of the Iron-Mines they discovered, as also of the Quarries of Marble, and Cole-Pits, and Places where they find Salt-Petre, with several other things." Joliet's map of 1674[2] (See fig. 1) shows the location of "Charbon de terre" (coal) near the present city of Utica. La Salle in his letter to Frontenac (1680) referring to the Illinois River[3] says, "We have seen no mines there though several Pieces of Copper are found in the Sand when the River is low. There is the best Hemp in that Country I have seen anywhere, though it grows naturally without culture. The Savages tell us, that they have found near this Village some yellow Metal; but that cannot be Gold, according to their own Relation, for the Oar of Gold cannot be too fine and bright as they told us. There are Coal-Pits on that River." Marquette's Journal was first published in France by Thévenot in 1681.[4] Accompanying the narrative was a map (See fig. 2) copied by Thévenot from one made by Marquette. Both original and copy show the same location of "Charbon de terre" as does Joliet's map.

Father Louis Hennepin, a Récollect priest, accompanied La Salle's expedition to the Illinois country in 1680 as chaplain and in his "A New Discovery of a Large Country in America," published in English in 1689, and dedicated to William III of England, says with reference to the country along

[1] Découvertes et Établissements des Francais, I, p. 261. Published at Paris, 1681.
[2] Thwaites, Jesuit Relations, Vol. 19, p. 86.
[3] Margry, Vol. I, p. 465.
[4] Recueil de Voyages.

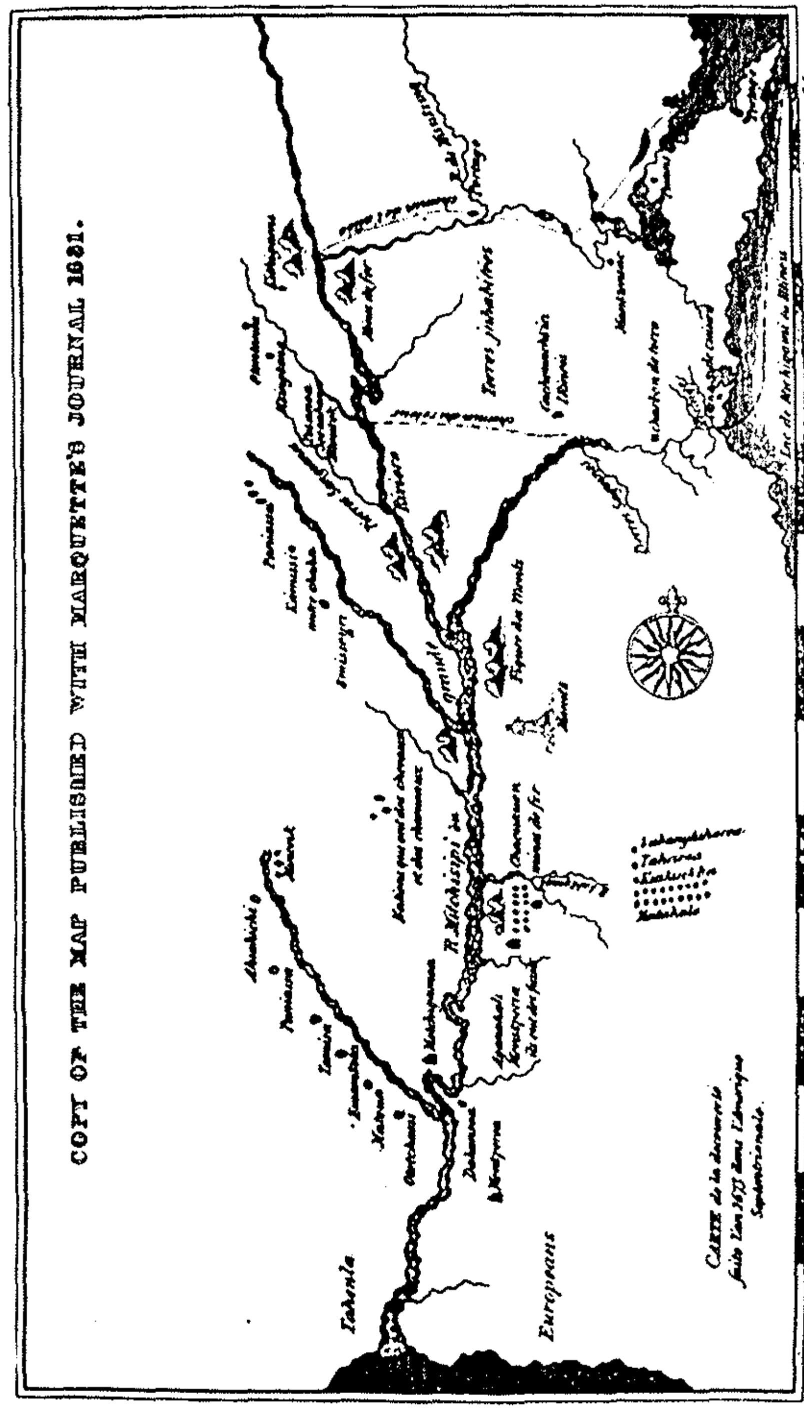


FIG. 2. Copy of Marquette's map published by Thévenot, 1681 (From "A History of the Mississippi Valley," by Spears and Clark)

the Illinois River from its source to the site of the present city of Peoria:[1] "There are Mines of Coal, Slate, and Iron; and several pieces of fine red copper, which I have found now and then upon the Surface of the Earth, makes me believe that there are Mines of it; and doubtless of other Metals and Minerals, which may be discovered one time or another. They have Already found Allom in the country of the Iroquoise." Hennepin's map accompanying this narrative[1] locates a "cole mine" on the Illinois River above Fort Crevecœur (Peoria) copied from Joliet's map and Marquette's.

On the twenty-seventh of September, 1720, Father Charlevoix arrived at the junction of the Kankakee and Illinois rivers.[2] He descended the Illinois to its junction with a river which he mentions as being called the Pisicoui and which flows from the country of Bonière "because they find many Coals in its Environs." (This country was in what is now La Salle County.)

In "Travels through the Interior Parts of North America in years 1766, 1767, and 1768, by J. Carver, Esq.", the statement is made:

"The Mississippi, runs from north to south and passes through the most fertile and temperate part of North America. The more northern parts of its valley contain lead, copper, iron, and coals."

Patrick Kennedy in his journal of an expedition undertaken in the year 1773 from Kaskaskias Village in the Illinois country in search of a copper mine, under the date of August 6, 1773, writes,[3] "At sun-set we passed a river called Michilimackinac (Mackinaw River in Tazewell County). Finding some pieces of coal, I was induced to walk up the river a few miles, though not far enough to reach a coal mine. In many places I also found clinkers, which inclined me to think that a coal mine, not far distant, was on fire, and I have since heard there was." On the 12th of August while near Utica he wrote, "On the northwestern side of this river is a coal mine that extends for half a mile along the middle of the bank of the river, which is high."

[1]Thwaites, Hennepin's New Discovery, Vol. I, p. 152.
[2]Perrin's History of Illinois.
[3]Hicks, Thomas Hutchins. A Topographical Description.

Morse's American Gazetteer, published in 1797 under the caption Illinois River states: "On the north-western side of this river (near La Salle) is a coal mine, which extends for half a mile along the middle of its banks, and about the same distance below the coal mine are two salt ponds, 100 yards in circumference and several feet in depth."

ANTE-RAILROAD PERIOD (1810-1850)

The gradual development of coal mining as the country became settled and as the available timber supply was consumed is best shown by extracts from the gazetteers of the period and from the journals of travellers to the Illinois country.

It was only natural that mining should begin near the American Bottom, for as Beck[1] said, "The most extensive and fertile within the limits of this state, is the American Bottom, a name which it received when it constituted a part of the western boundary of the United States, and which it has ever since retained. It commences at the confluence of the Kaskaskia river, and extends northwardly to the mouth of the Missouri, being bounded on the east by a chain of bluffs, which in some places are sandy, and in others rocky, and vary from 50 to 200 feet in height. This bottom is about 100 miles in length, and comprises an area of more than 500 square miles, or 320,000 acres. The first settlement of this state was commenced upon the tract of land above described, and its uncommon fertility gave emigrants a favorable idea of the whole country. Coal exists in abundance on this alluvion and the bluffs which bound it. Its first discovery was made in a very singular manner. Many years since, a tree taking fire, communicated to its roots, which continued burning for some time. Upon examination, they were found to communicate with a bed of coal, which continued to burn until the fire was completely smothered by the falling in of a large mass of incumbent earth. The appearance of fire is still evident for a

[1]A Gazetteer of the States of Illinois and Missouri, 1823.

considerable distance. About two miles from this place a coal bank has been opened—the vein is as thick as any at Pittsburg."

It was at the point mentioned by Beck that the first mine was opened and we have a record of the shipment of a flatboat load of coal to New Orleans in 1810 from Brownsville in Jackson County.

The existence of coal in other parts of Illinois was known but local need elsewhere had not arisen. In "A Full Description of the Military Land," Van Zandt in 1818 said, "Among the minerals are stone coal containing bitumen and sulphur. The coal is apparently of a very good quality, and may be found in very great abundance." The map accompanying Schoolcraft's Narrative Journal of Travels in 1820 shows a coal mine at the junction of the Fox and Illinois rivers. Schoolcraft writes, "There is a valuable and extensive bed of mineral coal, about forty miles southwest of Chicago on the Fox river of the Illinois, near the point of embouchure. The stratum of coal, which appears on the banks of the river, is said to have an extensive range towards the northwest, and is only covered by a light deposit of alluvial soil, of a few feet in thickness."

All the early explorers and travellers refer to outcrops as mines although no mining had been done in them.

A description of Illinois Territory in "A History of America" published in 1820 says, "Coal was observed extending half a mile along the high bank of the north-western side of the Illinois river, 276 miles from its outlet, 50 miles above Pioria lake, and near the Little Rocks, which are 60 miles from Forks. It is also found on the La Vase, or Muddy river." The same volume quoting Mr. Fearon says, "The inhabitants of Illinois may, perhaps be ranked as follows: First, the Indian hunters. 2nd, The "Squatters" who are half-civilized and half-savage. 3d, A medley of land jobbers, lawyers, doctors and farmers, who traverse this immense country, founding settlements, and engaging in all kinds of speculation. 4th, Some old French settlers, possessed of considerable property, and living in ease and comfort." Beck's Gazetteer of Illinois and Missouri published in 1823 shows

that at that time there existed a realization of the wide extent of workable coal seams. Speaking of the Illinois river, Beck says, "Coal is very abundant on this stream, and is valuable on account of the scarcity of timber." His references to coal in the various counties are as follows:

"Clark County. Coal is very abundant.

Greene County. The banks of the Mississippi in the southerly part of this country are generally composed of perpendicular cliffs, varying in height from 80 to 150 feet, consisting of horizontal strata of sand and stone, limestone, slate and coal—Although the latter does not appear on the face of the cliffs, it is found in great abundance a short distance from it near Alton. I would remark that coal is also found similarly situated on the banks of Kickapoo Creek, a small stream emptying into the Illinois near Fort Clark.

Jackson County. Muddy river, which meanders through the interior of this county, is navigable for a considerable distance, and affords to the inhabitants every facility for exporting their surplus produce. On this stream, near Brownsville, there is a saline, which has been leased for 10 years. A large body of good stone coal is also said to exist about 25 miles up this stream from which the smiths in the vicinity receive their supplies, and some is even taken to New Orleans.

Pike County. At different places on the Illinois, there are immense strata of coal, of the best quality.

Sangamon County. Coal is also abundant.

He makes further mention of the coal resources in his description of towns, creeks, and rivers, as follows:

Alton. Stone coal, of a good quality, is found in abundance at a short distance from this place.

Big Muddy river. About 25 miles from its mouth, stone coal of a good quality, is found in a sufficient quantity to supply the surrounding country, and afford a surplus for exportation.

Cahokia. Cahokia, a post village in St. Clair county, three-fourths of a mile east of the Mississippi river, and five miles south of St. Louis: Coal is found in the vicinity of this place. Its discovery was singular and deserves to be mentioned. (Here he repeats the story of the burning tree.)

Chicago Creek. This stream has, for nearly a century, been one of the most common routes to the Illinois and Mississippi. The greatest proportion of the furs of the northwest are conveyed through this channel to the lower lakes.

Crooked Creek. Coal abounds on the banks of Crooked Creek.

Fox River. (Beck quotes Schoolcraft's statement given on page 14.)

Kickapoo or Redbud Creek. On the banks of this stream is an extensive bed of coal, which furnished fuel to the garrison and the inhabitants of Peoria. The stratum is about 12 or 14 feet below the surface, and is overlaid by slate, limestone, and sandstone.

Otter Creek. Coal is found in abundance on the banks of this stream.

Peoria. A small settlement in Pike county on the west bank of the Illinois river, about 200 miles above its junction with the Mississippi. This section of country is not very rich in minerals. Coal, however, is abundant on the banks of Kickapoo creek, about one mile above its mouth. It was first discovered by the soldiers stationed at the fort (Clark), and being of a good quality, was used by them for fuel. It is found 12 or 14 feet below the surface; it is overlaid by slate, limestone and sandstone; and contains vegetable remains.

Spoon river. Coal, of a very fine quality, is abundant on the banks of this stream and will be valuable, on account of the scarcity of timber, particularly in the northern part of the military tract.

Sugar Creek. A small stream in the western parts of Madison and Washington counties. Coal is found in great abundance on the banks of this stream."

By 1830 the use of local coal by blacksmiths was quite general and in that year Joshua Hughes, a blacksmith of Centerville, St. Clair County, began taking coal from a hill side, about a half mile southeast of Centerville.[1]

[1]History of St. Clair County. MacDonough, 1881.

The increasing use of coal and the beginning of an industrial demand for it are shown in Peck's "A Guide for Emigrants", published in 1831. Referring to Jackson County Peck says:

"It is watered by Muddy river and its branches. Twelve miles up the stream is the village of Brownsville. The village now contains only fifteen to twenty families; but the preparations that are making to manufacture salt, and dig coal will be likely to cause an increase."

Describing Belleville and its industries he states:

"It has a steam flouring mill, which makes thirty barrels of flour per day. The engine is of twelve horse power. The fire consumes two cords of wood and seven bushels of bituminous coal in twenty-four hours. The wood costs one dollar per cord, and the coal five and one half cents per bushel, and is hauled five miles from the bluffs."

With reference to the widespread occurrence of coal Peck says:

"Stone coal abounds in Illinois. It may be seen frequently in the ravines and gullies, and in the points of the bluff. Exhaustless beds of this article exist in the bluffs of St. Clair County, bordering the American Bottom, of which large quantities are transported to St. Louis for fuel. It sells in St. Louis from ten to twelve and a half cents per bushel. From twelve to fifteen large ox waggons are employed most of the year in hauling it to market, the distance of seven miles across the American Bottom. There is scarcely a county in the State but what can furnish coal in reasonable quantities. Large beds are said to exist near the junction of Fox river with the Illinois and in the vicinity of the rapids of the latter."

Tanner in "A view of the Valley of the Mississippi," published in 1834, says:

"Bituminous coal is found abundantly in all parts of this state, in the bluffs, and the banks of the water courses. On the Illinois, and opposite to St. Louis, in St. Clair county, it is very abundant. And many thousands of bushels are sent to St. Louis annually, and sold at the rate of from ten to twelve and a half cents per bushel."

In 1834, G. W. Featherstonhaugh made a geological report on parts of Illinois. He states, "During my late tour I had occasion to examine the bituminous coal beds in various parts of Illinois; and in the bluff, distant about seven miles east from the city of St. Louis, a fine vein about eight feet thick is opened for the consumption of the city."

Because the water courses were the only ways along which the products of the country could be transported the movement of freight was of necessity southward. The need of an outlet for freight into Lake Michigan became apparent early and in 1816 the project of uniting the waters of Lake Michigan and the Illinois river was conceived and grew in popularity. In 1823 the route was explored by a board of commissioners and engineers who estimated the cost. At a special session of the legislature an act was passed in January, 1836, authorizing the construction of the canal. At this period in the United States every class was filled with the spirit of speculation and schemes of internal improvement absorbed the whole public attention. The canal scheme of Illinois combined with its plan for further internal improvements proved lacking in practical utility and resulted in disastrous consequences.

Brown in his "History of Illinois" published in 1844 says:

"The route of the canal was principally over marshy ground, covered, for a considerable portion of the time with water. Access to it was exceedingly difficult, and to facilitate the work, and enable the contractors to proceed, forty thousand dollars and upward, were expended by the acting commissioner, during the first year, upon a road leading thither.

The country along its route was, at that time, in a state of nature. Four years had scarcely elapsed, since it had been the theatre of an Indian massacre, and the whole of its scattered population had sought refuge from savage fury, beneath the guns of Fort Dearborn. Instead of supplying the contractors with provisions, they were supplied themselves, from Michigan, Ohio, and even from New York. Having no surplus for market and there being, at that time, but few settlers in the country, the necessity, or rather the utility of a canal, at that particular time, was more apparent to the owners of 'corner lots,' and 'water lots,' than to the candid or judicious observer."

Railroad construction, to the amount of 1341 miles, was authorized in 1837. The scheme as a whole, characterized by Brown as an absurdity, collapsed and in 1842 the State had to show for a debt of 12 million dollars, one railroad only, from Springfield to Meredosia and the whole income of the railroad was insufficient to keep it in repair. The canal was finally completed and opened in 1848. It was a disappointment because the upper Illinois needed much artificial aid for navigation.

During this period of expansion and speculation the coal mining industry was affected by the general tendency towards inflation and owners of small mines desired to increase their production as shown by the following letter in the Journal of the Franklin Institute for 1836:

"To the committee on Publication

Gentlemen—I have received the following information in relation to a locality of coal in Illinois, from Mr. Hall Neilson, of Richmond, Virginia, and consider it of sufficient importance to ask you to place it on the pages of your Journal for permanent reference. The coal alluded to is a dry bituminous coal, of which specimens have been placed in the Cabinet of the Franklin Institute, and of the American Philosophical Society.

The Mount Carbon Coal Mines are on the margin of Big Muddy River, near Brownsville, Jackson County, Illinois, a short distance from its junction with the Mississippi River.

The upper stratum of coal which is now opened, and has been worked on a limited scale for many years, is about six or seven feet thick, and lies in a horizontal position above high water mark, leaving room for wharfage between the river and the mines. This coal combines the qualities of the *anthracite* with pure *charcoal* with a remarkable freedom from sulphur, slate, and other impurities, makes an open fire, ignites very easily, and burns with much flame, and a strong heat, producing little smoke, cinder, or ashes. These rare qualities render this coal of great value, and importance in the manufacture of iron and steel, and particularly so, in the production of *steam*.

Coal must ere long, be generally adopted for the use of steamboats, and sugar plantations, on the Mississippi, and for foundries, steam mills, sugar refineries, cotton presses, and other works at New Orleans; there would, besides, if this coal were in the market be a large demand for the outward bound shipping from that port, and as ballast for those in the Havana and South American trade, indeed the demand may be considered almost unlimited.

It is understood, that the present proprietor of these mines wishes that their working should be undertaken by a company, to form which he has made arrangements.

A CORRESPONDENT."

In the "History of St. Clair County" the information is given that, "Pittsburg is situated on the bluff, in the extreme eastern portion of Cahokia precinct, in sec. 3. It was established in 1836, and at one time had a population of upwards of 200 inhabitants, mostly coal miners. Coal was obtained here by drifting into the bluff, where in places it cropped out to the surface. As many as seven drifts have been in operation at one time, and from twenty to thirty cars of coal mined in one day; but for several years the mines have been exhausted and abandoned."

Peck's "New Guide for Emigrants in the West" published in 1836 states: "There is scarce a county in the State, but what can furnish coal, in reasonable quantities. Large beds are said to exist, near the Vermilion of the Illinois, and in the vicinity of the rapids of the later." Peck gave the following table for increase of population in Illinois:

1810	12 282
1820	55,211
1830	157,575
1835	272,427

He refers to Chicago as the largest commercial town, saying, "It is situated at the junction of North and South branches, and along the main Chicago, near its entrance into lake Michigan, on a level prairie but elevated above the highest floods. A recent communication from a respectable mercantile house, gives the following statistics: 'Fifty-one stores, 30 groceries, 10 taverns, 12 physicians, 21 attorneys, and 4,000 inhabitants. We have four churches, and two more building, one bank, a Marine and Fire insurance company about to go into operation, and a brick hotel, containing 90 apartments.'

There were 9 arrivals and departures of steamboats in 1835, and 267 of brigs and schooners, containing 5,015 tons of merchandise and 9,400 barrels of salt, besides lumber, provisions, etc." He records an abundance of coal in the following counties: Bond, Calhoun, Greene, Jackson, La Salle, Madison, Monroe, Putnam and St. Clair.

In 1837[1] the first railroad in the Mississippi Valley called the Coal Mine Bluffs Railroad, was constructed for the purpose of delivering coal from the bluffs of the American Bottom to St. Louis. "It was built by Governor Reynolds, Samuel B. Chandler, George Walker and Daniel Pierce. In 'My Own Times', Governor Reynolds says: 'I had a large tract of land located on the Mississippi Bluff, six miles from St. Louis, which contained in it inexhaustible quantities of bituminous coal. This coal mine was the nearest to St. Louis, Mo., of any other on this side of the Mississippi River. I had also most of the land on which a railroad might be constructed to convey the coal into market. Under these circumstances, a few others with myself, decided to construct a railroad from the bluff to the Mississippi, opposite St. Louis. This road was about six miles long, and although short, the engineer made an erroneous calculation of the cost—making the estimate being less than one-half of the real cost. We all embarked in this enterprise when we knew very little about the construction of a railroad, or the capacity of the market for the use of the coal. In fact, the company had nothing but an excessive amount of energy and vigor, together with some wealth and standing, with which to construct the road: and we accomplished it. We were forced to bridge a lake over 2,000 feet across, and we drove down piles more than eighty feet into the mud and water of the lake, on which to erect the bridge. We put three piles on the top of one another, fastened the ends together, battering the piles down with a metal battering-ram of 1,400 pounds weight. The members of the company

[1]St. Clair County History. MacDonough.

themselves hired the hands—at times one hundred a day—and overlooked the work. They built shanties to board the hands in, and procured provisions and lodging for them. They graded the track, cut and hauled timber, piled the lake, built the road, and had it running in one season of the year 1837. This work was performed in opposition to much clamor against it, that it would not succeed, that we would break at it, and such predictions. We had not the means nor the time in one year to procure the iron for the rails, or the locomotive, so we were compelled to work the road without iron, and with horse-power. We did so, and delivered much coal to the river. It was strange how it was possible we could construct the road under these circumstances. It was the first railroad built in the Mississippi valley, and such an improvement was new to every one, as well as to our company. The members of the company and I—one of them—lay out on the premises of the road day and night while the work was progressing; and I assert that it was the greatest work or enterprise ever performed in Illinois under the circumstances. But it well-nigh broke us all.' "

The growth of Chicago, the beginning of work on the Illinois-Michigan canal, and the settlement of new towns attracted attention to various unworked coal deposits in the State. Mitchell in "Illinois in 1837&8," refers to coal in Rock Island County as follows: "Iron ore and stone-coal are found in several places along the Upper Rapids of the Mississippi. The latter article, of a good quality, prevades the Rock river bluffs extensively and will, before long, become a very important article of trade with the lead-mines, where the country is destitute of it. The recent improvement in smelting furnaces, and the contemplated introduction of steam-engines to drain the mines on the plan of the miners of Cornwall, England, which must take place before long, will cause the consumption of an immense quantity of stone-coal. They now send to St. Louis for it, and freight it up stream 500 miles. It will not be many years before the business of smelting will be done near the mouth of Rock river for nearly all the lead regions above, from the circumstances that the mineral can be much easier floated down to the fuel, than the fuel can be

freighted up to the mineral. This will throw into the lately located seat of justice of Rock Island county an immense trade, which is not generally looked upon as being alienable from the immediate neighborhood of the mines."

Describing the town of Rock Island, Mitchell states, "The country in the vicinity is abundantly supplied with timber, limestone, and coal. There have been several boat loads of coal taken from there this season to Galena, it being the nearest coal to that point yet discovered. The company who own this site obtained a charter at the last session of the legislature, for a canal to run from Rock river to the Mississippi, terminating at this point, leaving Rock river at the head of the rapids, avoiding the only serious obstacle to the navigation of that stream by a canal of only four miles in length. This will open through Milan all the trade of the Pekatonica and Rock river country, which is one of the best agricultural districts in the state. The transportation of coal alone would make the stock of this canal good property, there being inexhaustible beds along the whole length of it." This publication also refers to "a large vein of coal, several feet thick, and apparently exhaustless," which was struck in excavating the Illinois-Michigan canal, at a point a few miles below Ottawa. It also states that a bed of anthracite coal was discovered on Muddy river in Jackson County and that "the stone coal near Peoria is said to be little inferior to that of Pittsburg and is found in the bluffs of all the creeks and Illinois river. It is generally used for fuel at Peoria in winter; is hauled from one to three miles, and is worth 12 cents per bushel.

At Alton brick at the kiln sell for 7 to 9 dollars per 1000; pine boards 25 to 40 per 1000 (they are brought from the Ohio river); wood for fuel, $3 per cord; coal, 20 cents per bushel. The latter is obtained from the hills, one mile in the rear of the town; and both wood and coal can be got for very little more than the cost of cutting, digging, and hauling. The comparatively high price at which both sell will furnish another evidence of the high prices of labour and assure eastern labourers, who are working at this season of the year for 40 cents a day that here they may soon realize a little fortune.

This city is surrounded for several miles in extent with one of the finest bodies of timber in the state, from which vast quantities of lumber may be produced. Bituminous coal exists in great abundance at only a short distance from the town.

Peru is the point of termination of the Illinois and Michigan canal and is situated in the midst of a most fertile region, abounding in grain, in coal, in iron, and in hydraulic power. These things being considered, is it wrong to suppose that a large inland city will here arise?"

The possibilities of Chicago as a future coal market were foreseen in the following article on the Geology of Upper Illinois which appeared in 1838 in Silliman's American Journal of Science, Vol. XXXIV.

"Another point of interest occurs in the topography of the valley just before we reach Rockwell. It is where the Cosogin river cuts the bluff and enters the meadows.

The mineral resources so remarkably accumulated at this point, the future development of which is destined to confer upon Rockwell numerous commercial and manufacturing advantages.

It is within a few rods only of the eastern extremity of the Consogin basin, that the largest out-crop of coal in the valley of the Illinois occurs. A ravine will be noticed as one descends from the high prairie, at a distance of about seventy rods from the eastern boundaries of Rockwell. This is the Swanson ravine. Its bed is entirely within the coal strata, and very nearly conforms in direction to their basseting edges. The slopes of the ravine consist superficially, to a considerable extent, of soil and loose materials. Slight excavations, however, are all that is requisite to reveal the strata, which, on the west side at least are uniform and continuous to the valley. Commencing at the mouth of the ravine on its western side, we have a good view of the position of the coal-bed, where it has been partially laid open, for supplying to some extent fuel to the vicinity, especially for blacksmithing purposes.

I can only state what I was able to learn from others respecting its course beyond Vermilionville. Abundance of coal is said to occur at several points for ten or twelve miles up the river, all of which may reasonably be considered as belonging to one and the same stratum. Indeed it is not impossible that future researches will prove the extension of the present outcrop quite across the country, even to the Wabash, in Indiana.

A partial digging has been made into the bituminous shale and coal-seam of Rockwell.

And inasmuch as borings for salt have been made to the depth of one hundred and thirty feet below the surface of the river, at a place five miles west of Ottawa, near Starved Rock, we are able to say, that the coal is not repeated for a depth of at least one hundred and sixty feet, sandstone being the only rock for the whole of this depth.

We shall now treat of the economical value of the coal to this region. Bituminous coal is valuable in every part of our country; but to a rich prairie section, where the climate in winter is severe, and where wood is scarcely abundant enough to supply materials for fencing and building, its importance is almost incapable of being exaggerated.

The deposit, upon which main reliance is likely to be placed for coal, at least for a considerable time to come, is the stratum which crops out in the Swanson ravine. This bed will probably be found workable under the entire tract, bounded by the ravine on the east and the Little Vermilion on the west. At what depth below the surface it will be found, situated on the western portion of this tract, it is of course impossible to say; but from what is known of coal-fields in other countries, we are authorized in believing that as the bed is worked down, its present pitch will alter, and that at no great distance from the ravine it will assume a horizontal position.

The thin horizontal bed of coal which has been opened at so many points between Utica and Ottawa, and which is worked at several openings near the latter place, is undoubtedly capable of furnishing a large supply of this fuel. But the difference of expense in working a thin and a thick stratum is so great, especially where the thin bed, as in the present instance is horizontal in position, and overlaid by a vase accumulation of fissile strata, that it gives to the main deposit an obvious superiority. It is plain, therefore, that the canal commissioners have judged correctly, in affixing a high valuation to the coal-mines of the state on section thirteen.

The coal at Vermilionville, besides being a number of miles from navigable water, is so situated, with regard to the bed of the river in which it occurs, as to render its exploration unusually inconvenient and expensive. It will not, therefore, be likely to come into market, until the supply near the canal and the Illinois river has been to a degree exhausted. No coal is obtained from down the river short of Henry; nor even at this place within several miles of the river.

It appears quite certain therefore, that Chicago and the region bordering on the upper lakes are destined, on the completion of the canal, to receive their bituminous fuel very largely from Rockwell and its immediate vicinity, since there is little prospect of the discovery of any nearer source of supply. At present, the region referred to, is furnished by the coal mines of Ohio and Erie canal. It would seem, however, that coal can be delivered cheaper at Chicago from Rockwell, than at Cleveland, for although the distance is the same, yet the dimensions of the Chicago canal and its smaller amount of lockage, will give it a decided advantage over the Erie canal in the expense of transportation.[1]

The ease with which it burns and the abundant flame it emits, must serve to render it a most valuable fuel. For while it will afford a warm and cheerful fuel for the grate, it is peculiarly adapted also to steam boilers, and to all the operations of heating and evaporating fluids. It will also give rise to a coke of a medium quality, the presence of iron-pyrites not being found so considerable as to interfere with its employment by the blacksmiths of the country, who prefer it indeed in their work, to charcoal.

The quality of coal, so far as can be determined from the limited exploration thus far made of the Illinois beds is in no way inferior to that of the Ohio coal.

[1] "Coal is raised and delivered to the boats in Ohio, at four cents the bushel. It sells in Cleveland at from fourteen to sixteen cents, and in Chicago, at fifty."

One cubic foot of this coal will, therefore, weigh $79\frac{121}{1000}$ pounds, which will give for a bed six feet thick in one acre, nine thousand two hundred and thirty one tons."

By 1838 the general distribution of coal under nearly all of the State had been proved. James Hall in "Notes on the Western States in 1838," says: "As for fuel, there is no difficulty. No part of this country has been explored in which coal does not abound; it is found in the broken lands and bluff banks of all our large water courses, and though seldom met with within the area of a prairie it abounds on the borders of all the streams which meander among these plains. That it has not been brought into use, at all, is a proof of what we have asserted, viz. that wood is abundant."

Water transportation was still a factor and St. Louis was demanding more coal each year so that, although the possibilities of the northern part of Illinois were realized, new mines were constantly being opened in southern Illinois.

The "History of St. Clair County" gives the following biography of John Schultz: "For sixteen years he hauled coal from the bluffs to St. Louis. He followed this business in winter. The occupation was not the easiest. Coal brought, in St. Louis, from eight to twelve and a half cents a bushel. In 1840, after his father's death, he rented a farm on the bluffs, below Caseyville, where the Sweigart stone house now is, and mined coal, bought teams, and hauled the coal to St. Louis on his own account. This occupation was heavy and laborious, but profitable. In 1844 he bought eighty acres of land, in section fourteen of township two north, range nine west, for twelve dollars and a half an acre, which, at that time, was considered a high price."

Jones in "Illinois and the West" published in 1838 tells of the markets for Illinois products in that period as follows: "It may not be irrelevant to put in a note in this place; giving some information as to the market in Illinois. On all the great water courses, St. Louis and New Orleans are the great focuses to which nearly all the surplus produce will go. Rock River, at least the upper part of it, Fox river, and the whole neighborhood of the lake and the great canal which is to connect the Illinois with Lake Michigan, form an exception to this general rule. To all this region, embracing the northeastern part of Illinois, the northern part of Indiana, the northwestern part of Michigan, and the southeastern part of Wisconsin, the northern markets, via the lakes, offer the greatest inducements, and must eventually attract and monopolize the largest portion of the production of these territories. But, at present, there is a *home* market for all this region. It is in fact, worthy of recollection, that bread stuffs are annually imported into the region in large quantities, there not being enough raised to meet the consumption. This is owing entirely to the immense tide of immigration, which is constantly pouring in there, and consuming, like a cloud of locusts, all that is raised and much more. In the summer of 1838, prior to the time of harvests, everything bore the highest prices. Flour, \$14, corn, \$1.50, potatoes \$2, and so on through the whole list of prices current. And this market will continue for years to come; and long before the production shall exceed the consumption, an easy and cheap egress in the northern and southern markets will be afforded to the producers.''

All mining operations were along the water courses because it was impossible to transport coal overland for any distance. The condition of the roads is described by Jones. Writing of the country near Peoria he says, ''Our road through the timber was exceedingly rough and tiresome. *Road* it ought not to be called, *track* is a fitter name. Not a tree had been fallen, and everyone went hither and thither among the trees, in search of a better path, as his judgment dictated or his horse inclined. Large and deep holes, still filled with water, whose surface was thickly coated with green slime, continually obstructed our way. Into these were we occasionally obliged to plunge, much to our own annoyance, and that of our poor animals, who were ready to sink under the intense heat.''

The commercial possibilities of the southwest portion of the State were estimated by Forrest Shepherd, Esq. in his report and map (See fig. 3) in 1840 to the Boston Association for purchasing Mineral Property in Missouri and Illinois.

Having made an examination of the mineral deposits of these states he reports on Illinois as follows:

''To the Boston Association for purchasing Mineral Property in Missouri and Illinois.

Gentlemen:—It seemed very desirable to add some convenient workable coal beds to the above valuable deposits of

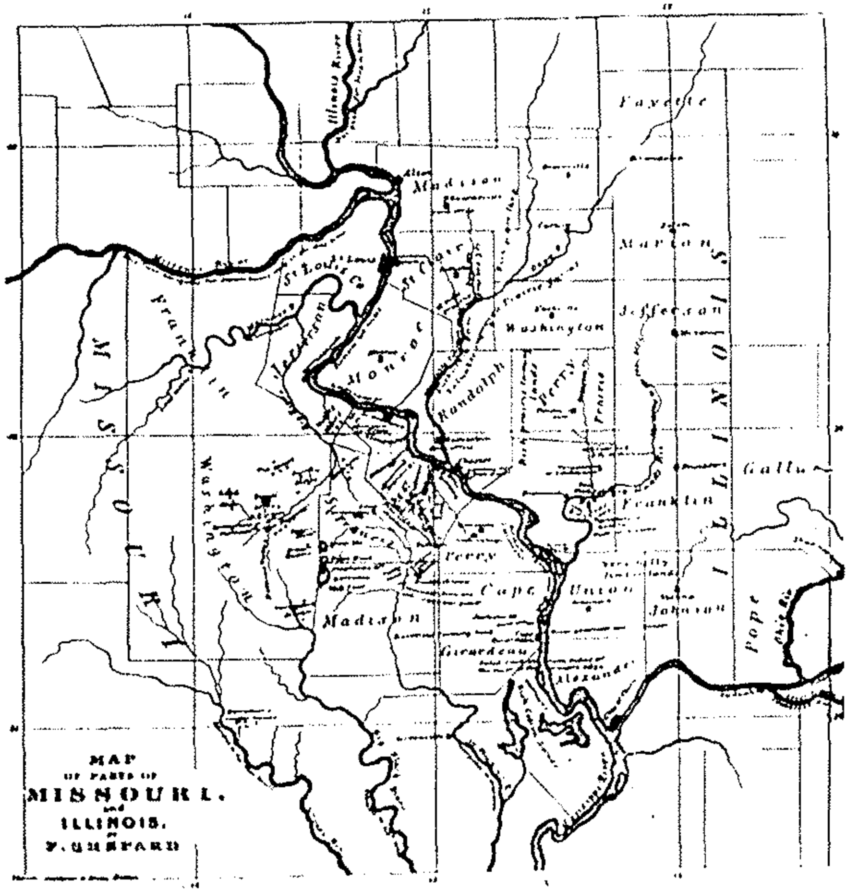


FIG. 3. Map drawn by Shepard, 1840

iron ore; and having by repeated and laborious explorations, satisfied myself that such beds do *not* exist in the vicinity of the Missouri Iron Mountains, nor yet between those mountains and Mississippi river, I turned my attention to Illinois, where the first thing of its kind worthy of note, was a bed of excellent bituminous coal, very free from sulphur and earthy impurities, and workable 8 feet in thickness without intervention of slate. Its covering is a thin band of shale, and above that, a solid limestone rock.

No. 13, is the purchase of the east half of the southeast quarter section No. 29, in township No. 6 south, of range No. 2 west, containing 80 acres. This tract lies a short distance eastward of Beaucoup creek, and the above coal bed underlies the surface throughout, a little above the level of the stream. The surface of this tract is for the most part level, and the soil is of the very first quality for wheat and corn. The above creek has been navigated by flat-boats to Brownsville in time of high water.

Nos. 14, 15, 16, and 17 are purchases of about 300 acres on the navigable waters of Big Muddy river in Jackson county. These tracts are covered with a large growth of valuable timber, and possess a soil second to none in the State of Illinois; but their principal value consists in their mineral riches; namely, their coal and iron beds, and a salt region beneath the coal. No. 17, which has been more particularly examined, I shall here particularly describe. About three miles above Brownsville, the county seat, immediately upon the south bank of the river, in the south half of the southwest quarter of section No. 9, in township No. 9 south, of range No. 2 west, and a few feet above ordinary water level, is a coal bed presenting a breast of five feet in thickness of excellent workable coal. Above the five feet of coal, comes one foot of shale, and immediately above that another foot of good coal. Directly over this last coal seam is a bed of the argillaceous carbonate of iron, from 10 to 15 feet in thickness and as extensive as the coal formation. The ore consists in nodules and balls, imbedded in soft slate or clay, and may be easily excavated. Both the coal and iron beds, with all the accompanying strata, rise gradually as they recede from the river, so as to afford spontaneous drainage to the levels when worked. When I first discovered this ore bed,

I felt that I would gladly exchange the privilege of making iron in almost any other place for the opportunity presented here. For with one hand, I could reach the coal, and with the other, the ore containing its own flux; while at my feet was a navigable stream for a great part of the year, to carry the iron to market. The deposits of iron ore and coal on this tract alone, I am confident cannot possibly be exhausted in a period of many years. A little higher up the river, on the property of H. Neilson, Esq., the above coal bed has been opened, and carried in boats to the New Orleans market, where I am informed it uniformly commands a higher price than any other coal. Specimens of the coal and iron ore are in possession of Professor Shepard.

Believing that a point on the Mississippi river, where the products of both States may be concentrated for the purposes of manufacturing, would materially enhance the value of the above purchases, the young but enterprising town of Chester was accordingly selected, and,

No. 18, is a landing on the Mississippi of two acres, not subject to inundation, with a sufficient depth of water at all times, and on a rock foundation. This has been purchased on certain stipulated conditions for the Association, for the purpose above-named, and if necessary, a large number of acres may be added to the landing, without increasing the rate of purchase money per acre.

All which is respectfully submitted by

Your obedient servant,

FORREST SHEPHERD.

(For the information of those who are unacquainted with Mr. F. Shepherd, it may be proper to state, that he is well acquainted with practical geology and mineral surveying, and has been employed for several years past by different mining companies, in exploring mineral deposits. He is permitted to refer to Professor Silliman and Olmsted, and President Day, of Yale Col. In the purchases described in this Report are nearly 2000 acres embracing much good farming land, and eight or ten mill sites.)"

The analysis of Big Muddy Coal made by Prof. Charles V. Shepard and included in the report checks closely with present day analyses:

"Gentlemen:—I beg leave to offer the following statement respecting the Ores and Coal from the mining tracts mentioned in the foregoing Report of Mr. Forrest Shepherd.

3d. Bituminous Coal and Iron Stone of Illinois.

The coal of Big Muddy and Beaucoup river is possessed of very promising qualities. Its specific gravity is 1.31. It is rich in bituminous matter, burning freely and with a bright flame, without at the same time being so redundant in bitumen as to melt into a slag, which clogs the free circulation of air among the fuel. The bituminous and volatile matters amount from 33.5 to 37.5 per cent., and the carbon or combustible portion of the coke, equals from 58 to 55 per cent; while the earthy ash which remains, rises only to 8.5 parts in the hundred. The specimens presented are quite free from sulphuret of iron, which shows that this coal is admirably adapted to domestic and metallurgical uses."

By 1840 the coal mining industry had reached considerable proportions. MacGregor in "Commercial Statistics of All Nations," Vol. 3, gives the following data on coal mining in 1840 copied in part from the U. S. Census Report.

AGGREGATE VALUE OF PRODUCE, AND NUMBER OF PERSONS EMPLOYED IN THE MINES OF ILLINOIS, 1840

COAL

Anthracite			Bituminous		
Tons raised (28 bushels each)	No. of men employed	Capital invested	No. of bushels raised	No. of men employed	Capital invested
132	2	....	424,187	152	120,076

The U. S. Census Report for 1840 credits coal mining in Illinois with a capitalization of $120,076, with 152 employees and with a production of 424,187 bushels, distributed according to the following table:

Counties	Capital	Men	Bushels
Adams	......	5	2,700
Edwards	......	1	2,000
Gallatin	......	2	1,500
Henry	......	2	2,250
Jackson	100,000	21	15,000
Lawrence	110	6	1,650
Madison	1,900	25	97,250
Marshall	200	3	4,000
Morgan	1,000	3	2,000
Peoria	600	8	12,000
Perry	......	1	1,500
Randolph	525	11	6,011
Sangamon	650	10	82,000
Schuyler	10	5	5,230
Scott	2,331	18	52,200
Shelby	500	2	2,700
St. Clair	12,250	24	129,396
Vermilion	......	..	2,800
Warren	......	..	2,800

Hunt's Merchants Magazine for 1841 states: "The coal of Illinois is of the bituminous character, and lies principally in the ravines and points of the bluffs. Exhaustless beds are found in the bluffs of St. Clair county, bordering on the American Bottom, and large quantities are carried across to St. Louis, for fuel. There is, however, scarce a county in the state in which it does not abound. The quantity dug in 1839 was over 376,000 bushels.

The following particulars are derived from a tabular statement prepared by J. A. Townsend, of Alton, Illinois

No. of persons employed in mining..........1,227"

Mrs. Steele in "A Summer Journey in the West" published in 1841 writes of Ottawa thus: "It is the center of an extensive coal basin which cropt out in various places in the neighborhood. Chicago now receives supplies of that article here, which she once obtained from Ohio."

The mines in the vicinity of Ottawa were opened on the room-and-pillar system but about 1870 were changed to the longwall system, the Oglesby Coal Company being among the first to make the change in method of mining.

The development of the industry was retarded by lack of transportation. Ten years after the authorization by the legislature of the comprehensive program of internal improvement there were in operation in Illinois only two railroads listed by Colton in "The Western Tourist" published in 1846. These two roads were:

"Northern Cross railroad completed from Springfield to Meredosia on the Illinois river, a distance of 53 miles.

Coal Mine Bluffs railroad extends 6 miles from the Mississippi river to the coal mine."

During the session of 1846-7 the legislature granted a charter for constructing a macadamized road from Belleville to St. Louis. The road, almost fourteen miles long, was built. This was the first macadamized road in the State.[1] "The improvement was one of great value to the country and gave the city of Belleville its first advance toward prosperity."

The opening of the Illinois-Michigan canal in 1848 was the precursor of better transportation conditions and marks the end of the ante-railroad period.

RAILROAD PERIOD (1850—1915)

The total mileage of railroads in the State in 1850 was insignificant. The first railroad completed was the six-mile coal track across the American Bottom in 1837. The second road was the small section of the Northern Cross road from Meredosia to Springfield. The third was the Galena and Chicago begun in 1849 and opened for a length of ten miles in 1850.[2] In that year congress donated about three million acres of land as security for the building of the Illinois Central Railroad. Construction on the Illinois Central began in 1852 and the work went rapidly forward.

The first line from Chicago to the Mississippi was the Chicago and Rock Island completed in 1854 and the second opened to the Mississippi was made up in part of the Galena and Chicago and of the Illinois Central.[3] Until 1854, coal was hauled by wood burning locomotives and the greatest impetus given to the expansion of the coal industry after the construction of railroads was the purchase by the Galena and Chicago

[1] History of St. Clair County. MacDonough.
[2] Poor's Manual of Railroads. 1876.
[3] Poor. op. cit.

TABLE 1.—*Coal production and main track mileage of railroads*[1]

Year	Coal tonnage	Main track mileage	Year	Coal tonnage	Main track mileage	Year	Coal tonnage	Main track mileage
1833	6,000	0	1860	728,400	2790	1887	12,423,066	9647
1834	7,500	0	1861	670,000	2917	1888	14,328,181	9900
1835	8,000	0	1862	780,000	2998	1889	12,104,272	9964
1836	10,000	0	1863	890,000	3156	1890	12,292,420	10165
1837	12,500	6	1864	1,000,000	3156	1891	15,660,698	10189
1838	14,000	6	1865	1,260,000	3157	1892	17,862,276	10349
1839	15,038	6	1866	1,580,000	3191	1893	19,949,564	10405
1840	16,967	6	1867	1,800,000	3224	1894	17,113,576	10564
1841	35,000	22	1868	2,000,000	3440	1895	17,735,864	10673
1842	58,000	22	1869	1,854,000	4031	1896	19,786,626	.....
1843	75,000	22	1870	2,624,163	4823	1897	20,072,758	10847
1844	120,000	22	1871	3,000,000	5904	1898	18,599,299	10861
1845	150,000	22	1872	3,360,000	6361	1899	24,439,019	10989
1846	165,000	22	1873	3,920,000	6589	1900	25,767,981	11048
1847	180,000	22	1874	4,203,000	6759	1901	27,331,552	11231
1848	200,000	22	1875	4,453,178	7109	1902	32,939,373	11398
1849	260,000	52	1876	5,000,000	7285	1903	36,957,104	11502
1850	300,000	111	1877	5,350,000	7334	1904	36,475,060	11742
1851	320,000	271	1878	5,700,000	7448	1905	38,434,363	11959
1852	340,000	412	1879	5,000,000	7578	1906	41,480,104	12085
1853	375,000	759	1880	6,115,377	7851	1907	51,317,146	12201
1854	385,000	788	1881	6,720,000	8260	1908	47,659,690	12215
1855	400,000	887	1882	9,115,653	8670	1909	50,904,990	[illegible]
1856	410,000	2,235	1883	12,123,456	8868	1910	45,900,246	12111
1857	450,000	2,502	1884	12,208,075	8908	1911	53,679,118	12132
1858	490,000	2,730	1885	11,834,459	8901	1912	59,885,226	.....
1859	530,000	2,781	1886	11,175,241	9276	1913	61,618,744	12168
						Total......	965,516,323	

[1] Compiled from Mineral Resources of the U. S., 1913, and Poor's Manual of Railroads, 1913.

in that year of five locomotives "guaranteed to burn the bituminous coal mined in Illinois."[1]

The increase of main track mileage of all railroads in Illinois and the coincident development of coal mining is shown in Table 1 and by a graph in fig. 4.

In 1851 "a railroad was built by the Illinois Coal Company[2] operating at Caseyville, from that point to Brooklyn, a short distance north of East St. Louis, which was completed in February, 1851. It was supplied with T rails. Up to this

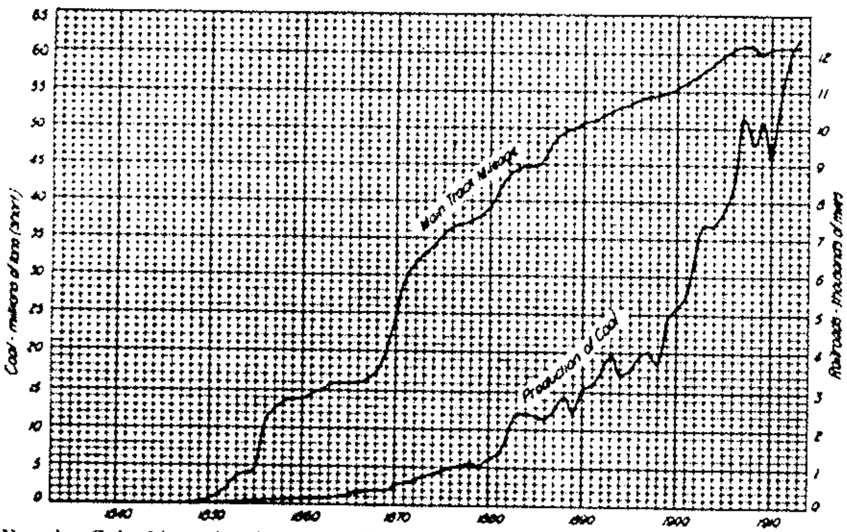


FIG. 4. Coincident development of main track mileage and production of coal

time the company had hauled coal by ox and mule teams to St. Louis. In three years the company failed; the road and fixtures were sold to the Ohio and Mississippi Railroad Company and the rails were taken up and used in the construction of that road. The old road bed can still be traced."

The Gartside Coal Company sunk its first shaft at Alma in St. Clair County in 1851.

Until 1854 the current of Illinois river had carried southward most of the products of central Illinois and only those

[1] History of the Illinois Central Railroad.
[2] St. Clair County History. MacDonough.

from the northern part of the state sought the Lake outlet.[1] But from this time the stream of traffic was deflected at right angles towards the eastern market and by 1856 Chicago had become the center of railroads radiating to the Mississippi.

In 1855 Taylor in his "Statistics of Coal" says: "A Chicago paper states there are, or will be, in operation on the 1st of July, 1855, in the State of Illinois, 3,715 miles of railroad. There are now in operation, leading into the City of Chicago, 1,626 miles of railroad." All over the State new mines were opened up along new railroads. Fig. 5 shows a typical surface plant of this period.

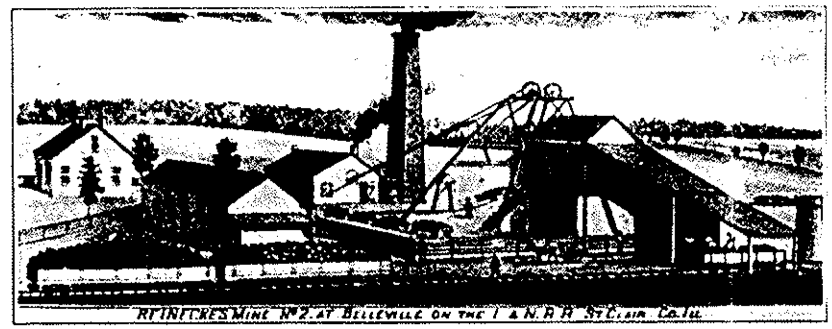


FIG. 5. Surface plant of early railroad period

Taylor, describing coal fields in the United States, says further, "Passing now to the southward, we enter the great Illinois coal-field, which occupies an extent nearly equal to that of England; yet the State has but recently commenced to make use of the coal with which nature has so bountifully provided her. Except in the vicinity of the larger towns and rivers, the business of mining coal here had made but small progress."

The coal trade of the lakes in 1855 is discussed by Taylor who says, "Large quantities of bituminous coal are obtained from coalfields in the north-western part of Pennsylvania, 60 to 80 miles south of Lake Erie. Another source of supply of bituminous coals, is from beds lying on the line of the Michigan and Illinois canal, in Illinois, distant from Chicago on

[1] American History and Its Geographical Conditions. Semple.

Lake Michigan, 60 to 80 miles. This canal was opened in 1848, and but little coal came to market that year. In 1849, 5,150 tons reached Chicago. The upper part of these beds furnished coal highly charged with sulphur, which confines the use of it principally for household purposes. Boats and other machinery make but little use of it for steam, it being so destructive to grate-bars and boilers. But the quality of coal is improving the deeper the beds are worked, and the prospect is that coal of equal quality will soon be raised from them, as free from this objectionable matter as the Cleveland and Erie. The production of these mines is not definitely known, but a writer in the Cleveland Herald, estimates the entire consumption of coal by the Lake region in 1853, at 300,000 tons."

He gives details of the production of Illinois in 1855 as follows: "There is no coal on the Ohio river nearer to its junction with the Mississippi than Saline, near Shawneetown, 116 miles above the mouth of the first named river. On the Mississippi, it is rather a shorter distance, being sixty miles to Muddy creek, and thence twenty-five miles up that creek to the first coal-bed there, or twelve miles of land. Some coal operations commenced here some few years ago, having in view the supply of the towns along the Mississippi, as far even as New Orleans. The present supplies of coal to the lower country are obtained from a vast distance up the Cumberland and Tennessee rivers, but especially from Wheeling, Pittsburg, and the intermediate points, 900 miles further from the market than the Illinois coal of Muddy creek. The estimated expense of delivering this coal at New Orleans, by arks, is about $2.25 per ton; while the minimum price of coal there is 25 cents a bushel, or $7.50 per ton. In winter time from 50 to 62½ cents per bushel, or $12 to $15 per ton have been occasionally the retail price there. This Muddy Creek coal seam is a horizontal bed six or seven feet thick, above which is another vein, not heretofore worked. Coal can be thrown from the mouth of the drift into a boat. Its quality is most excellent, igniting readily, and caking together perfectly, without making much clinker. It has been used for

fifty years by the old French settlers, to make edge tools, which have borne a high reputation.

What is termed St. Louis coal, supplied to the steamers, burns with a good flame, and cements like that of Pittsburg; ashes dark gray, in small quantity, and consumes with little waste. It is often mixed with yellow sulphuret of iron in flakes occurring on each face of the sectional fracture; and consequently is not, we understand, in so good repute for the purposes of iron manufacturing.

Toward the north-west boundary of this district, several coal seams are seen in the tongue of land which lies between the Mississippi and Rock rivers. One of these beds is from five to six feet thick; its quality is fair, and evidently improves as the workings proceed.

To the south of Rock river are several good coal seams which are capable of supplying almost any required quantity of this fuel. Their local position and advantages render them of great value to the country lying north of this."

With the advent of transportation facilities new fields were opened away from the large towns and rivers. The railroad network spread and the markets of the State were opened to coal from a distance. In 1856[1] three companies in La Salle County sunk shafts from 100 to 200 feet deep: The La Salle Coal Mining Company, the Northern Illinois Coal and Iron Company, and the Peru Coal Mining Company. By 1860[2] Illinois had 73 mines producing 728,400 tons valued at $1,285,500. There were employed in the mines 1430 men and boys.

Mining in St. Clair County still offered possibilities to the investor. Joseph Yoch opened a mine known as Yoch's mine in 1859 on the old Breeze farm, two and a half miles west of Belleville and the Van Court mine east of O'Fallon with a seven foot vein lying at a depth of 207 feet was opened in 1863.[3]

In 1865 coal was found in digging a well on a newly settled farm in the Wilmington district in Will County. This region soon assumed considerable importance. In 1866 the

[1]Coal Regions of America. MacFarlane. 1873.
[2]U. S. Census Report. 1860.
[3]History of St. Clair County. MacDonough.

Chicago and Wilmington Coal Company[1] was organized by Boston and Chicago capitalists and shortly after its formation it was consolidated with the Vermilion Coal Company, a new concern under the name of the Chicago, Wilmington and Vermilion Coal Company. Operations were immediately started on a large scale, all the product being shipped to Chicago over the Chicago and Alton railroad.

In the Vermilion County field mining on a commercial scale began in 1866 when Wm. Kirkland, Hugh Blankeney and Mr. Graves opened a stripping mine on Grape Creek.

In the Caseyville precinct of St. Clair County the first shaft of the Abby Coal Mining Company was sunk on the Vandalia line in 1868 by Maule and Williams.

The U. S. Census Report for 1870 credits Illinois with an output of 2,624,163 tons of coal pro rated among the various counties as follows:

COAL PRODUCT OF ILLINOIS IN TONS

Counties	Year 1870
Bureau	32,339
Christian	60
Clinton	9,000
Fulton	22,850
Gallatin	11,600
Grundy	51,375
Henry	62,750
Jackson	166,800
Jersey	2,623
Knox	97,225
La Salle	173,864
Livingston	49,360
Logan	17,000
McDonough	60,750
McLean	55,000
Macoupin	7,000
Madison	116,924
Marshall	17,330
Menard	17,360
Mercer	14,040
Montgomery	18,000
Peoria	6,000
Perry	195,400
Randolph	11,000
Rock Island	127,630
Sangamon	84,500
Schuyler	8,100
Scott	2,950
Shelby	5,700
Stark	14,554
St. Clair	798,810
Tazewell	5,300
Vermilion	116,640
Warren	11,729
Will	228,000
Williamson	1,600
Woodford	4,000
Total	2,624,163

[1]Engineering and Mining Journal. 1874, p. 306.

In 1870 considerable work was done at the West Vermilion Heights shaft in Vermilion County and through the early seventies the Grape Creek Coal Company opened up what are now known as the old Grape Creek mines, about four miles southeast of Danville, midway between Danville and Westville on the line of the C. & E. I. R. R.

The Abby shaft No. 2 in St. Clair County[1] was sunk in 1873 by the Abby Coal Mining Company. "The depth and vein is about the same as at the other mine. The Springfield mine, still east of the others, was sunk in 1874, by the Bartlett Coal Company, and is now operated by the Springfield Company. Coal is reached at 160 feet, and the vein is full six feet in thickness."

Bennett's coal mine, two miles west of Lebanon, in St. Clair County, on the O. and M. Railroad, was opened in 1873 by Jeremiah Bennett, and a five and one-half foot vein was reached at a depth of 180 feet.

In 1874 the Grundy County deposits which had been prospected in 1866 were opened up. Upon the completion of the Chicago and Illinois River Railroad across La Salle County in 1874 the county began to supply outside markets. Along the Illinois Central railroad in this same year three new companies sunk shafts,[2] the Chicago Coal Company, the Illinois Valley Coal Company and the Kenoska Coal Company.

The Belleville district in St. Clair County in 1875 was the most important mining district in the State and an excellent description of mining conditions there in that year is given in the History of East St. Louis by R. A. Tyson. He says, "St. Louis obtains its principal supply of bituminous

[1]St. Clair County History. MacDonough.
[2]Coal Regions of America. MacFarlane, 1873.

coal from what is known in coal regions as the Belleville district, in St. Clair County, Illinois. It is brought to East St. Louis by the St. Louis and Illinois, commonly known as the Pittsburg Railroad. This Railroad is only 12 miles long, from East St. Louis to Belleville, but it intersects the western boundry of the coal measures at Centerville six miles out from E. St. Louis, and runs six miles through the coal field. St. Clair county, contains 450 square miles of coal, or three-fourths of the county, embracing all the central and eastern portions, with a thickness of about 300 feet of the lower and most productive of the coal measures, embracing five coal seams, only two of which, however, appear to be of economical value at this time.

In 1871 there were transported by this railroad, from Belleville, and Centerville to East St. Louis, 361,630 tons. The last United States census reports the coal production of St. Clair County at 798,810 tons. This is, therefore, by far the most productive, and, in that respect, the most important coal region in Illinois. The thickest coal seam outcrops in the river and along the western borders of the coal measures in the southwest portion of the county. The dip is very moderate, not more than five or six feet to the mile, and is in an easterly direction, or a little north of east, and in consequence the coal lies deepest below the surface in the eastern portion of the country, and crops out to the surface near East St. Louis. The Belleville coal seam, No. 6, is the principal one worked, and it was probably the first ever worked in the State. Its natural outcrop along the bluffs, in such close proximity to St. Louis, called attention to its value at an early day. Its general thickness in this county ranges from five to seven feet, and it has a solid limestone roof, so that it can be worked with safety and in the most economical manner.

This coal is generally quite regularly stratified, and the two upper layers, which vary in their aggregate thickness from 16 to 24 inches, are much the purest in quality. It is usually separated from the lower coal, and sold at about three cents per bushel higher, as a blacksmith coal; thus: heating coal, six cents; blacksmith coal, nine cents per bushel.

The main coal seam No. 6 has been opened at many points about Belleville, and the river bluffs back of the outcrop. It is reached by twenty-five shafts, sunk to the depth of from 50 to 150 feet. In Alma shaft the coal was found at a depth of 170 feet below the surface, and the seam is seven feet thick. It is the same thickness at Mascoutah, at 132 feet deep, and 6½ thick at Urbana or Freeburg, and about the same depth below the surface.

In the southern part of the county the Belleville coal is opened at many places along its outcrop, and retains its full thickness of about seven feet. Everywhere it seems to be from six to seven feet thick.

It will be seen that the coal measures underlie all the highlands in the county of St. Clair, except a narrow belt from three to five miles wide across the southwest border, and the land is also among the most productive agricultural lands in Southern Illinois. The analysis of the Belleville coal shows the following results:

	Specific gravity	Loss in coking	W't of coke	Moisture	Vol'e matter	Carbon in coke	Ash	Carbon coal
Casey's mines	1.304	39.8	60.2	6.0	33.8	55.2	5.0	55.3
Pfeifer's mines	1.293	44.3	55.7	8.5	35.8	51.2	4.5	57.5
Belleville m.	1.293	45.0	55.0	5.5	39.5	49.6	5.4	54.6
Dill & Knapp's m.	1.340	42.51	57.49	4.43	38.8	44.48	13.9	54.28
Churchill m.	1.315	45.40	54.60	6.00	39.40	45.70	8.90	52.63
Belcher m.	1.296	44.66	56.34	8.10	35.56	47.71	8.60	54.50

Professor Worthen says that from the analysis, the Belleville coal will compare favorable with the average of bituminous coals from the other localities either of this or adjoining States.

Cheap Coal in East St. Louis.

Coal is cheaper in East St. Louis by the cost of transportation across the Mississippi. It is brought in wagons and cars on a down grade, six or eight miles from the outcrop in the bluffs to East St. Louis. The process at the mines is as follows:

After the coal is mined the cars are drawn horizontally up grade into the mine by a mule. The mule is detached; the cars filled, started out of the mine by hand, and carried down grade by their own weight to a trestle at the entrance. Here they are dumped. Coal cars receive the falling coal. These are standing ready to receive it. When full the coal train starts and moves a considerable distance down grade, unaided. Engines are then attached, which complete the transportation to East St. Louis.

Coal can be delivered to any part of East St. Louis on railroad track or switches at six cents per bushel

There are 80 lbs. in a bushel; 2,000 lbs. in a ton. There are as many bushels in a ton as equal the number of times which 2,000 lbs. contain eighty lbs; equals 25 bushels; 25 x .06 equals $1.50 per ton, far cheaper than cord wood in the forest regions. It can be delivered to the manufacturing establishments of East St. Louis at from one-third to one-half less than it can be delivered west of the river.

Tracks can be run from almost any road to any furnace door. Coal can be contracted for by the year, and thus this great want be conveniently and cheaply met.

Enough coal to last for ages

All this coal is of easy access by rail on a down grade to the very doors of the furnaces of the East St. Louis manufactories, costing but $1.60 per ton delivered.''

The development of the industry to the proportions it had reached by 1875 had not been unaccompanied by labor disputes nor by periods of depression and ruinous competition. Tyson appends the following extract from the Belleville Democrat of August, 1875:

''Coal mining in detail—by a miner

Appended is a document which appeared in the Belleville Democrat, during August, 1875, which is of interest to coal producers and consumers. It will be seen that an immaterial advance of a cent per bushel in price is asked by this union:

Platform and Constitution of the Reorganized Miners of St. Clair and Adjoining Counties.

Resolved. 1st. That we demand *three cents per bushel* for mining, and will take no less.

2nd. That we have fair and just railroad weight, and are paid twice a month—upon the 5th and 20th of each month.

3rd. That no coal shall have a screen to exceed one inch between the bars of said screens.

4th. That we will not mine coal for any coal mining company that will sell coal for less than seven and one-half cents per bushel in the coal yard on this side of the river, and eight and three-quarter cents in the yard on the Missouri side, and eleven cents per bushel when delivered in or with wagons.

5th. That we will not mine any coal for any coal operators who will sell coal to another operator when his miners are on a strike, when the same is made a known fact.

We have given the above resolutions due consideration, and do not see in them anything that is of an extortionate or tyrannical character. It is a known fact that less than three cents is not a living price for mining coal, though we will admit that three cents is more than we have had for the last nine months; but in viewing our condition we also know that we have been going in debt all the time, and many of us cannot get out of debt in the next twelve months, even at three cents and steady work. As for steady work, we know that we cannot all get it; and let me say, right here, that if the grocery men and butchers were to stop giving us credit, we would be starving or else stealing for a living. These statements are facts. This being the case, most assuredly we are entitled to a fair price for our labor. The 2d, 3d, 4th and 5th of our resolutions are to protect the three cents for mining. Past experience has taught us than when the warm season comes there is not work for us all. Then we forget our brother coal miner, and only think of self. Then in order to get steady work we come down on the price. Some coal boss will say to the miners that are working for him, 'Boys, there is a contract to be let, and if you miners will take two and three-quarters, or two and a half cents per bushel, and say nothing about it, I can get that contract, and you will have steady work.' The answer will be, 'all right; go ahead and get the contract.' The contract is then taken at a reduced price that will not allow *three cents for mining*. Then go and ask these men how it is and they will reply, 'I don't know; we are getting district prices.' That is the beginning of the reduction of price, and the downfall of our Union. Now, I claim that a uniform price in the market will show every one of us that the coal is sold for a price that is not too high for the consumer, and will give the miners three cents for mining. But when sales are being made every day that show clearly to other coal operators that they cannot sell so low and save themselves, it will naturally be supposed that the miners are mining cheaper, and generally they are right; so there comes strife and contention with the coal operators, and also with the miners that are at work at some other mine. They cannot see how it is that such a coal operator can make anything on that contract. If he does, he is bound to cheat his men in some way. The fact of the case is, his miners have told him what to bid, or at least they told him what they would do—how much cheaper they would mine if they could get steady work. So the contract is taken at such low figures that no other coal operator can sell coal at the same price without losing money. If he does not sell at the same price he will lose his trade. So he begins to grumble with his miners, stating that there is something wrong. By this time there is another contract to let. They then go for it at the least price—perhaps a half-dozen bids in, with an understanding with the men that they will mine under price if they get the contract. When the bids are opened they find that their black bids are nowhere by the side of some other black bids. After they and their black bids are defeated, then their miners curse and fume and swear that they can dig coal as cheap as any blacklegs that ever lived, so down goes the price for mining and down goes the price in market. When we look fairly into the coal business we perceive that the whole cause of the price coming down is through the miners and operators, not through the consumer. That taken for a fact, we can safely say if we fail to get a living out of the trade, it is our own fault. The consumers must have coal, and will pay a living price for it if we will demand it, but we must not demand it, we must not demand an unreasonable price. We must at all times take into consideration the condition of the country financially, and base our demands in proportion. Now, three cents is a very low price for mining this

coal, and seven and a half in the yard is cheap on this side of the river. Eight and three fourths is cheap on the Missouri side in the yard, and eleven cents delivered is equally cheap. For proof:

Three cents for mining	3
Two and a half cents for freight	2½
One half cent for royalty	½
One and a half cent for hoisting and margin	1½
In the yard on this side	7½
Shipping across the bridge	1¼
In the yard on the Missouri side	8¾
Three and a half cents for hauling and delivering this side of the river	7½
Hauling from river	3½
Deliver by wagon	11"

The prosperity of East St. Louis was accounted for by the number of railroads radiating from it in 1875. Tyson gives the following list:

1st. The Illinois and St. Louis Coal Road. First built of wooden rails, in 1837, by Ex-Gov. Reynolds and others, from here, six miles, to the coal bluffs, and extended six miles further to Belleville, in 1870. Horse power was first used.

2nd. Ohio and Mississippi Railroad. Ground broke in 1852. Terminated here, June, 1857.

3rd. Terre Haute, Alton and St. Louis Railroad, now known as the Indianapolis and St. Louis Railroad.

4th. Illinoistown and Belleville Railroad, now known as the Cairo Short Line. This road now runs to Duquoin, on the Illinois Central, and connects there for Cairo.

5th. The Chicago, Alton and St. Louis Railroad. Its first termini were at Chicago and Alton.

6th. The St. Louis, Vandalia and Terre Haute Railroad, now known as the Vandalia Line.

7th. The Decatur and East St. Louis Railroad, now owned by and known as the Toledo, Wabash and Western.

8th. The Rockford, Rock Island, and St. Louis Railroad. This Road comes in from Alton Junction, on the track of the Vandalia line.

9th. St. Louis and Southeastern, which has several branches.

10th. The American Bottom Lime, Marble and Coal Company, now known as the East St. Louis and Carondelet Railway. It has a branch running to Falling Springs.

11th. Cairo and St. Louis Railroad. This Company commenced running on the 15th of September, 1873, to McLeansboro, Ill., 90 miles; there tapping the celebrated Big Muddy coal fields—which coal is the best for smelting purposes in the United States. The company soon formed a contract to transport coal for three years to supply the South St. Louis furnaces with fuel. For the year ending May 31, 1875, its gross receipts were $267,884.94. Operating expenses were about 60 per cent of receipts. During the same year (ending May 31) the coal traffic ran very light, owing to the closing of most of the furnaces at St. Louis."

In 1880 the production of coal in Illinois amounted to six million tons produced by counties as follows:

Counties	Tons	Counties	Tons
Brown	400	Marshall	5,450
Bureau	65,890	Menard	61,120
Clinton	40,000	Mercer	79,531
Coles	320	Montgomery	42,400
Fulton	336,171	Morgan	13,500
Gallatin	80,400	Peoria	273,640
Greene	3,260	Perry	222,186
Grundy	183,812	Randolph	69,958
Henry	155,695	Rock Island	237,589
Jackson	64.412	Saline	2,320
Jasper	24	Sangamon	427,619
Jersey	2,300	Schuyler	5,115
Johnson	27,000	Scott	5,700
Kankakee	1,000	Shelby	6,504
Knox	26,462	Stark	22,143
LaSalle	716,487	Saint Clair	956,265
Logan	60,000	Tazewell	61,348
Livingston	118,230	Vermilion	228 850
Macoupin	247,284	Warren	15,467
McDonough	82,304	Washington	4,000
McLean	63,000	Will	611,311
Madison	273,807	Williamson	73,500
Marion	39,943	Woodford	101,060

In 1881 the First Biennial Report of the Bureau of Labor Statistics was published which contained a report on the coal mines of the State. The history of Illinois mining from 1881 is available in the reports of the Bureau and in the subsequent Reports of the State Mining Board.

DIVISION OF THE STATE INTO DISTRICTS

The Illinois Coal Mining Investigations preparatory to its study of mining conditions in Illinois divided the State into eight districts as shown in fig. 6, on a basis of geographical location and physical and geological conditions. The boundaries of these districts were so chosen that all the mines in a district work under similar conditions.

One hundred typical mines were chosen for examination, distributed among the districts proportionately to their importance and in accordance with the variations of mining methods in the mines of each district. Three of the mines thus chosen were dropped from the list for various reasons, but the remaining 97 were examined in great detail. The engineers who made this detailed study were S. O. Andros, C. M. Young, J. J. Rutledge and R. Y. Williams. Based upon this field examination and a great volume of subsequent correspondence with mining men in the State a detailed report of mining practice in each district has been published. Complete details of the organization of the staff and of the methods of collecting data can be found in Bulletin 1, "A Preliminary Report on Organization and Method."

The averages in the tables in this bulletin based upon the 97 mines examined compared with similar averages for all the mines of the State as given in the Coal Reports of the State Mining Board show that the 97 mines examined are really typical of the mines of the State and that conclusions based upon the data gathered at the chosen mines apply to the State as a whole.

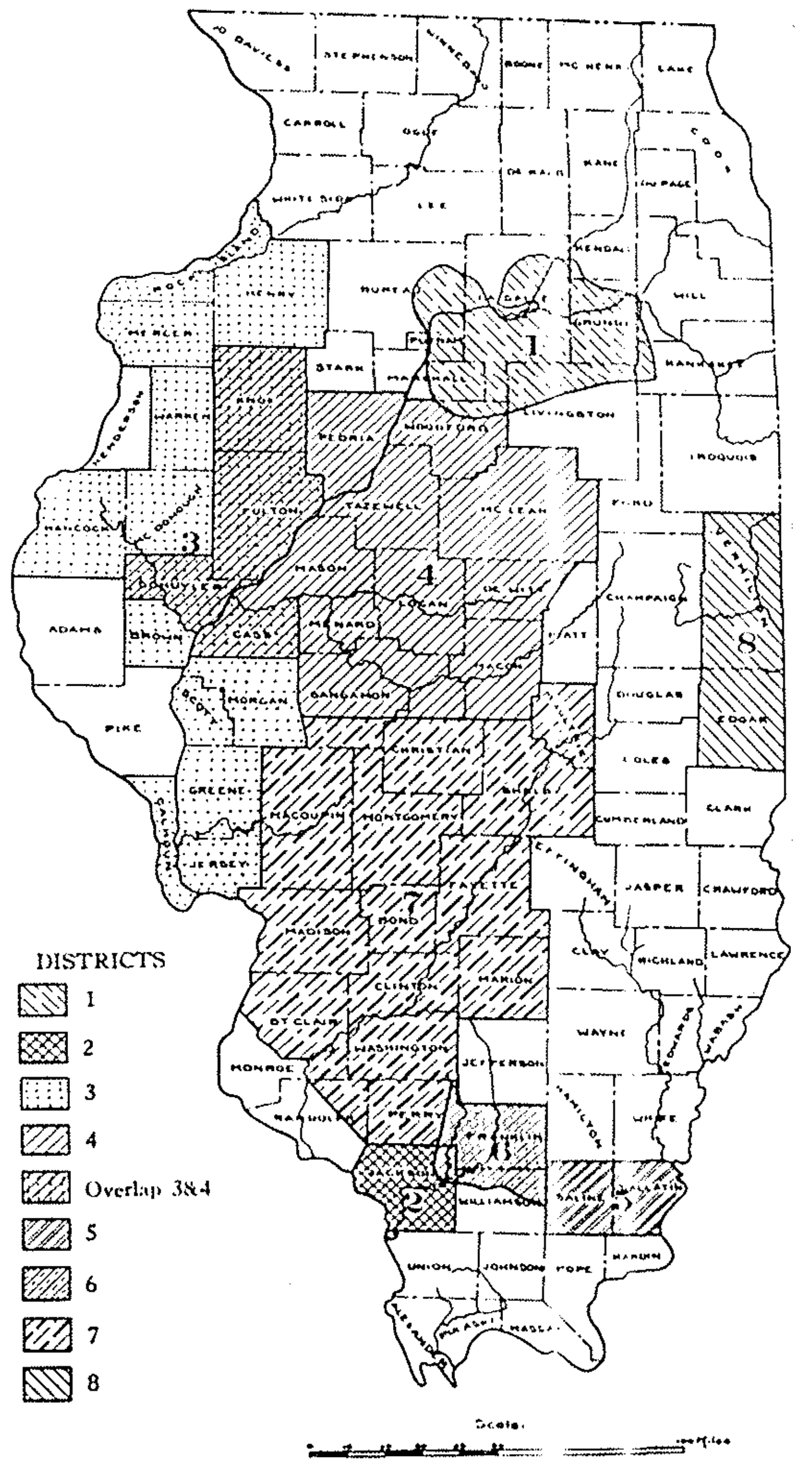


FIG. 6 Division of the State into districts

Table 2 gives the districting of the State by counties.

TABLE 2.—*Districts into which the State has been divided for the purpose of investigation*

Investigations district	Coal seam	Method of mining	Counties	Investigations numbers for mines examined
I	2	Longwall	Bureau, Grundy, LaSalle, Marshall, Putnam, Will, Woodford	1 to 11
II	2	Room-and-pillar	Jackson	12 to 16
III	1 and 2	Room-and-pillar	Brown, Calhoun, Cass, Fulton, Greene, Hancock, Henry, Jersey, Knox, McDonough, Mercer, Morgan, Rock Island, Schuyler, Scott, Warren	17 to 24
IV	5	Room-and-pillar	Cass, DeWitt, Fulton, Knox, Logan, Macon, Mason, McLean, Menard, Peoria, Sangamon, Schuyler, Tazewell, Woodford	25 to 42
V	5	Room-and-pillar	Gallatin, Saline	43 to 49
VI	6 (East of Duquoin anticline)	Room-and-pillar	Franklin, Jackson, Perry, Williamson	50 to 65
VII	6 (West of Duquoin anticline)	Room-and-pillar	Bond, Christian, Clinton, Macoupin, Madison, Marion, Montgomery, Moultrie, Perry, Randolph, Sangamon, Shelby, St. Clair, Washington	66 to 90
VIII	6 and 7 (Danville)	Room-and-pillar	Edgar, Vermilion	91 to 97

For convenience in reference an alphabetical arrangement by counties is given in Table 3.

These districts do not contain quite all the mines operating in Illinois because there are a few which do not fall into the arrangement such as the Assumption mine, 1004 feet deep, operating in Seam 1 at Assumption in Christian County and a few small room-and-pillar mines in Seam 2 in the longwall field. From the mines included in the eight districts of the Coal Mining Investigations, however, there is produced 98.3 per cent of the tonnage of the State and 97.6 per cent of all the employees in coal mines in Illinois work in these districts.

TABLE 3.—*Alphabetical arrangement by counties*

County	Coal seam	District	County	Coal seam	District
Bond	6	VII	Marshall	2	I
Brown	1, 2	III	McDonough	1, 2	III
Bureau	2	I	McLean	5	IV
Calhoun	1, 2	III	Menard	5	IV
Cass	1, 2, 5	III, IV	Mercer	1, 2	III
Christian	6	VII	Montgomery	6	VII
Clinton	6	VII	Moultrie	6	VII
Edgar	6, 7	VIII	Peoria	5	IV
Franklin	6	VII	Perry	6	VI, VII
Fulton	1, 2, 5	III, IV	Putnam	2	I
Gallatin	5	V	Randolph	6	VII
Greene	1, 2	III	Rock Island	1, 2	III
Grundy	2	I	St. Clair	6	VII
Hancock	1, 2	III	Saline	5	V
Henry	1, 2	III	Sangamon	5, 6	IV, VII
Jackson	2, 6	II, VI	Schuyler	1, 2, 5	III, IV
Jersey	1, 2	III	Scott	1, 2	III
Knox	5	IV	Shelby	6	VII
LaSalle	2	I	Tazewell	5	IV
Logan	5	IV	Vermilion	6, 7	VIII
Macon	5	IV	Warren	1, 2	III
Mason	5	IV	Washington	6	VII
Macoupin	6	VII	Will	2	I
Madison	6	VII	Williamson	6	VI
Marion	6	VII	Woodford	2, 5	I, IV

Table 4 gives for the year ended June 30, 1912, general data by districts comparing the general conditions in each district. Later statistics are available but those for the year ended June 30, 1912, have been used in order to make this report comformable with the previous reports of this series.

TABLE 4.—*Comparative percentages by districts*[1]

	Totals for the State	PERCENTAGES BY DISTRICTS I	II	III	IV	V	VI	VII	VIII
Production, tons	57,514,240	8.7	0.9	0.9	14.8	7.2	20.9	39.1	5.8
Kegs of powder used in blasting coal	1,313,448	1.3	0.3	1.9	31.2	4.1	18.0[2]	32.4	9.1
Total no. employees	79,411	14.7	0.9	1.4	16.1	6.1	18.3	35.1	5.0
No. days work performed	12,765,760	19.1	0.9	1.2	15.8	6.5	19.0	34.6	5.8
No. surface employees	7,049	12.9	1.3	2.0	15.7	5.9	20.4	33.4	4.3
No. underground employees	72,362	14.8	0.9	1.3	16.2	6.1	18.2	35.3	5.1
Average no. face workers (miners, loaders, machine men)[3]	53,318	15.9	0.8	0.8	17.4	5.1	18.8	36.3	4.7
No. fatal accidents	180	6.7	0.0	2.2	8.3	15.5	21.1	34.4	10.0
No. non-fatal accidents	800	24.5	1.0	0.7	4.4	8.1	15.7	35.6	7.4
Total no. accidents	980	21.2	0.8	1.0	5.1	9.5	16.7	35.4	7.9

[1] For the year ended June 30, 1912.
[2] 326,925 pounds of permissible explosives also used.
[3] Shipping mines only.

A comparison of the production in 1912 and 1914 indicates that since 1912 there has been no material change in the general conditions upon which the comparisons in this bulletin are based.

DESCRIPTION OF COAL SEAMS

The chemical composition and calorific value of the coal from the seams worked in the eight districts are given in Table 5.[1]

The following brief description of seams is intended to cover only those geological conditions which affect mining practice. The detailed geology of District I is given in Bulletin 10, Illinois Coal Mining Investigations, Coal Resources of District 1 (Longwall), by G. H. Cady and that of District VII in Bulletin 11, Illinois Coal Mining Investigations, Coal Resources of District VII, by F. H. Kay. Reports on the geology of the other districts will be made in similar bulletins which will be published in the future. References to other publications on the general geology of the Illinois coal fields are included in the bibliography appended to this bulletin.

In this description the coal seams are numbered according to the correlation of the State Geological Survey.

DISTRICT I, SEAM 2

Seam 2 in District I varies in thickness from 2 feet, 8 inches to 4 feet, averaging 3 feet, 2 inches.

The chief physical characteristic is the fine lamination of alternately bright and dull coal. On account of these laminations the luster is not so pronounced as that of the coal from the No. 6 seam; but this aspect is not due to impurities. The persistent dirt and sulphur bands of No. 6 are absent, but in places are thin bands of flat or lenticular pyrites. There is, however, no regularity in the distribution at any horizon of the layers of pyrites or of the local bands of pyritous mother coal and dirt bands. The thickness of these various layers of impurities varies from ½ inch to 4 inches.

The La Salle anticline which runs in a general northwest-southeast direction divides the district into two fields with slightly different physical conditions: the Wilmington on the

[1]Complete chemical data upon the 97 mines sampled will be found in Bulletin 3, Illinois Coal Mining Investigations, A Chemical Study of Illinois Coals, by Prof. S. W. Parr.

TABLE 5.—*Average analyses of coal by districts*[1]

District	Seam	No. samples	Proximate analysis of coal: 1st; "as rec'd," with total moisture. 2nd; "Dry," or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	B. t. u.	Unit coal B. t. u.
I	2	33	16.18 Dry	38.83 46.38	37.89 45.21	7.08 8.45	2.89 3.45	10,981 13,101	 14,528
II	2	15	9.28 Dry	33.98 37.46	51.02 56.24	5.72 6.30	1.29 1.42	12,488 13,765	 14,818
III	1	11	15.58 Dry	30.17 46.40	35.80 42.41	9.45 11.19	4.69 5.55	10,673 12,643	 14,546
	2	3	17.40 Dry	33.30 40.32	41.48 50.23	7.82 9.48	2.03 2.45	10,811 13,091	 14,663
IV	5	54	15.10 Dry	36.79 43.33	37.59 44.28	10.53 12.40	3.52 4.15	10,514 12,384	 14,447
V	5	27	6.75 Dry	35.49 38.06	48.72 52.25	9.04 9.69	2.92 3.13	12,276 13,165	 14,812
VI	6	58	9.21 Dry	34.00 37.45	48.08 52.96	8.71 9.59	1.53 1.68	11,825 13,025	 14,585
VII	6	76	12.56 Dry	38.05 43.52	39.06 44.67	10.33 11.81	4.01 4.59	9,848 12,406	 14,377
VIII	6	31	14.45 Dry	35.88 41.94	40.33 47.14	9.34 10.92	2.55 2.98	10,919 12,764	 14,557
	7	18	12.99 Dry	38.29 44.01	38.75 44.53	9.98 11.47	2.93 3.37	11,143 12,807	 14,740

[1] Analyses made by J. M. Lindgren under direction of Prof. S. W. Parr.

east and the La Salle, locally called the Third Vein field, on the west. The coal lies at greater depth on the west of the anticline where it has 350 to 550 feet of cover.

The immediate roof in the Wilmington field is usually a smooth gray shale, called "soapstone" by the miners. In places sandstone forms the roof material and causes difficulty in brushing. In the La Salle field the roof is generally a gray shale, free from grit but containing small flattened nodules of ironstone which make difficult the manufacture of brick from the roof material.

Near the anticline the immediate roof is in some portions a gray, calcareous shale, called "soapstone"; in others, a black, carbonaceous shale. The black shale is generally laminated and commonly includes "niggerheads" of pyritous material. It is harder than the gray shale.

In the Wilmington field a dark-gray fireclay generally lies directly under the coal and varies in thickness from a few inches to several feet. The clay heaves badly under pressure when wet. In some localities ironstone balls and root remains have been found imbedded in the clay. In the La Salle field the coal is generally underlain by fireclay, but in parts of some mines a hard sandstone lies directly beneath the coal.

Generally bed No. 2 in this district lies nearly flat or is slightly rolling, but on the La Salle anticline it dips as much as 51 degrees.

DISTRICT II, SEAM 2

Bed 2 in Jackson County has only a shallow cover, the coal lying at depths varying from 25 to 160 feet. A characteristic feature of the bed is its division into two benches by a gray laminated shale band varying in thickness from 1/8-inch to 36 feet. Where this parting is thick the lower bench has sometimes been called, erroneously, seam 1. The bottom bench varies in thickness from 3½ to 4 feet, averaging 3¾ feet. The top bench averages 2 feet.

The bed contains few nodular concretions of iron pyrites, but has a layer of bone 2 to 3 inches thick, generally next to the floor. This floor in most places is sandstone, but in sections is shale or fireclay. The coal shows a pronounced cleavage, northeast to southwest.

Where the parting is thin and the two benches are united, the roof over the coal is a hard gray shale, but where the parting is thick and only the lower bench is worked the parting becomes the roof. Where this parting is a light gray shale it is easy to support; where it is dark colored it slakes much on exposure to the air.

Numerous small faults occur in all mines and horses, usually of a hard dark gray micaceous sandstone, are found in the vicinity of the faults.

The presence in places of a quicksand deposit about thirty feet below the surface has a marked effect on surface subsidence after roof-caves.

Reference to Table 5 shows the superiority of the coal in District II. It has less volatile matter, more fixed carbon, less ash and moisture, and a higher calorific value than the coal of any other district.

DISTRICT III, SEAM 1—SEAM 2

SEAM 1 in the mines examined lies at depths varying from 40 to 213 feet. The topography of the surface in many places is rolling, with hills about 150 feet high near Matherville. The seam averages 4 feet in thickness and is broken in places by small faults, slips, clay veins, and rolls. The coal has weak vertical cleavage, dull luster, and banded texture. On cleavage faces thick plates of calcite and iron pyrites are deposited. Near Ellisville sulphur bands 2 to 6 inches thick and in places 50 feet long are found at various horizons. A poorly developed parting divides the bed into two benches, the upper of which is in most places about 2 feet thick.

The immediate roof in the northwestern part of the district is a hard black shale that is easy to support. In the southern part of the district in places a bituminous calcareous shale, 2 to 5 inches thick, lies immediately over the coal. This shale, called clod, is hard when first exposed but after exposure to the air becomes soft and falls. Throughout the district the cap rock is limestone. In limited areas where the shale is missing this limestone is the immediate roof over the coal. Above the cap rock is a dense, fine-grained non-crystalline limestone locally called "blue rock."

Below seam 1 in places there is an irregular band of hard bone, 3 to 6 inches thick. The floor proper is a light gray micaceous fireclay which contains plant stems and roots. This clay heaves badly when wet and in places swells enough to fill the entry. In parts of some mines a carbonaceous shale lies between the fireclay floor and the coal and in other parts, sandstone. These casual deposits are called "false bottoms."

Seam 2 varies in thickness from 1 foot, 10 inches to 4 feet and averages 2½ feet. The seam has a slight east dip for the district. The coal has a weak cleavage and dull luster, is finely laminated and has numerous bands of mother coal and dirt, none of which is continuous. A band of mother coal and iron pyrites persists throughout the seam at a distance of 14 inches from the roof.

The immediate roof is a calcareous shale known locally as soapstone. It is regular and smooth and contains fossil leaves in places.

The floor is a soft gray fireclay which contains nodular concretions of iron pyrites called "sulphur balls."

DISTRICT IV, SEAM 5

The topography of the surface in District IV is flat in some areas, and rolling, with hills as high as 300 feet in others. No. 5 coal outcrops in Peoria, Fulton, and Knox Counties but lies at depths of 300 to 600 feet in Macon County, 400 feet in McLean, and 260 to 300 feet in Logan.

The average thickness of the coal is 4 feet, 8 inches as reported in the Thirty-first Annual Coal Report of Illinois from 240 mines. The seam has a uniform appearance from top to bottom and the coal is hard and massive. It shows fine laminations with knife-edge mother coal partings. In some places there are discontinuous bands of pyrites near

the middle of the seam. The seam lacks the blue-band characteristic of No. 6[1]. Udden states that, "in the mines near East Peoria and at Edwards the coal runs out against the drift in several of the entries. Miners recognize that these defects in the coal are due to erosion and they speak of the drift as 'wash.' The drift generally consists of sand or silt, which in some places has been found to contain embedded trunks of trees and other vegetation. Experience has shown that the surface of the bedrock does not always conform to the present topography of the land and operators are careful to avoid unprofitable explorations of places where 'wash' has been encountered[2].

The immediate roof is a black sheety shale locally called slate. This shale varies in thickness from a few inches to 35 feet and in places contains "niggerheads" of iron pyrites. In many mines between the coal and the shale there is in places a layer of iron pyrites two or three inches thick. Where this layer is present the shale is protected from the air and stays up; where it is not present the shale falls badly and in places caves to a height of 35 feet.

The cap rock in most mines is limestone but in a few is a fine-grained micaceous sandstone. In some places the shale of the immediate roof is absent and the cap rock comes in contact with the coal. "When the limestone is disseminated and mingled with the shale the roof is soft and weathers quickly owing perhaps to the presence of marcasite.[3] It is then called clod and the niggerheads are iron carbonate.

From the viewpoint of the miner the chief characteristic of the district is the great number of clay veins extending through the coal and the roof shale crossing their bedding plans. Fig. 7 shows a typical clay vein. These clay veins are fissures which have been filled with a hard light-gray clay. Besides clay veins the physical features which affect mining are small faults, slips, and rolls. In one mine where the shale of the immediate roof is absent the sandstone has cut out the coal for 150 feet along an entry.

[1]Bulletin 14, Illinois Geological Survey, Coal Resources of Illinois, DeWolf.
[2]Bull. 506, U. S. G. S., Geology and Mineral Resources of the Peoria Quadrangle, Illinois, Udden.
[3]Udden, op. cit.

The coal in this district in many places sticks to the roof and is separated from it with difficulty. In one mine about an inch of coal is left up to protect the roof shale from the moisture of the air.

FIG. 7. Typical clay vein in District IV

The floor in most places is a dark gray fireclay which heaves badly when wet. At one mine the floor is a blue fireclay containing nodular concretions of iron pyrites.

DISTRICT V, SEAM 5

Seam 5 in Saline and Gallatin Counties lies at a depth of 25 to 40 feet, being nearer the surface along the southern portion. The seam varies in thickness from 4 to 8 feet, averaging 5⅓ feet in Saline County and 4 feet in Gallatin County.

The roof of No. 5 in this district is a shale varying in color from light gray to black, and locally may be laminated and interbedded with bone and stringers of coal for a distance of 3 feet above the seam. The roof usually contains also many concretions of iron pyrites called "niggerheads". These have more cohesion with the rest of the roof material than do the niggerheads in the Danville district.

The floor is fireclay which in places contains much sand and heaves badly when wet. The bed does not lie as flat as the unfaulted No. 6, but contains many hills and rolls causing

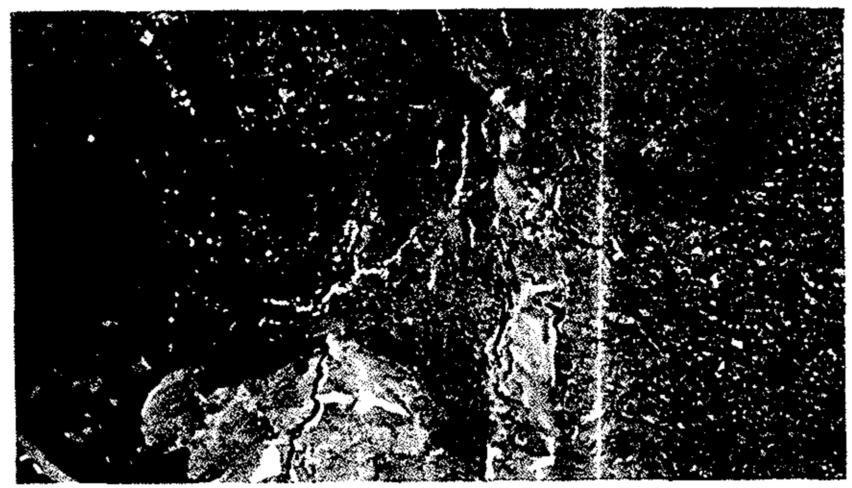


FIG. 8. Igneous dike in coal in District V

grades as high as 15 per cent in the entries of some mines. The coal is not pinched out at these hills but follows their contours with undiminished thickness.

The district is characterized by the presence of an igneous intrusion identified by Albert Johansen, formerly of the U. S. Geological Survey, as mica-peridotite. This dike in some places penetrates and has its apex in the coal, as shown in fig. 8; in others it extends on through the bed into the overlying strata. The dike varies in thickness at the coal horizon from a few inches to many feet, and can be traced lineally for several miles. Considerable gas and water are generally found in the vicinity of the intrusion.

DISTRICT VI, SEAM 6

Seam 6 is described as follows by E. W. Shaw and T. E. Savage in Folio No. 185, U. S. Geological Survey:

"The bed is uniformly thick, ranging from 7½ to 14 feet and averaging 9 feet 5 inches in 130 borings. The coal is shining black, commonly banded, and on close inspection appears laminated with alternating bright and dull lines. A 'blue band' or dirt band, found almost everywhere 18 to 30 inches above the floor, generally consists of bone or shaly coal or of gray shale. Its thickness varies from one-half to 2½ inches, with an average of 1⅓ inches.

"A clean persistent parting of mother coal lies 14 to 24 inches below the top of the bed, and a second parting generally appears 5 to 8 inches lower down. Above the upper parting the coal is in layers 3 to 6 inches thick, with partings of mother coal between them. Local lenses of mother coal, 6 inches to 5 feet in length and 1 inch to 4 inches thick, are common in the upper third of the bed. Small pyrite lenses and streaks of bone, varying from a few inches to a foot or more in length and from one-fourth inch to 1 inch in thickness, are found here and there in the middle portion of the bed, a short distance above the 'blue band.' In the middle and lower parts of the bed the lamination is less distinct but the bedding is still evident.

"Above the coal there is a bed of gray, impure shale, 15 to 110 feet thick, the lower part of which generally contains a great number of plant impressions. This shale does not stand well when the coal is removed, and for this reason the 18 to 30 (60)[1] inch zone of coal above the charcoal parting is usually left for a roof until the rooms are mined out, after which it may be taken down. The clay beneath the coal is hard and generally thin, ranging in thickness from 4 inches to 8 feet. It is generally underlain by a limestone. Some rock rolls occur at the top, the larger ones extending down into the coal 2 to 3 feet."

[1]Author.

In addition to the structural features mentioned above, faults of considerable magnitude for Illinois have been discovered in mining. One block fault in which the block has dropped 50 feet has been recorded by F. H. Kay of the State Geological Survey.

In a few mines where cleat in the coal is developed the roof is jointed and can be easily supported only in rooms driven east and west.

In some mines there are small areas in which the cap rock is lacking. If the coal is removed under these areas the roof caves in filling the entries with clay and sand and causing surface subsidence.

DISTRICT VII, SEAM 6

In District VII the No. 6 coal does not have the bright luster of the No. 6 coal to the east of the Duquoin anticline. The thickness varies from 2½ to 14 feet, averaging 7 feet. The seam is characterized by its numerous dirt and sulphur bands of which the most persistent throughout the district is the "blue band" of hard dark gray or black shale from ½-inch to 4 inches thick situated in places 6 inches above the floor but at an average height of 18 inches. Bands of pyrites from ½-inch to 4 inches thick are located at varying heights in the bed; in places are other bands of impurities called by the miner "steel band", "nine-inch band", or "dirt band", according to their hardness and location. There is a well-defined parting plane in the coal about 18 inches from the roof. The upper bench or "top coal" is left where the roof is black shale and where the coal is 7 feet thick or over. The roof is either a non-calcareous black shale, a calcareous gray shale called locally whitetop or soapstone, an unconsolidated dark-gray or black shale called clod made up of fragments of varying size and hardness and extremely difficult to support, or a hard gray limestone called "rock top." A poorly defined cleat or cleavage in the coal may be seen in some places.

DISTRICT VIII, SEAM 6—SEAM 7

In District VIII seams 6 and 7 are mined. In both seams there are numerous rolls of roof and floor called "faults" or "horsebacks" by the miners. In many cases the roll entirely displaces the coal.

SEAM 6 averages 6 feet in thickness. Its chief characteristic in the presence of a blue-band which divides it into upper and lower benches. This blue-band varies from soft dust to hard gray shale and occurs about 2 feet above the floor. In addition to this blue-band there are several shale and sulphur-bands of variable horizontal and vertical extent.

The roof over coal No. 6 is variable. Near Danville the immediate roof is a grayish black shale about 6 feet thick. This shale, lying between the coal and the cap-rock of dark gray nodular limestone makes an easily supported roof. In the vicinity of Westville and Georgetown, the immediate roof is usually a gray shale which shows no distinct bedding, has little cohesion, falls in conchoidal masses, and is extremely difficult to support. Further, stringers of coal extend from the seam proper into the roof material and render the roof more difficult of support. In isolated cases there are 3 to 4 inches of black shale between the coal and the gray shale which forms the cap rock. Wherever this black shale is broken, air and moisture disintegrate the gray shale cap-rock and the roof becomes insupportable.

In all parts of the Danville district the floor is a soft fireclay.

SEAM 7 varies in thickness from 2½ to 5½ feet and averages 5 feet. The coal has two benches separated by a clay-band 1 inch thick, which persists through the bed from 6 to 8 inches above the floor. The two benches present no great difference in appearance or in physical character except locally where the top bench is harder and has a brighter luster. The No. 7 seam generally has slightly more impurities than the No. 6 seam, higher volatile matter, lower fixed carbon, and higher sulphur content as shown by Table 5. The bands of pyrites occur persistently at a height of 20 to 26 inches above the floor and "sulphur balls" or nodular concretions

of pyrites are present in such quantity as to make profitable their separation from the coal by hand picking in the mine and by a further separation on the surface in rotating cylinders.

MINING PRACTICE

The earliest mining in Illinois consisted in gophering in outcrops in the river bluffs or in stripping the shallow overburden from seams lying near the surface. The coal thus obtained was used by blacksmiths and to a limited extent for domestic purposes. The demand for coal for industrial purposes developed rapidly after 1850 and the profit in coal mining led to the opening of mines requiring slopes and shafts and to the extension of the earlier drift mines further under cover. The mines opened previous to 1870 were shallow and a crude room-and-pillar system of mining was developed with the relation between room and pillar widths determined largely by trial and failure. The operators of the period from 1870 to 1890 were usually men of small means but having chosen those portions of the seams most easily worked could mine profitably even with crude methods because the market for coal occasioned by the marvelous industrial growth of Illinois and by the increasing population readily absorbed the production at a comparatively high price. These shallow mines were cheaply opened and by 1900 there were over 900 mines in the State. The change in the number and size of the mines in the State is shown by Table 6.

About 1890 the deep and thick No. 6 seam of southern Illinois began to be worked and the mines in this seam opened since that time, and especially since 1900, were designed for large production, and required a greater initial outlay of capital and greater technical skill in development. The need of an immediate return on this capital investment, however, prevented the projection of a retreating mining system calling for several years of develpoment work before a large tonnage could be produced but an improvement was made on the earlier system. Many of these new mines were projected on the panel system but the coal is gained almost entirely on the advance and the unsuitable dimensions of rooms and pillars of the older mines usually have been retained.

There are at the present time in Illinois five types of coal mines: 1, the small "country-bank" or "local mine" with a

TABLE 6.—*Number of mines of specified annual tonnage 1883-1914*[1]

Year	Under 1,000 tons	1,000 and under 10,000 tons	10,000 and under 50,000 tons	50,000 and under 100,000 tons	100,000 and under 200,000 tons	200,000 tons and over	Total mines
1883	209	233	133	39	10	15	639
1884	262	273	148	38	16	4	741
1885	286	290	143	40	13	6	778
1886	316	280	135	44	11	3	780
1887	320	278	141	42	18	2	801
1888	327	272	151	47	20	5	822
1889	321	316	139	55	20	3	854
1890	398	301	155	54	24	4	936
1891	402	260	161	52	37	6	918
1892	332	239	151	65	46	6	839
1893	282	232	140	75	47	12	788
1894	312	252	161	61	44	6	836
1895	319	276	145	61	45	9	855
1896	330	280	128	63	45	16	862
1897	346	250	120	79	41	17	853
1898	351	244	151	86	42	7	881
1899	346	261	123	77	57	25	889
1900	340	295	123	70	65	27	920
1901	313	308	124	79	58	33	915
1902	314	263	152	76	72	38	915
1903	313	293	120	75	87	45	933
1904	301	275	140	72	98	46	932
1905	321	299	147	83	88	52	990
1906	336	282	167	89	97	47	1,018
1907	260	262	145	91	95	80	933
1908	248	256	146	98	92	82	922
1909	270	239	134	66	90	87	886
1910	261	239	125	87	94	75	881
1911	235	213	138	82	101	76	845
1912	266	228	119	70	91	105	879
1913	239	231	108	66	82	114	840
1914	236	208	90	64	95	103	796

[1] Thirty-third Annual Coal Report of Illinois.

production of 10 to 50 tons per day existing solely for the supply of a small local demand; 2, the unmodified room-and-pillar mine, including (a) the mine opened 15 to 40 years ago and still operated on a crude unmodified room-and-pillar system, and (b) the room-and-pillar mine opened recently;

3, the panel mine, including (a) the older mine which has changed its system from unmodified room-and-pillar to panel, and (b) the mine opened in recent years on the panel system; 4, the longwall mine in seams not thicker than 4½ feet; and 5, the stripping mine.

LOCAL MINES

Only a few of the mines examined are local mines, called "country-banks", because although in number they comprise 56.8 per cent of all the mines in the State they are unimportant as a factor in the coal production, their annual output amounting to only 2.5 per cent of the tonnage of Illinois. There is no uniformity in the operation of local mines and they frequently consist of one entry with a honeycomb of rooms off each side. The area covered by their workings is usually small. At one of the local mines examined the workings consisted of one room 35 feet wide and 600 feet long; at another from both sides of a single entry 6 feet wide rooms 15 feet wide are turned on 20-foot centers. In District II where the coal is nearly all worked out there are no local mines but they are found in every other district and comprise 96.9 per cent of the mines in District III. Table 7 gives the relation between local and shipping mines for each district.

TABLE 7.—*Relation between local and shipping mines*

District	No. mines Total	Local	Shipping	Percentage of local mines in district
I	36	2	34	5.6
II	8	0	8	0
III	128	123	5	96.9
IV	240	165	75	68.9
V	33	12	21	36.3
VI	78	18	60	23.1
VII	196	46	150	23.5
VIII	49	31	18	63.3
State	879	499	380	56.8

UNMODIFIED ROOM-AND-PILLAR MINES

A typical unmodified room-and-pillar mine where the coal is reached by a shaft, as shown in fig. 9, has two parallel entries, one used for haulage (A) called the main entry varying in width from 6 to 21 feet and averaging 12 feet, and one (B) for carrying the intake ventilating current called the back entry. These entries are driven on each side of the shaft through the solid coal towards the property boundaries. Cleavage or "cleat" is not usually sufficiently pronounced in Illinois coal to determine the direction chosen for driving entries or rooms in Illinois. The main-entry pillar between these two entries varies in width at the mines examined from 12 to 80 feet and averages 31. The entries are advanced simultaneously, and outside the shaft pillar are connected at 60-foot intervals by crosscuts for the purpose of maintaining a flow of air through the entries to the working face.

At a distance from the shaft, commonly 300 feet, such that the solid coal surrounding the shaft will be sufficient to protect the shaft from injury by surface subsidence, a pair of cross-entries is driven to the right and left of the main entries and at a right angle to them. These cross-entries vary in width from 6 to 21 feet, averaging 12 and the coal between them, called the cross-entry pillar, varies from 12 to 50 feet, averaging 27.

Rooms are turned off at a right angle to the cross-entries at a distance of 50 to 150 feet from the main entries, and thereafter at regular distances. The coal between the main-entry or the back entry and the first room is the main-barrier pillar and varies in width from 10 to 150 feet, averaging 46.

The rooms vary in width from 15 to 43 feet. The room necks vary from 6 to 21 feet in width and 6 to 25 feet in length, the average neck being 12 feet long and 12 feet wide. In widening the rooms either of the two following methods is adopted:

1. One side of the necks is continued in a straight line forming a side of the room. In this case the width of the room is gained by driving off the opposite side of the neck at an angle either of 45 degrees or of 90 degrees from the direc-

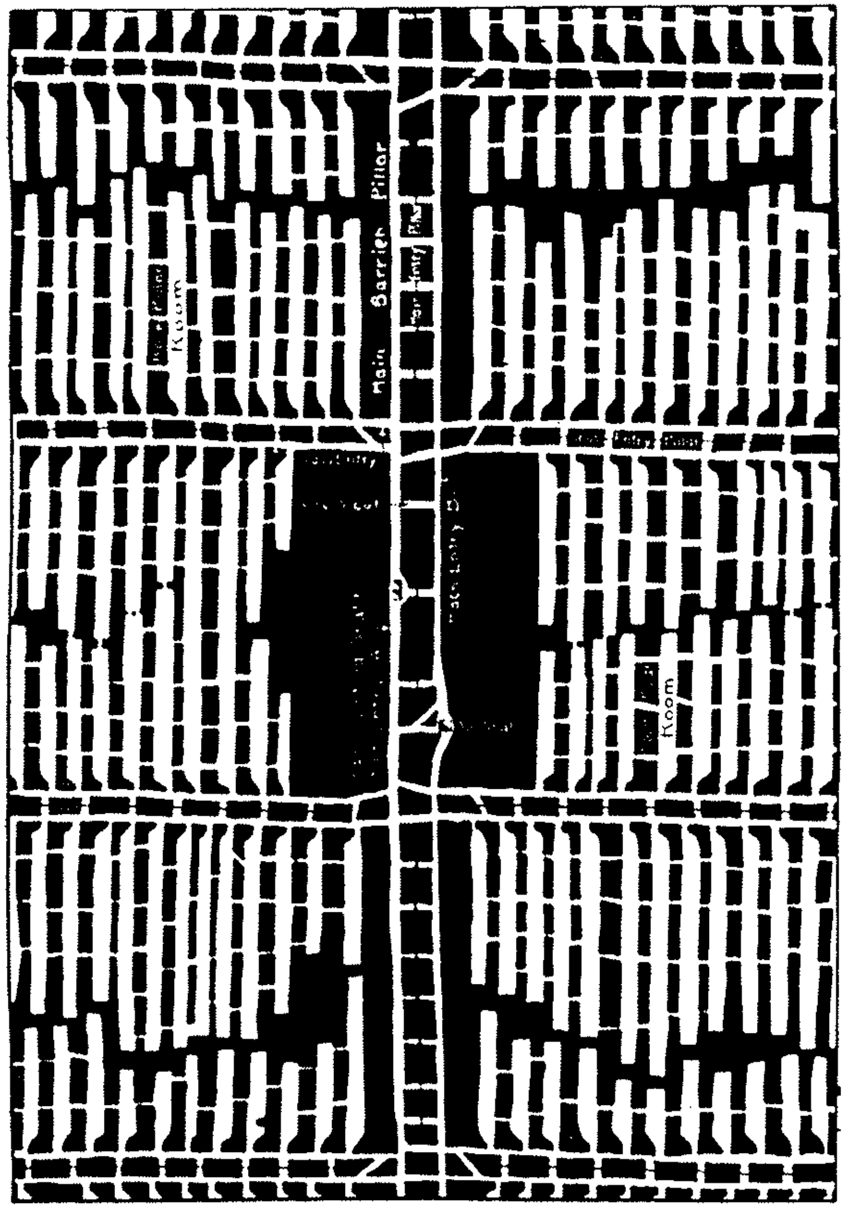


Fig. 9. Plan of unmodified room-and-pillar mine

tion in which the neck was driven, until the full width of the room has been reached;

2. An angle of 45 degrees or of 90 degrees is turned off each side of the neck, and when the full room width is reached the driving is continued parallel to the direction of the room neck.

In a few mines rooms have no necks but are turned full width from the entry.

The length of rooms varies from 100 to 500 feet, averaging 250 and the coal remaining between the rooms, called the room pillar, varies from 3 to 45 feet, averaging 19. Table 8 gives dimensions of workings for the unmodified room-and-pillar mines examined.

The mines in District I are operated on the longwall system but the unmodified room-and-pillar system is used exclusively in Districts III, V, and VIII and in a great proportion of the mines of all other districts in Illinois. The wide range between minimum and maximum dimensions is an index of the great variation in roof conditions and difference in judgment of the management. The worst immediate roof in the State is in Districts V and VIII. In District VIII entries are driven narrow but room pillars are commonly insufficient. In District V entries are much too wide and clean-up expense from roof falls is high. Room pillars are narrow and because too little surveying is done and oversight is lax there are frequent blows-through. The easiest immediate roof to support is in Districts III and IV.

The mines in District VI are the deepest of those examined and the heavy roof weight causes squeezes in mines with unsuitable pillar dimensions. A squeeze is the crushing of coal by the weight of the overlying strata insufficiently supported by too narrow pillars. In one mine 85 acres were squeezed; in another 80. There have been from one to six squeezes in every unmodified room-and-pillar mine examined in this district and attempts to stop them have seldom been successful. In one mine in which they advance slowly, enough pillars are drawn ahead of a squeeze to cause a break; the roof weight is relieved and the squeeze sometimes is checked. In many mines where rooms are wide and room pillars nar-

TABLE 8.—*Dimensions in feet of workings of unmodified room-and-pillar mines*

District	No. of seam	No. of mine	Depth of hoisting shaft	Entry width: Main	Entry width: Cross	Entry pillar width: Main	Entry pillar width: Cross	Main barrier pillar width	Room: Width	Room: Length	Width of room pillar	Room neck: Width	Room neck: Length	Dist. from entry to full room width	Dist. between room centers	Width of room stump	Width of cross cuts	Has mine had squeezes?	Percentage of seam gained
		12	125	8	8	12	12	23	24	150	18	8	10	20	42	34	8	No	44
II	2	14	135	8	8	18	18	30	28	250	22	18	12	22	50	42	8	No	46
		15	160	8	8	18	18	20	25	240	17	8	10	20	42	34	10	No	49
	1	17	210	8	8	30	30	50	20	250	20	8	7	14	40	32	12	No	96
	1	18	69	12	12	42	15	36	26	250	19	8	7	12	45	37	12	Yes	96
III	1	19	70	12	12	18	18	18	24	250	18	8	7	25	42	34	8	No	50
	2	22	60	6	6	..	..	..	15	250	15	6	15	25	30	24	15	Yes	45
	1	24	40	12	12	20	20	15	24	300	21	8	7	29	45	37	15	No	70
		26	196	8	8	30	21	50	26	190	6	8	8	30	32	24	8	No	56
		29	185	8	8	36	24	40	24	180	8	8	7	18	32	24	8	No	57
IV	5	30	60	10	8	15	12	25	22	210	10	8	7	18	32	24	13	No	57
		34	200	8	10	30	34	38	28	180	10	10	9	30	38	28	4	Yes	42
		41	365	16	16	20	30	80	25	200	10	12	9	15	35	23	8	No	56
		43	160	14	14	30	30	40	30	250	20	18	10	20	50	32	18	Yes	65
		44	270	15	18	25	25	50	22	250	24	18	12	18	46	28	18	Yes	59
		45	320	16	16	24	20	..	27	250	20	19	12	30	47	28	15	No	64
V	5	46	450	14	14	20	20	50	33	200	7	19	12	25	40	21	19	Yes	82
		47	90	14	19	20	12	20	22	250	12	8	6	13	34	26	12	No	68
		48	76½	14	14	25	25	50	24	300	21	12	6	15	45	33	12	No	59
		49	337	14	14	30	21	35	24	250	9	12	9	25	33	21	12	Yes	73

TABLE 8.—*Continued*

District	No. of seam	No. of mine	Depth of hoisting shaft	Entry width: Main	Entry width: Cross	Entry pillar width: Main	Entry pillar width: Cross	Main barrier pillar width	Room: Width	Room: Length	Width of room pillar	Room neck: Width	Room neck: Length	Dist. from entry to full room width	Dist. between room centers	Width of room stump	Width of cross-cuts	Has mine had squeezes?	Percentage of seam gained
		50	726	12	12	35	40	100	22	250	25	12	24	34	47	35	22	Yes	58
		55	160	10	9	50	50	50	25	250	26	15	12	19	51	36	15	Yes	46
		56	580	12	12	40	30	100	26	250	26	12	23	45	52	40	11	No	50
		59	200	9	9	20	20	50	23	225	15	12	16	32	38	26	15	Yes	68
VI	6	60	220	12	12	20	18	20	21	300	12	12	6	24	33	21	12	Yes	51
		62	190	10	10	30	30	75	20	250	15	10	15	15	35	25	10	Yes	51
		63	140	10	10	30	30	40	22	500	18	10	12	18	40	30	12	Yes	..
		64	120	11	11	22	19	38	20	300	15	9	8	15	35	26	8	No	64
		65	90	12	12	20	20	10	21	250	9	10	6	24	30	20	10	Yes	58
		68	387	21	16	40	40	27	32	235	33	9	15	27	65	56	20	Yes	50
		70	92	14	14	50	50	50	30	300	30	21	25	50	60	39	21	No	50
		72	287	21	21	40	40	..	30	300	30	21	6	..	60	39	21	No	56
		78	[illegible]	21	21	55	45	55	32	250	41	21	24	34	73	52	21	Yes	56
		79	127	21	21	60	30	60	30	300	30	21	12	24	60	39	21	No	62
		80	145	12	14	18	35	60	30	250	30	21	18	38	60	39	21	No	59
VII	6	81	200	21	21	80	40	60	35	250	45	21	25	40	80	59	21	Yes	55
		82	192	14	21	42	42	60	40	250	40	21	18	36	80	59	30	No	63
		84	320	21	21	39	39	40	30	240	30	21	15	25	60	39	21	No	60
		87	707	12	12	40	40	150	30	300	30	12	20	50	60	48	20	No	58
		88	85	12	12	20	20	40	29	250	17	12	6	16	46	34	12	Yes	65
		89	[illegible]	8	8	20	15	40	25	200	20	8	10	24	45	37	8	Yes	48
		90	160	21	9	60	30	30	33	250	17	9	12	24	50	41	12	No	63

TABLE 8.—*Continued*

District	No. of seam	No. of mine	Depth of hoisting shaft	Entry width: Main	Entry width: Cross	Entry pillar width: Main	Entry pillar width: Cross	Main barrier pillar width	Room: Width	Room: Length	Width of room pillar	Room neck: Width	Room neck: Length	Dist. from entry to full room width	Dist. between room centers	Width of room stump	Width of cross cuts	Has mine had squeezes?	Percentage of seam gained
	6	91	217	9	9	25	21	40	43	200	4	9	19	18	47	38	5	Yes	55
	6	92	240	7	7	35	30	60	24	240	3	9	18	18	27	18	9	Yes	68
VIII	6	93	186	8	9	21	21	50	24	200	16	9	9	9	40	31	9	Yes	75
	7	94	90	7	6	16	12	17	24	240	6	9	9	9	30	21	9	No	81
	6	95	90	6	6	..	..	..	25	500	11	9	12	12	36	27	9	No	82
	7	97	223	7	8	21	21	50	21	150	9	9	12	12	30	21	7	No	68
Averages by districts																			
II	2		140	8	8	16	16	23	26	213	19	8	11	21	45	37	9	...	46
III	1 & 2		90	10	10	28	21	30	22	260	18	8	9	21	40	33	12	...	71
IV	5		201	10	10	26	24	47	25	192	9	9	8	22	34	25	8	...	54
V	5		243	15	16	25	22	41	26	250	16	15	10	21	42	27	15	...	67
VI	6		270	11	11	30	28	54	22	264	18	11	14	24	40	29	13	...	56
VII	6		227	17	16	43	36	52	31	260	30	17	16	32	61	45	19	...	57
VIII	6 & 7		174	7	7	24	21	43	27	255	8	9	13	13	35	26	8	...	71
Average of 48 unmodified room-and-pillar mines			208	12	12	31	27	46	26	250	19	12	12	24	45	33	13	...	54

row, squeezes travel rapidly and there is not sufficient time to draw pillars. Cog building and shooting the roof have often been resorted to, in one instance at a cost of $2,000, but these efforts seldom check a squeeze, which may continue till a fault or barrier pillar is reached. In one mine in this district operating on the unmodified room-and-pillar system every tenth room along the cross entries is omitted, leaving a pillar 49 feet wide to check possible squeezes.

In a few mines in District VI an east-west cleat in the coal is so pronounced that top coal will not stay up if rooms are driven north or south. In one mine formerly operating on panels, which made necessary the driving of rooms north and south, the system has been changed to unmodified room-and-pillar in order that rooms may have an east-west direction. Pronounced cleat is also found in some mines in District VII.

The chief cause of squeezes in all districts is that too great a proportion of the coal is taken out on the advance working. Frequently after the first crosscut is reached in driving rooms the pillar is gouged, sometimes to the extent that the pillar between rooms is broken through.

In District VII where the roof is in some places limestone, called "rock top", and in others shale, dimensions are often unsuitable under the limestone. In 13 of the 25 mines examined in this district squeezes have occurred and they generally began in a section where the roof was limestone. In many mines entries and rooms under rock top are too wide and pillars too narrow—a condition that has brought about squeezes which sometimes even jeopardized the shaft. In one mine a squeeze was brought on by turning rooms off the main air-course. Main entries 35 feet wide in places in which no timbering was done were found in this district. In one mine room pillars were so gouged under rock top that on 65-foot room centers the dimensions were: room width, 55 feet; room pillar width, 10 feet, and in two mines squeezes causing surface subsidence occurred in sections where rooms were 30 feet wide and room pillars 5 feet wide.

Slight variations of the standard unmodified double entry room-and-pillar system are made in some districts as would be expected where so great difference exists in thickness of seams, thickness of cover, and physical conditions of roof and floor.

In District II the variable shale parting in the seam gives rise to two sets of conditions. Where the parting is less than 4 inches thick, the two benches of the seam are worked as one and the working faces in rooms and entries are 6 to 7 feet high in places. Where the parting is over 4 inches thick the lower bench only is mined and the parting becomes

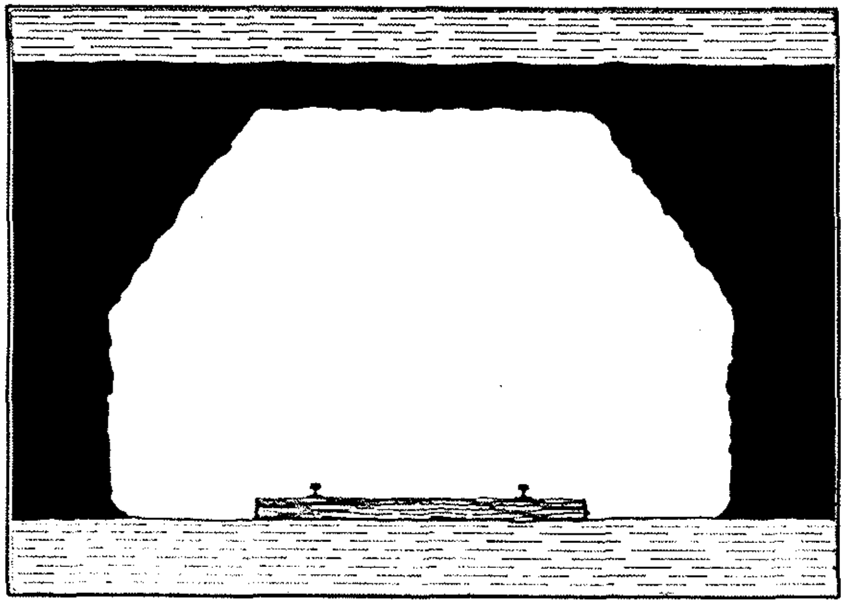


FIG. 10 Arching of top coal in entries in District II

the mine roof. The lower bench averages $3\frac{3}{4}$ feet. Where both benches are worked and the bed is over 6 feet thick only the lower 6 feet of coal is mined, 8 to 12 inches of top coal being left. Where it is possible to leave top coal in entries the roof is arched, as shown in fig. 10. In driving entries the lower 3 feet of coal is drilled and shot off the solid; but all arching in the upper 3 feet is hand sheared, with the result that the top coal remains permanently in place and requires no support except where fractured by slips. Top coal is

arched in several districts in Illinois, but usually the arch is roughly formed by shooting, and the top coal is often fractured by the shots. Where the two benches of the seam are united but the coal is not over 6 feet thick the full thickness of the bed is mined, and the gray shale overlying the coal becomes the roof. In rooms, 2 to 4 inches of this shale is

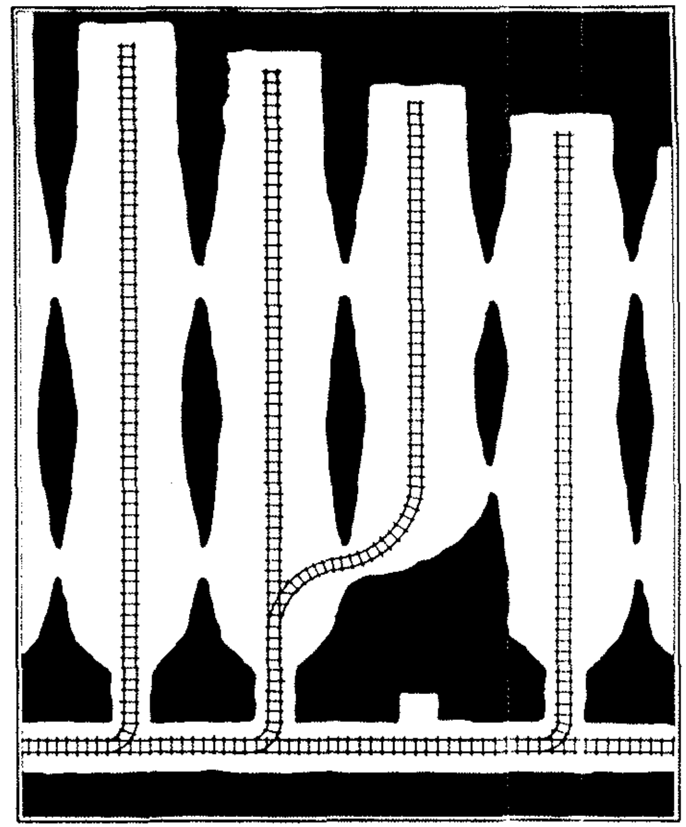


FIG. 11. Wing-room turned to avoid roll in District IV

drawn or comes down with the coal. Where the lower bench only is worked, by the terms of the Illinois State Agreement between the Illinois Coal Operators' Association and the United Mine Workers of America the miner brushes 14 inches of roof over roadways in rooms. The width of brushing varies from 5 to 8 feet. The gob obtained is laid along both sides of the track. Numerous horses of micaceous sandstone and small faults cause difficulty in mining and add considerably to the cost of coal production. In places these horses are of great length, one of them extending throughout a mine. In driving through these, blasting with dynamite is done off the solid.

In two mines in District III in the first room, number 1, on each entry the room-pillar crosscuts are closed by gob stoppings after the number 1 rooms have holed through; the line of number 1 rooms is kept open, thus providing two additional air courses inasmuch as cross-entries are turned off both sides of the main haulage entry.

Districts IV and VIII are characterized by many rolls where the roof, either sandstone or limestone, cuts out the coal. The rolls make uncertain the total tonnage which can be extracted from any area, and they interfere seriously with any projected plan because they are expensive to cut through. In District IV where a roll is encountered in turning a room off an entry work on this room is stopped and a "wing-room" is turned off the adjacent room, fig. 11. The wing-room carries the side of the roll as a rib and follows its course until the room reaches the position it would have occupied if it had cut through the roll. It is then continued on its proper course. The floor in District IV is a fireclay which heaves badly even when dry. The principal cause of the heaving floor is insufficient pillar width.

In one mine in District V triple main entries were driven, two for intake air and one for return air and haulage, as shown in fig. 12. The shale of the immediate roof is weak in District V, often containing coal fingers, and breaks quickly when unsupported in wide spans. The roof shale is drawn when it shows a strongly developed parting not over 4 inches above the coal; but such a parting rarely occurs, and the coal bed is so thin that top coal cannot profitably be left in place. Consequently when subjected to changes of temperature and humidity in the air current the immediate roof spalls badly and as timber is used sparingly in this district both the danger of accidents and the clean-up expense are increased.

In some mines about 9 inches of bottom coal is left below the shale band but as this bottom coal is not of good quality, increased facility in shooting recompenses for the loss of the coal. The igneous dike in the district has not caused a modi-

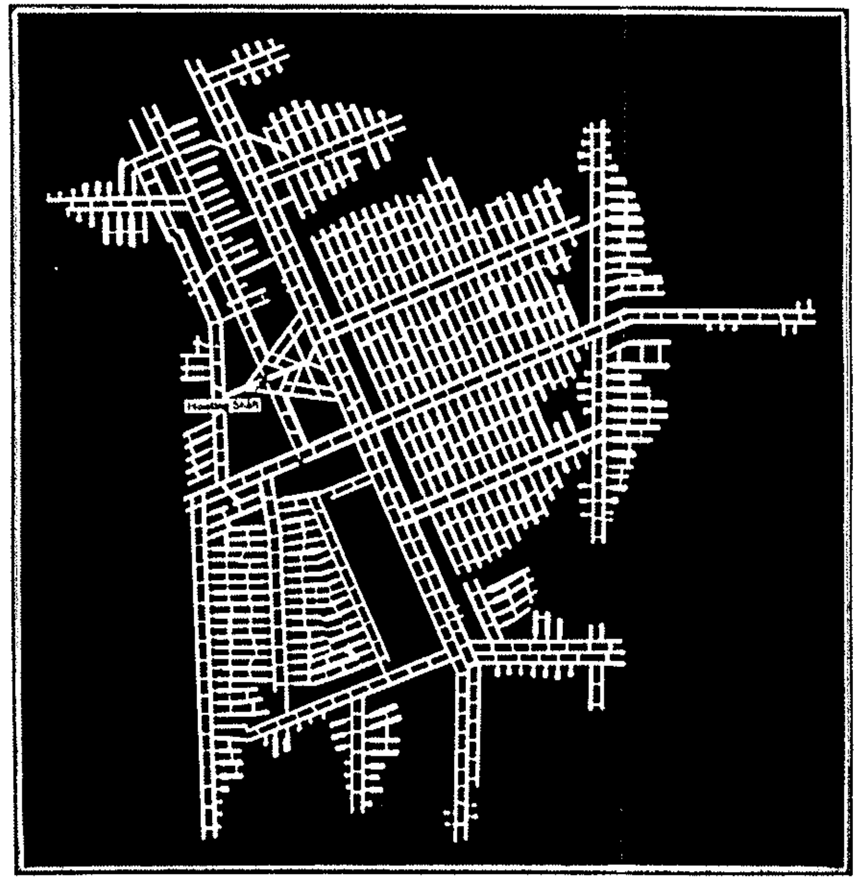


FIG. 12. Plan of mine in District V with triple main entries

fication of the system of mining, although it has added locally to the expense because of the greatly increased cost of driving through hard rock.

In an attempt to shorten the haul at one mine, in District VI pairs of cross entries are driven 600 feet apart. Rooms are turned off each entry of a pair, but are not advanced at an equal rate on both sides. Those whose direction is toward the hoisting shaft are stopped when they have been driven 100 feet. Those whose direction is away from the shaft are driven 500 feet to hole through into the rooms 100 feet long from the adjoining entry. The immediate roof overlying the coal falls in slabs after short exposure to the air and from 18 to 30 inches of top coal is usually left for a roof until rooms are driven up.

In one mine in District VII to avoid paying yardage and to lessen the danger of a squeeze crosscuts between main and back entries and between cross-entries are driven wide and offset as shown in fig 13. In another mine in the same district narrow work is lessened and a small stopping provided for as shown in fig. 14. The crosscut is driven its full width of 21 feet from one entry, while from the other of the pair it is driven only 6 feet wide for a distance of 12 feet. A large area of unsupported roof is left where this method is followed.

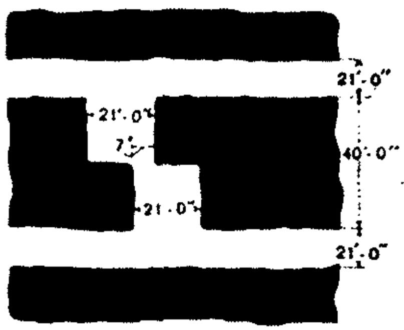


Fig. 13 Offset crosscut in District VII

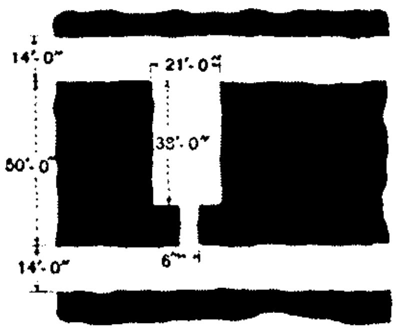


Fig. 14 Crosscut in District VII to provide small stopping

An occasional instance of shearing the rib is found but the practice is not general. Shearing in a crosscut near an air shaft in a mine in District VII is shown in fig. 15. At this mine all narrow hand work is driven 8 feet wide, and all narrow machine work 10 feet wide.

In District VIII as in District IV the frequent occurrence of rolls has a marked effect on the manner of driving rooms and when a roll is encountered it is customary to change the direction of the room and to drive it parallel to the roll until the coal resumes its normal condition. Often it is necessary to abandon a room before it has been driven its normal length. In Districts IV and VII in several mines every second or third room pillar is left solid without crosscuts for the purpose of limiting the number of rooms that can be affected by any fire which may require sealing off.

PANEL MINES

In mines operating on a true panel system rooms are not turned off from the cross-entries, but, as shown in fig. 16, at intervals of 500 to 600 feet along the cross-entries pairs of room-entries, often called panel entries, are turned off at a right angle to the cross-entries. The solid pillar of coal between the cross-entry and the first room, called the cross-barrier pillar, in Illinois varies in width from 20 to 150 feet and averages 56. The main barrier-pillar which is the coal left between the main entry and the ends of the rooms turned off those room-entries which are nearest to the main entry, varies in width from 20 to 150 feet, averaging 68. The num-

Fig. 15. Shearing the ribs in District VII

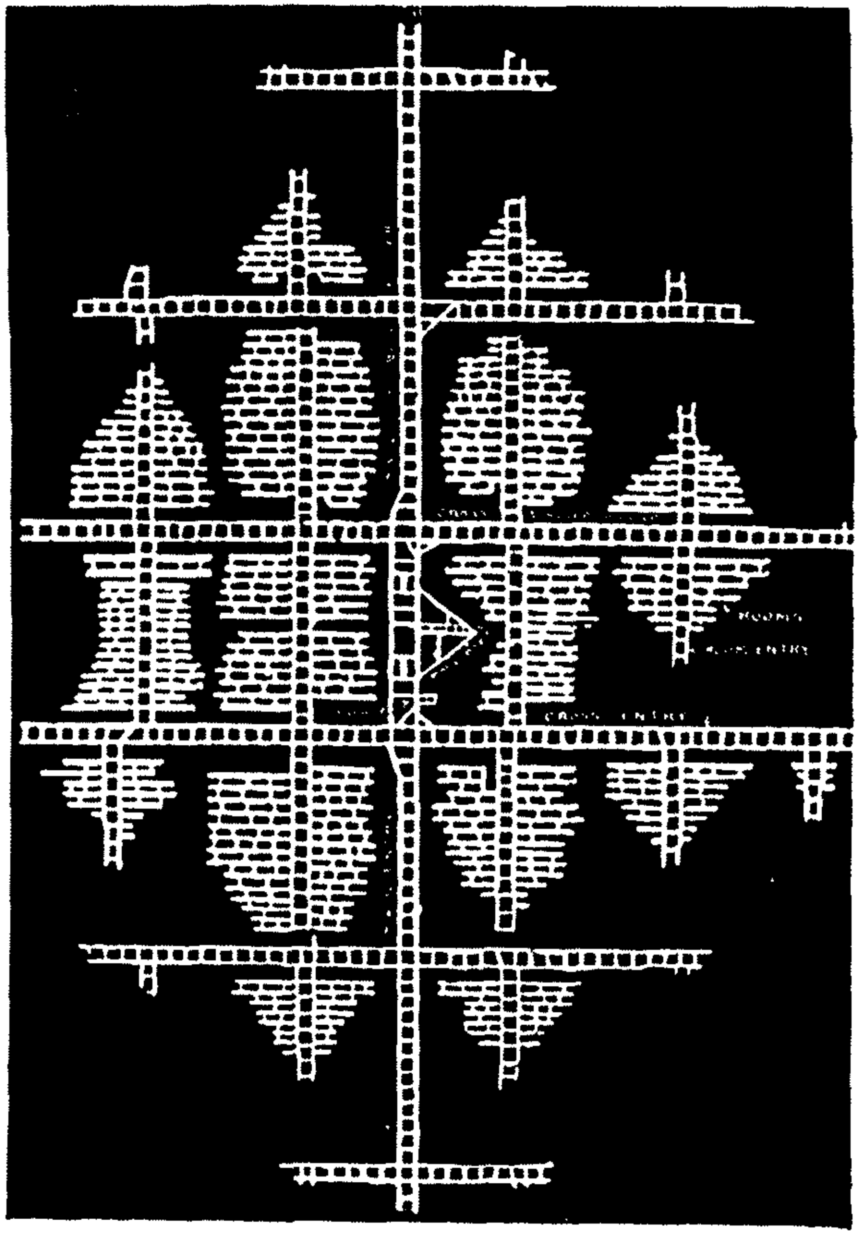


FIG. 16. Plan of panel mine

ber of rooms on a room-entry varies in Illinois from 12 to 35 and averages 23.

The obvious advantage of a true panel system is that each panel is surrounded on all sides by a pillar of solid coal and is a separate unit in operation. A squeeze occurring in any panel is confined by the barrier pillars, if large enough. The ventilating current can be regulated so as to supply air according to the needs of each panel and pillar-drawing can be more advantageously practiced, thus giving a higher coal-recovery.

In Illinois some of the newer mines were opened on the panel system and some of the older mines which had been unsuccessful in preventing squeezes under the unmodified room-and-pillar system have changed their system to panel. There are, however, only a few mines operating on a true panel system with proper barrier pillars. In many mines no panel is maintained but rooms are driven to hole through, the main barrier pillar is gouged, and the cross barrier pillar is left so narrow that squeezes originating in rooms ride over it and travel to the main barrier pillar and to the solid coal at the entry face. Thus perverted this system is nothing better than a block room-and-pillar system and a typical mine plan of this type is shown in fig. 17. These mines, however, are called panel mines and they are listed as such in this segregation. This perversion of the panel system is the prime factor in the number of squeezes which have occurred in panel mines in Illinois.

Sixty per cent of the mines listed by the Investigations as panel mines have had squeezes as against 46 per cent in the unmodified room-and-pillar system. The relative dimensions of the earlier room-and-pillar mines have often been retained in panel mines as shown in Table 9. Inasmuch as unusually bad roof is one reason for working on a panel system any gouging of pillars is certain to lead to a squeeze. The high percentage of squeezes in panel mines examined as compared with that in unmodified room-and pillar mines is not an indictment of the panel system but is an adverse commentary on the bad management which allows pillar gouging and inadequate barrier pillars.

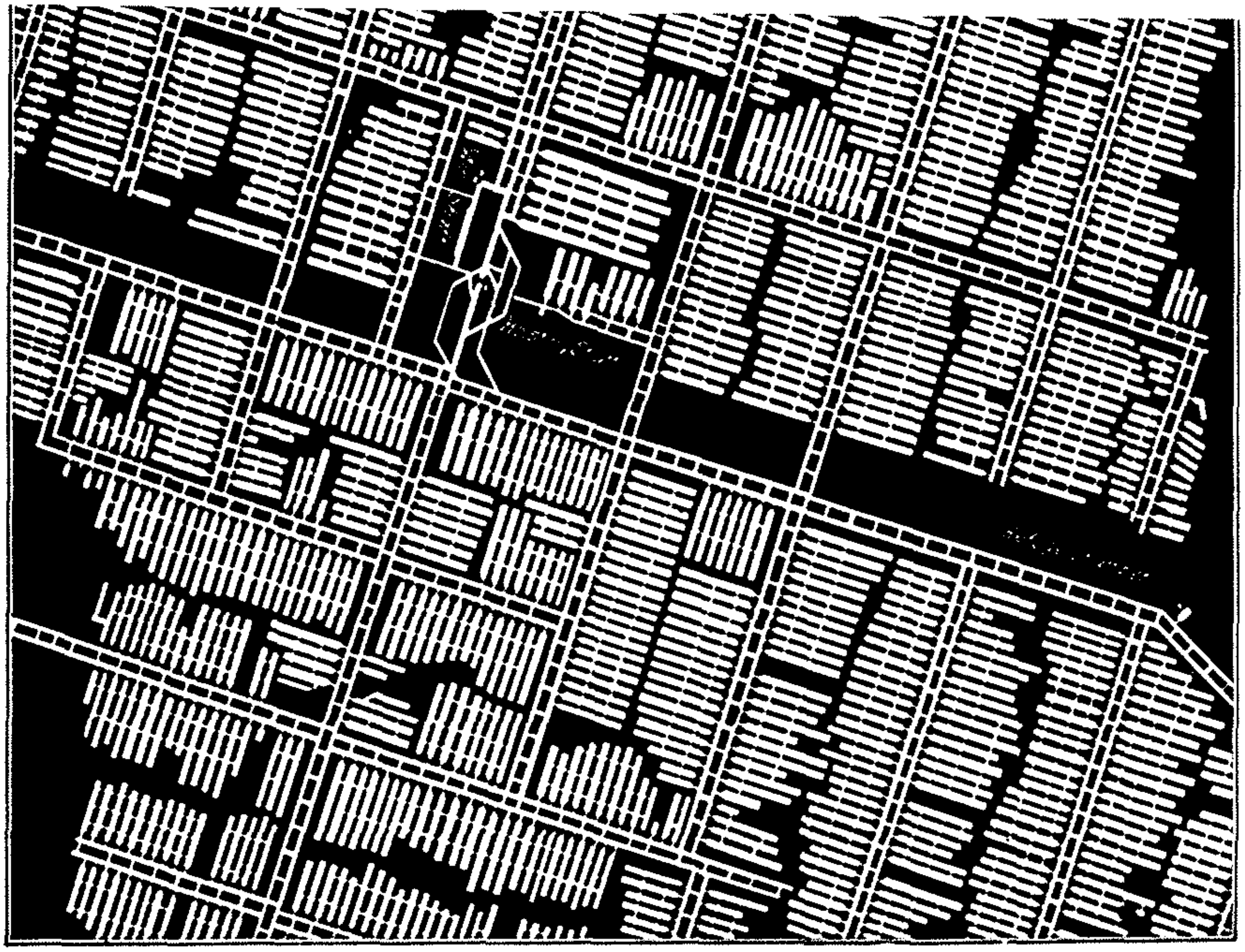


FIG. 17. Typical block room-and-pillar mine

TABLE 9.—*Dimensions in feet of workings of panel mines*

District	No. of seam	No. of mine	Depth of hoisting shaft	Entry width: Main	Entry width: Cross	Entry width: Room	Entry pillar width: Main	Entry pillar width: Cross	Entry pillar width: Room	Barrier pillar width: Main	Barrier pillar width: Cross	No. rooms on room entry	Room: Width	Room: Length	Width of room pillar	Room neck: Width	Room neck: Length	Dist. from entry to full room width	Dist. between room centers	Width of room stump	Width of cross cuts	Has mine had squeezes?	Percentage of seam gained
II	2	13	114	9	9	9	20	20	20	30	30	16	24	250	20	9	4	20	44	35	9	No	55
		25	185	8	8	8	36	30	24	50	24	23	24	180	6	8	7	18	30	22	8	Yes	54
		27	170	12	12	12	20	15	12	50	50	30	30	200	8	8	9	20	38	30	8	No	53
		28	150	8	8	8	25	20	8	40	20	18	24	180	10	8	10	15	34	26	8	Yes	54
		32	68	8	8	8	30	30	24	20	20	30	20	150	12	8	10	15	32	24	8	No	57
		33	285	8	8	8	20	20	20	50	40	15	30	150	6	8	10	35	36	28	6	No	64
IV	5	35	187	8	8	8	35	35	30	60	50	14	26	200	9	8	9	27	35	27	8	Yes	56
		36	238	12	12	12	30	24	10	30	20	24	25	240	10	8	9	27	35	27	12	Yes	48
		37	235	10	10	10	30	30	20	60	40	18	30	240	12	12	15	15	42	30	10	Yes	41
		38	245	10	10	10	27	24	20	35	35	25	30	200	6	10	9	20	36	26	10	No	62
		39	204	12	12	12	30	30	20	30	30	15	30	250	12	12	11	18	42	30	10	Yes	65
		40	270	10	10	10	30	24	20	35	35	27	24	200	6	8	9	18	30	22	7	Yes	50
		51	494	9	9	9	30	30	30	100	100	16	24	250	16	9	18	38	40	31	18	Yes	52
		52	640	12	12	12	50	50	38	150	100	30	25	250	25	12	18	41	50	38	12	No	58
VI	6	53	450	12	16	16	28	50	50	100	100	35	28	300	11	20	18	18	40	22		Yes	65
		54	380	15	7	7	50	50	30	150	150	21	20	250	25	9	11	35	45	34	7	Yes	58
		57	320	12	12	12	50	38	38	100	100	20	25	300	25	12	10	32	50	38	18	No	55
		58	516	12	12	12	25	20	20	125	125	32	22	200	12	12	15	34	34	22	12	Yes	56

TABLE 9.—*Continued*

District	No. of seam	No. of mine	Depth of hoisting shaft	Entry width: Main	Entry width: Cross	Entry width: Room	Entry pillar width: Main	Entry pillar width: Cross	Entry pillar width: Room	Barrier pillar width: Main	Barrier pillar width: Cross	No. rooms on room entry	Room: Width	Room: Length	Width of room pillar	Room neck: Width	Room neck: Length	Dist. from entry to full room width	Dist. between room centers	Width of room stump	Width of cross-cuts	Has mine had squeezes?	Percentage of seam gained
VII	6	66	332	21	21	21	40	40	40	110	75	30	30	300	30	21	25	50	60	39	21	Yes	56
		67	320	12	12	12	30	30	24	60	60	30	30	300	10	9	6	32	40	31	9	No	63
		69	290	12	12	12	30	30	30	60	60	27	23	200	22	12	9	30	45	33	12	No	47
		71	194	10	10	10	40	40	40	75	60	...	38	200	27	9	18	36	63	56	10	Yes	51
		73	318	21	21	21	60	40	13	60	60	13	30	300	20	21	12	30	50	29	21	No	60
		74	330	12	12	12	60	60	12	50	50	14	30	265	30	12	12	30	60	48	12	Yes	50
		75	310	12	12	12	50	40	25	50	50	25	30	250	18	12	18	30	48	36	12	Yes	52
		76	370	10	10	10	50	40	...	75	75	...	28	225	27	10	20	35	55	45	10	Yes	44
		77	462	14	14	14	50	50	40	100	100	40	30	250	25	22	22	28	55	33	21	Yes	63
		83	140	21	21	21	35	35	12	35	35	12	27	600	43	21	12	24	70	49	21	Yes	50
		85	440	12	12	12	50	50	25	50	50	25	35	250	19	9	9	25	44	35	12	Yes	55
		86	536	12	8	12	100	50	16	100	50	16	26	400	25	12	18	30	50	32	8	No	52
Averages by districts																							
II	2		114	9	9	9	20	20	20	30	30	16	24	250	20	9	4	20	44	35	9	...	55
IV	5		203	10	10	10	28	26	19	42	33	22	27	190	9	9	10	21	35	27	9	...	55
VI	6		466	12	11	11	39	40	34	121	112	26	24	258	19	12	15	33	43	31	13	...	57
VII	6		337	14	14	14	50	42	25	69	60	23	30	297	25	14	15	32	54	39	14	...	54
Aver. of 30 panel mines			306	12	12	12	39	35	25	68	56	23	27	251	18	12	13	24	45	33	11	...	55
Average of 48 room-and-pillar-mines			208	12	12	...	31	27	...	46	...	...	26	250	19	12	12	24	45	33	13	...	54

In one panel mine in District VI ribs are hand-sheared in all entries. In another, all entries are driven on two benches. The upper bench, 4 feet high, is carried 6 feet ahead of the lower bench, which is 3 feet high. In an 18-foot entry a cut wide enough for a man to work in is hand-sheared 6 feet from the rib, and extends from the top coal to the lower bench. It is claimed that this method of entry driving is faster than undercutting with machines. In another mine, rooms but not entries are driven on two benches.

PILLAR DRAWING

Pillar drawing is not general in Illinois. The mineral resources of the State should not longer be subjected to the drain occasioned by the waste of 45 per cent of the coal in the seam through unsuitable or antiquated mining methods. In other states, notably western Pennsylvania, West Virginia, and Maryland, almost complete recovery of the seam is being made by driving narrow rooms and leaving wide pillars, mining most of the coal in the second working. The small value per ton of the coal in the ground based on the purchase price of the coal rights is a factor in Illinojs that makes for wasteful mining. At 100 dollars per acre for coal 6 feet thick the value per ton in the ground is approximately 1 cent per ton. Very much of the coal land now being worked has been purchased for a price a great deal less than 100 dollars per acre. In a number of cases in Illinois where surface subsidence has followed a squeeze or the drawing of pillars the mining company owning only the mineral rights has had to pay damages greatly in excess of the value of the land. Companies that are financially able should, therefore, secure the surface right before beginning mining and systematically take out all of the coal by working on the retreating system or on some other system by which all of the pillars may be drawn. The surface can then be tiled and resold. The waste of pillar coal is due largely to a lack of understanding of the comparative cheapness of pillar work and to the fact that if the space left by the removal of the coal is not filled with packing surface subsidence may occur with the removal of the pillars. In several districts the surface has subsided over certain sections of some shallow mines so as to outline plainly the rooms in the workings below. Subsidence is sometimes gradual but it may take place rapidly. Within 36 hours after one squeeze the surface subsided 4 feet over an area of ten acres. Houses have sometimes been damaged and fences and sidewalks broken as the surface settled. In several mines the cap rock over the coal is missing in some places, and where the coal is removed clay and sand break through into the rooms or entries and sink-holes appear on the surface.

In District II at one mine some pillar coal is recovered. In this mine adjacent rooms are driven up and the room pillar is drawn, where it has not been gouged, by taking a 6-foot slice off each rib. It is said that one-half of the pillar coal is thus drawn.

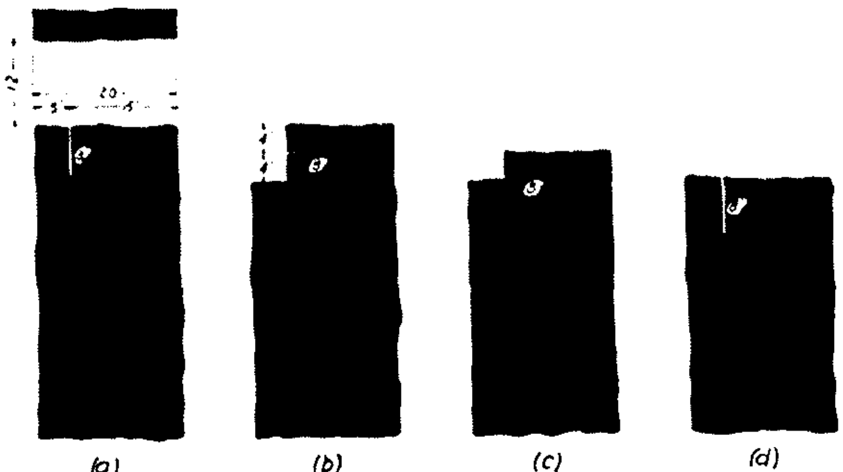


FIG. 18. Method of drawing pillars in District III

A very successful example of pillar drawing is found in the mines of the Coal Valley Mining Company in District III. These mines are worked on the unmodified room-and-pillar system. After the cross-entry has been driven to the boundary and the rooms on it worked out, beginning with the last pillar on the entry, room pillars are drawn until the pillar between rooms 3 and 4 is reached. The room pillars between the main entry and room 4 are left as a protection to

the main entry and air course. The method of drawing pillars is shown in fig. 18. When the room is driven up full length a 12-foot cut is made at the face of the room through the pillar (Fig. 18, "a"). A slab 5 feet wide (Fig. 18, "a") is then shot off the side of the pillar, after which a slab 4 feet wide is shot off the end (Fig. 18, "b"), and the pillar end is squared up again by shooting another slab 4 feet wide off the end (Fig. 18, "c"). The slabs shown in fig. 18, "b" and "c", are usually shot off with one 8-foot hole and a pop shot but occasionally a pop shot is unnecessary as the first shot sometimes breaks off the entire slab. The process is repeated beginning again as in fig. 18, "d". The hard roof is easy of support and often stands before a break takes place while 25 to 200 feet of pillar is being drawn. When the roof weight becomes too heavy the roof breaks at the pillar ends but the cracking of the props gives ample warning of the break and work is discontinued until the roof comes down. The interval between the first heavy cracking of props and the roof break is usually not more than 12 hours.

A break line of about 25 degrees with the face of the rooms is roughly maintained. It sometimes happens that roof falls prevent the men from getting into the squared-up pillar ends to continue drawing as described above, in which case a 12-foot cut is again made completely through the pillar as was done at the face of the room when drawing began and with this new pillar end the procedure continues as before. Very little pillar coal is lost from this cause. Mr. Carl Scholz, President, Coal Valley Mining Company, states that at mine No. 3 at Matherville not more than 4 per cent of the pillar coal is lost.

The cost of producing coal is much less on pillars than on advance work in rooms. Room coal costs an average of $1.25 per ton at the pit mouth at the No. 3 mine of the Coal Valley Mining Company and pillar coal, $1.015. This difference in cost exists because track, yardage, bottom digging, and driving through rolls and slips, are very properly charges against room coal while there are no such charges against pillar coal. When pillars are drawn, therefore, the average cost per ton for the total production is materially reduced.

At this mine rooms are worked with one man at the face but two men are placed at each pillar and at the face of each entry.

In District IV pillars are drawn in only a few mines and in these drawing is not done systematically but is confined to shooting slabs off the pillars where they are thickest. In nearly all mines in this district room-pillars are tapered to cross-cuts as shown in fig. 11. In one mine an attempt was made to draw pillars and track was laid along the rib but objections were raised by the miners to this position of the track and the attempt was abandoned.

In District VI in some mines an attempt is made to draw pillars and pull top coal but it is doubtful if more than 5 to 10

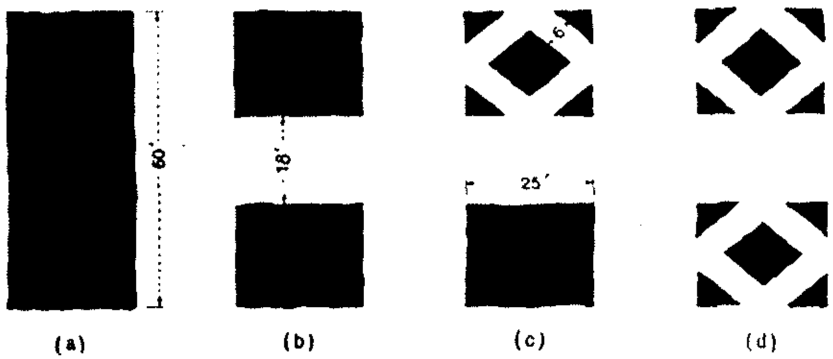


FIG. 19. Method of drawing pillars in District VI

per cent of the top coal is recovered. It is usually pulled before pillars are drawn. At one mine a fairly good recovery of it is made after rooms are driven up by making a cut in it 12 inches wide across the room at the face and a cut 5 feet long along each rib beginning at the face. Props under the block of top coal thus cut out are then pulled and the coal falls. After this block has fallen the cuts along the ribs are extended 5 feet further and the props are pulled under this second block letting the coal come down. This procedure is continued as far as possible along the room. In this mine about one-half of the top coal in the rooms is thus recovered.

The most common methods of gaining pillar coal in District VI are: (1) Taking a 5-foot slab from each rib, and

(2) making a cut about 18 feet wide through the pillar half-way between the cross-cuts required by law. The first method seems to be productive of squeezes inasmuch as the span of unsupported roof is widened by slabbing the pillars. The second method does not make a sufficient recovery. A more elaborate but seldom used method is shown in fig. 19. In this sketch "a" shows the pillar between the two cross-cuts; "b", the first cut through the pillar; "c", the second step in drawing; and "d", the pillar after drawing is completed. There would probably be less waste if the blocks were divided into rectangles rather than triangles.

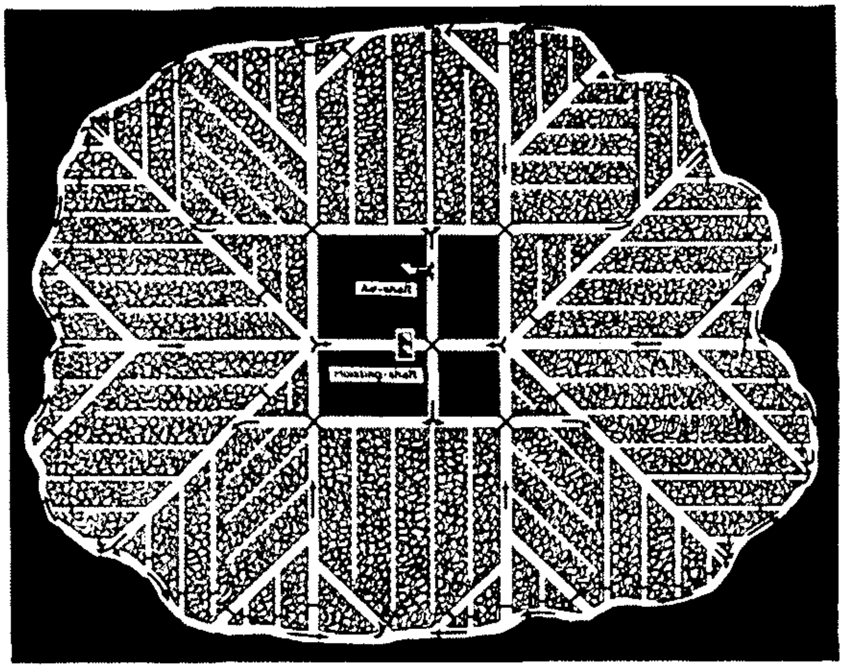
Room stumps, if recovered, are not drawn till all rooms on the entry have been driven up and all room pillars drawn.

LONGWALL MINES

Nearly all of the longwall mines in Illinois are located in District I but there are 4 in District IV. They all are worked according to the advancing system. Whether the coal is reached by a shaft, slope, or drift, the entire seam is removed during the advance, the work progressing in a long continuous face as shown in fig. 20.

In an Illinois shaft mine operated on the longwall system the workings may be likened to a wheel. The hub may represent either the pillar of coal left to preserve the air and hoisting shafts, or the building about these shafts if no shaft pillar is left for roof support. The haulage ways maintained through the gob represent the spokes of this wheel, and the working face represents the rim. For some mines this wheel would be elliptical rather than circular. In a slope or in a drift mine in which the longwall system is used the workings could be shown by one-half of this wheel, either a semicircle or a semi-ellipse.

The greatest difficulty in starting longwall operations is in leaving the shaft pillar and establishing the longwall face. A common method of procedure in this district, after the hoisting shaft and air shaft have reached the coal, is to drive a main entry, as shown in fig. 21, from each side of the hoisting shaft for a distance of about 225 feet. From the airshaft two entries are driven in opposite directions at right angles to the main entry, and are continued until each entry reaches that point where a side of the shaft pillar is to be blocked out, or the air shaft may be offset from the line of this entry as shown in fig. 20. The shaft pillar is now usually blocked out by driving a narrow entry around it, called the "entry-around-pillar." No formula is used to determine the size of shaft pillar necessary with a given thickness of overlying



Overcasts shown thus. X
Curtains shown thus —

FIG. 20 Plan of longwall mine showing direction of ventilating current (After Swift)

strata, and pillars are found in the district as small as 60 feet square where the coal has 100 feet of cover. Large pillars are desirable because, in addition to preserving the integrity of the shafts, they provide for more mining places when operations begin.

A critical time in longwall mining is when the first roof-break occurs at the working face. The roof may not break

until the face has advanced about 100 feet from the shaft pillar; and after the face break has taken place there is a large area of settling roof overhanging from and supported by the shaft pillar. Consequently the roof will break at the shaft-pillar. The subsidence of roof following this break continues violently for three weeks and more gradually for a year.

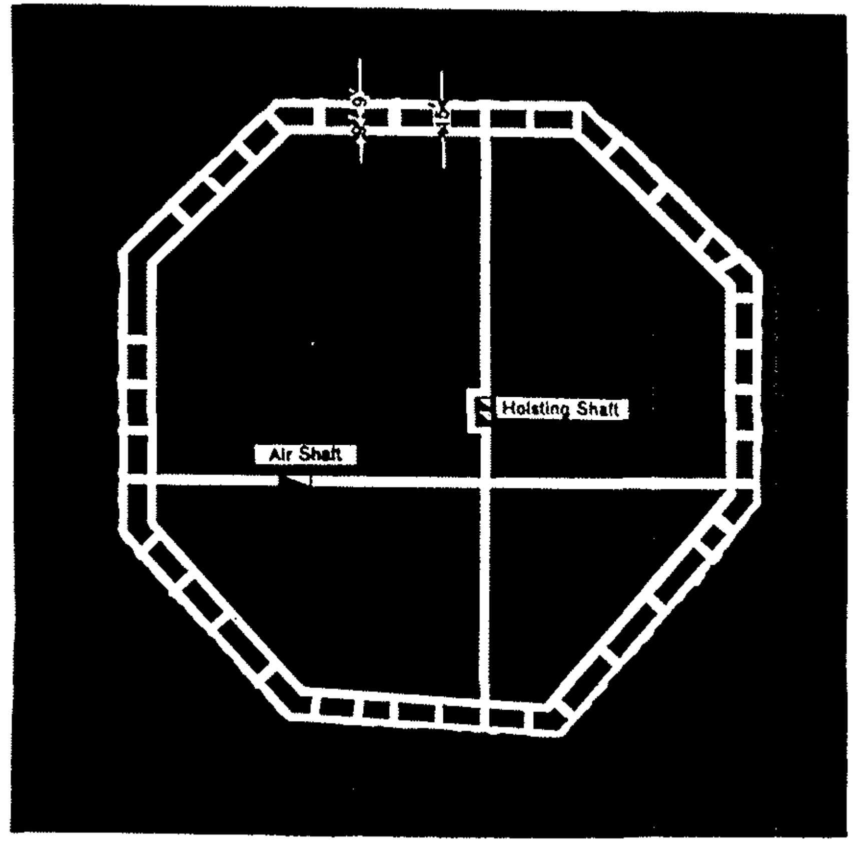


FIG. 21. Entries in shaft pillar in longwall mine

Unless the entry-around-pillar is protected by a pack wall or coal pillar, it will be closed by this first violent roof subsidence. After the entry-around-pillar has been established, openings 9 feet wide as shown in fig. 21, which is a sketch of an actual shaft pillar, are driven into the coal face at intervals usually of 42 feet. When these openings have progressed 15 feet, cuts 9 feet wide are made on each side of each opening at a right angle and are driven until the cut at the left of one opening meets the cut driven from the right of the one adjacent. These cuts serve the double purpose of establishing the longwall face and of leaving a 15-foot coal pillar for the protection of the entry-around-pillar.

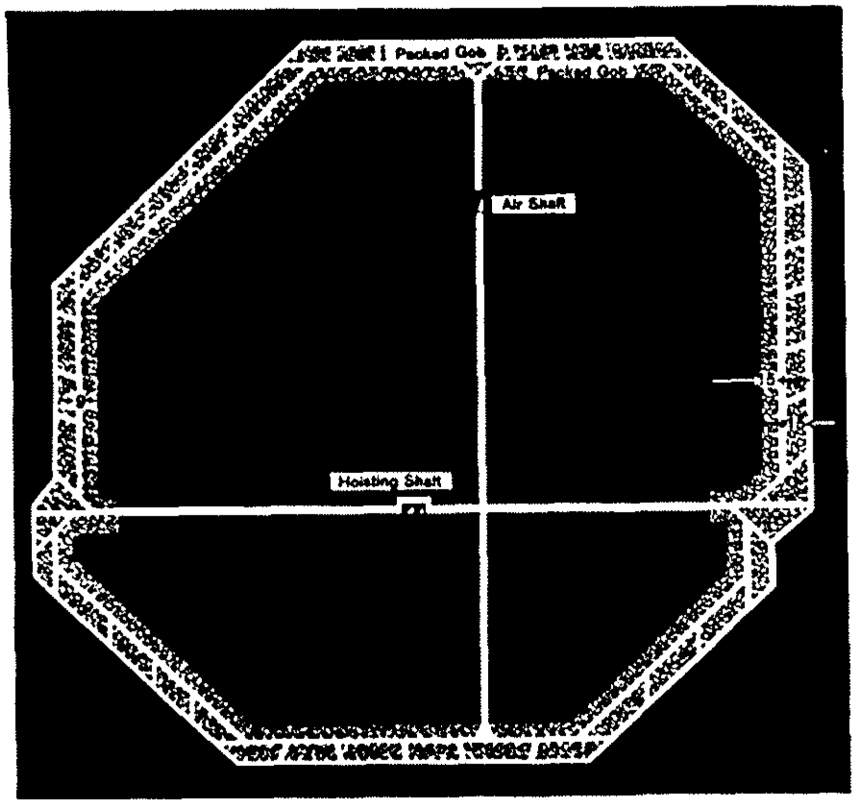


FIG. 22. Pack walls around shaft pillar in longwall mine

Sometimes when it is feared that the coal of the shaft pillar and entry pillar may spall off into the roadway a strip of coal 15 feet wide is sliced off completely around the shaft pillar as shown in fig. 22 and is replaced by a pack wall. The 15-foot pillar left for entry protection is also replaced by a

pack wall. The method of blocking out the shaft pillar by driving narrow entries around it is in general use, but occasionally entries 27 feet wide are driven around the pillar, and two pack walls are built as the entry advances. One pack wall 12 feet wide is built alongside the shaft pillar, and one 6 feet wide on the future longwall face, leaving a haulage road 9 feet wide between the two walls. The necessary openings through the walls are left for haulage. From the time when both hoisting shaft and air shaft reach the coal, 7 to 10 months are required for driving entries through the shaft pillar and for blocking it out. Actual mining is not usually begun until the entries-around-pillar are connected, inasmuch as there is no direct ventilation before the entries are holed through except by means of temporary air-boxes or pipes.

An elliptical shaft pillar may be used instead of the rectangular.

In nearly all new mines opened in the district a pillar of coal has been left around the hoisting and air shafts, but among the older mines occasional examples are found where no coal has been left to support the roof; a total coal extraction having allowed the roof around the shaft to settle gradually till roof and floor meet. When no shaft pillar is to be left for roof support, as soon as the hoisting shaft reaches the bottom of the coal the horned set is placed on soft wood doorhead posts, about 12 by 12 inches in size, and the coal is removed from all sides of the shaft. The space left by the removal of the coal is filled with soft wood cogs called shanties, and with packs of brushing and mining rock. Through the gob a 7-foot roadway is opened up from each side and from each end of the shaft. The roadway props are sawed off at the top an inch at a time as the roof settles and new cap pieces are driven in. In some cases this sawing must be attended to daily and the roadways brushed every few days to keep them open. As the roof settles the packs and shanties are compressed and squeezed into the fireclay till roof and floor meet. The shaft bottom is then widened and timbered.

The advantages claimed for removing the coal around the shaft are that the expense of timbering the bottom is reduced, and that the roof-weight begins sooner to ride on the working face. Those operators who leave coal for shaft pillars admit these advantages but reason that the uncertainty of being able so to control subsidence that the shafts will not be thrown out of plumb when the pillar is removed is too great. After the shaft pillar has been blocked out and removed and the longwall face established the work progresses regularly in a long continuous line. From each side of the

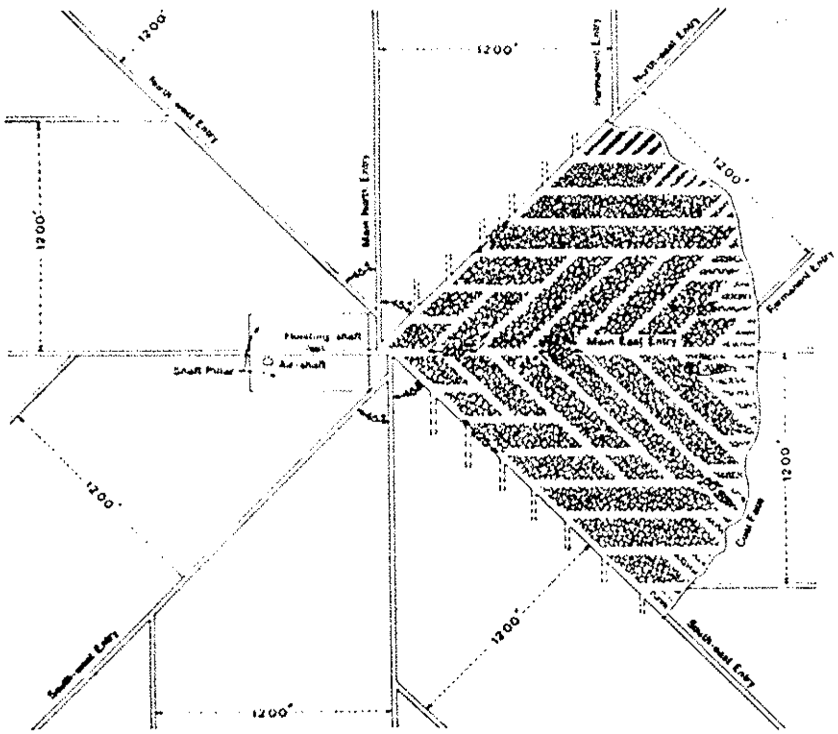


FIG. 23. Plan of longwall mine with auxiliary permanent entries

centers of the openings which were left in the entry pillar the coal of the face is removed. In order to provide for haulage from all parts of the face to the shaft, roadways 9 feet wide, called rooms, are maintained as shown in fig. 20, by building pack walls of rock. These rooms are continuations of the openings through the entry pillar, and the pack walls protecting them are usually 12 feet thick. When pack walls are first made they are often spaced 10 to 12 feet apart to allow

for bulging when the roof weight sets on them which causes narrowing of the roadways. A track is laid to the face of each room. In order to save the expense of a road for haulage from the face of each room to the main entry in the shaft pillar, cross-entries maintained through the gob by pack walls, are turned off near the shaft pillar as shown in fig. 20 and intersect the rooms at an angle of 45 degrees. The second set of cross-entries is usually 225 to 300 feet from the first. This distance is maintained throughout the workings.

This form of longwall working, often called the "Scotch 45-degree system," prevails where no unusual conditions obtain, but various modifications of the system are found where

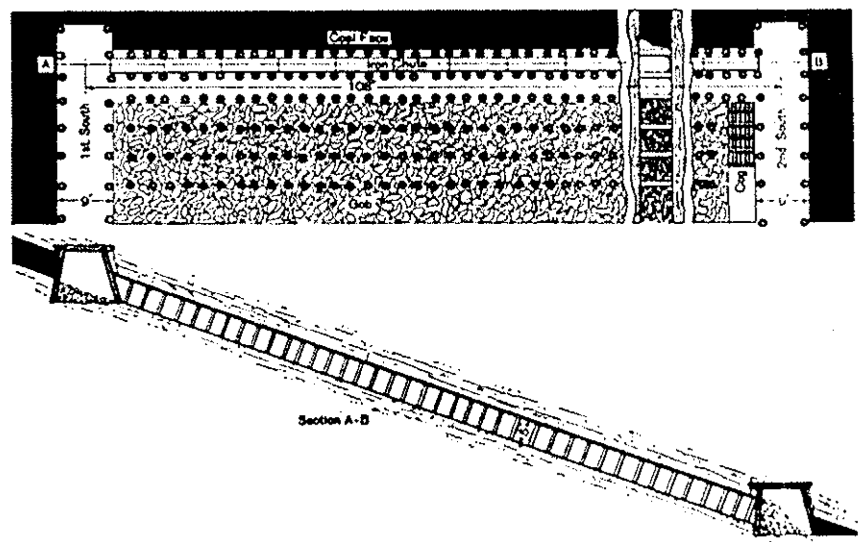


FIG. 24. Method of working panel long wall. (After Ede)

the seam dips steeply or where roof and floor characteristics necessitate a departure from the usual method. To provide a better haulage from the face in one mine where heavy timbering is necessary, entries are maintained from the shaft pillar as shown in fig. 23, bisecting each quadrant formed by the four main roadways, making eight main haulage ways in the mine. From both sides of these eight main roads at 225-foot intervals cross-entries are maintained at an angle of 45 degrees. When the cross-entries from adjacent permanent roads intersect, one entry is continued and the other is abandoned. Every 1,700 feet along the left side of each of the eight main haulage roads is turned a haulage entry permanently timbered.

Where the coal seam lies in the LaSalle anticline its dip becomes as steep as 51 degrees, and the methods of work approach those of metalliferous mining. While the general longwall system of main and cross-entries and rooms on the 45-degree plan is followed, a longwall panel is operated at the face as shown in fig. 24. The coal from all the face below

TABLE 10.—*Dimensions of workings in longwall mines*

Number of mine	Depth of shaft in feet	Thickness of bed in inches	Size of shaft pillar in feet	Distance between cross entries in feet	Angle of cross entry with main entry—degrees	Angle of room with cross entry—degrees	Distance between room centers at face in feet	Width of roadways in feet			Width in feet of buildings on roadsides
								Main	Cross	Room	
1	413	39	400 by 600	225	45	45	42	9	9	8	12
2	465	44	250 by 250	225	45	45	42	9	9	9	9
3	398	42	550 by 550	240	45	45	42	9	9	9	9
4	546	40	No pillar	200	70	70	42	10	10	10	12
5	135	36	300 by 500	275	45	45	42	7	7	7	12
6	100	36	150 by 300	225	45	45	42	7	7	7	9
7	200	37	350 by 450	....	45	45	42	8	8	8	9
8	300	40	....	225	45	45	42	9	9	8	12
9	Slope	42	....	320	30	30	40	8	8	5	9
10	480	42	500 by 500	225	45	45	42	9	9	7½	12
11	530	34	600 by [1]3,600	225	45	45	49	8	8	8	12

[1]This pillar was left for the protection of three hoisting shafts.

a cross-entry is thrown on a sheetiron chute (Fig. 25), down which it slides to the entry below, fig. 26. The chute is built of small sheets 3 feet wide and 8 feet long each having a flat hook at one end and a hole at the other to receive the hook of the next sheet. The chute is moved forward daily as the face progresses. In several mines cross-entries are driven off at an angle of 70 degrees with the main entries for the purpose of increasing the size of the cog built to support the roof over the switches at the junction of main roadway and cross-entries. Table 10 gives dimensions of workings at each mine examined.

In all classes of longwall operation the same general method of filling the space left by the removal of the coal prevails. The rock obtained from brushing the roof, that which remains after building pack walls, and the clay obtained from undermining the coal are thrown behind the pack walls lining the roads. The space between the pack walls and also the waste material itself is called the gob. The gob area is usually filled with rock and clay to within 2 to 5 feet of the coal face. This loose rock and clay helps to support the roof and con-

FIG. 25. Face of longwall panel mine in dipping seam (photo by H. I. Smith, U. S. Bureau of Mines)

trol the roof weight on the coal face. After the first break at the shaft pillar and face—if the gob area has been properly filled so that the roof weight rides on the face of the coal—other roof breaks occur every 2 inches to 6 feet parallel to the coal face and extending upward away from the face and toward the gob as the face advances. The distance between breaks depends principally upon the character of the roof and the packing of the gob. With proper packing the distance between breaks should correspond to the width of coal brought down. At the face of solid coal the cracks in the roof are difficult to see, and they do not become easily visible until the face has advanced 4 to 5 feet.

The distance to which these mining breaks extend into the roof depends upon the roof material, but they rarely extend more than 15 feet above the coal. The angle made by these breaks varies from 50 to 90 degrees from the horizontal, depending upon the roof material and the rate of settling. In summer when the face progresses slowly the cracks are more nearly vertical.

The seam in the district is thin and the price paid the miner per ton of coal mined includes brushing the roof of the roadways to provide height for haulage. In the La Salle field the miner is paid 90 cents per ton of coal mined and he must take down 24 inches of roof over the roadways, but any subsequent brushing necessary is done by the company. In the Wilmington field the miner is paid 95 cents per ton of coal mined, but he must maintain the roof of his roadway 4 feet above the rail between a point 40 feet back from the face and the switch, provided this distance does not exceed 300 feet. He is not required to clean up any fall on this roadway which is not due to his failure to secure the roof properly.

In each of the mines examined squeezes closing the working place by filling them with roof material have occurred. A squeeze takes place when a room is driven ahead of adjacent rooms; when a room is allowed to lag behind; and most commonly when defective pack walls have been built and the gob area has not been sufficiently filled with waste. The amount of waste necessary to be thrown back into the gob to insure safety from squeeze depends upon the conditions in the rooms, such as the thickness and character of the coal, the nature of the roof and the method of mining. The waste should fill the gob sufficiently to allow the roof to come down gradually without breaking off short at the face of the pack walls, but should not fill the gob so completely that it carries too much of the roof and does not throw enough weight on the face of the coal. The better the gob is packed, the better the coal works. The width of the pack wall, called "building," necessary to prevent the walls from squeezing out and filling the

roadway when the roof weight comes on them depends upon local conditions. The Third Vein District Agreement between the Illinois Coal Operators' Association and the United Mine Workers of America in Article 1 provides: "The miner shall build 4 yards of wall at each side of his road, and if he has more rock than is required therefor he shall not load any of it until he has filled his place therewith. In case the miner has not rock enough to build his 4 yards he shall, at the request of the company, begin his wall 4 yards from

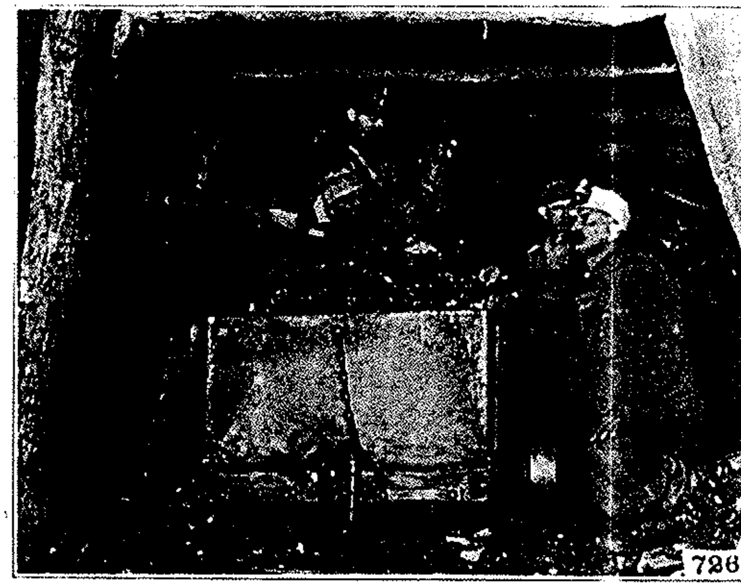


FIG. 26. Chute in panel longwall mine in dipping seam (photo by H. I. Smith, U. S. Bureau of Mines)

the roadside; provided, that the above shall not prohibit the miner, at his option, from beginning his wall at any greater distance upon the request of the company." When some part of the face has been allowed to lag behind and the working face has squeezed, the area is not usually cleaned up, but the face is diverted to pass around the squeezed area, sometimes leaving a small block of coal in the gob.

The effect of the subsidence of the roof upon the overlying strata and upon the surface after the coal has been removed has not been clearly determined. Surface subsidence has been the subject of extended litigation. While it is undoubtedly true that there is subsidence of the strata immediately overlying the coal, opinion is divided as to the extent of this subsidence. There are not sufficient data available from which to formulate a general rule for the amount that results from mining seams of different thicknesses lying at different depts and under different kinds of cover.

Work at the Face

Room centers at the longwall face are usually 42 feet apart. Half-way between the center of the road head of each

Fig. 27. Props and sprags at face of longwall mine (photo by H. I. Smith, U. S. Bureau of Mines)

room and the center of the road head of the adjacent rooms a prop called the "march prop" is set. The 42 feet of coal face included between two march props is called a "place." Until recent years two miners worked at every place in all longwall mines, but at present on account of the scarcity of

labor probably one-half of the places in longwall mines contain only one miner. Upon the one miner or two miners, as the case may be, assigned to a place, is the charge of proper building of pack walls along the roadway of the room, and of proper gobbing of the space between the marches.

When the bed is underlain by fireclay, beginning at the center of the roadway each miner picks out the clay under the coal and makes an undercut 8 to 12 inches high. This undercut sometimes extends 2 to 2½ feet under the coal. To prevent it from falling on the miner while he is undermining, sprags are placed against the coal, spaced 6 to 8 feet along the face. To support the roof, props, as shown in fig. 27, are set 2 to 5 feet from the face and are spaced 6 to 8 feet apart. With an average depth of undermining, a good miner can undercut about 20 feet of face a day when working in soft clay 8 to 12 inches thick.

When a car is to be loaded, that portion of the coal is taken which has been standing longest on sprags. These are knocked away from the coal with a sledge and if the gob has been properly filled so that the roof weight is riding on the face, the coal breaks away from the roof and is ready for loading. If the coal sticks to the roof and does not break when the sprags are knocked away, it is pried down with wedges driven by a sledge between the roof and the coal.

The operators in the district report that under reasonably good conditions of longwall mining, approximately 80 per cent of 1¼-inch lump is produced; but with varying physical characteristics of roof, coal, and floor modifications of mining procedure are found. These modifications may be disadvantageous to the operator by increasing the amount of slack and may endanger the life and limb of the miner by increasing the number of falls of coal and roof.

If the fireclay usually underlying the coal is absent and the floor material is sandstone, or if the fireclay is much over 18 inches in thickness, undermining is done in the coal itself. The amount of slack made by undermining the coal is large. The practice is further undesirable in that it increases the number of gob fires because more fine coal is thrown into the gob with the waste.

To save time and labor the miner often neglects to support the coal on sprags until the usual two feet of undermining is completed, but he makes a cut 4 to 8 inches deep and pries down the undermined coal with a pick, or wedges it down. This method does not allow the slow breaking of the coal by roof weight; consequently more accidents occur, and more slack and smaller coal result than when full undermining is insisted upon. Enforcement of spragging would be a distinct advantage to the miner and to the operator. The disproportionate number of accidents in the district in ratio to its tonnage would be decreased, and 10 to 15 per cent more lump coal would be made if proper undermining were enforced.

TABLE 11.—*Blasting in longwall mines*

Is coal shot down?	Size of powder	Explosive used in brushing roof	Undermining in clay or coal	Per cent of lump coal over 1¼ in.[1]	Drill holes in coal	
					Diameter in inches	Length in feet
No	......	None	Both	80	.....	.....
Under nigger heads	FF	Black powder	Clay	83	1¼	2½
Under black shale only	FF	40 per cent dynamite	..do	79	1½	4
Yes	FFF	Black powder	Coal	65	1½	5
Yes	FF	40 per cent dynamite	Clay	70	1¾	4
No	......	..do	..do	80	.....	.....
Yes	FF	60 per cent dynamite	..do	[2]73	1½	4
Under black shale only	FF	Black powder	..do	73	2	4
Yes	FF	35 per cent dynamite	..do	Mine run	2½	7
No	......	30 per cent dynamite	Both	83	.....	.....
No	......	45 per cent dynamite	..do	[3]83	.....	.....

[1] Figures furnished by operators.
[2] Over 1½ inches
[3] Over ¾ inch.

If niggerheads make up part of the roof and if the floor contains rolls, explosives are used to bring down the coal. In this district black powder is used unnecessarily in several mines. The effect of its use is illustrated in one mine where owing to niggerheads in the black shale roof the coal is shot down in a small section of the mine. Ten per cent more slack results in the section where shooting is necessary than in the other sections of the mine. The roof is injured by the blasts and is made difficult to support at the working places. Table 11 gives data on blasting in longwall mines.

No longwall undercutting machines are used in this district.

Inasmuch as the coal seam contains many pyrite concretions which if thrown into the gob with the waste or built into the pack walls might, it is believed, cause gob-fires, an attempt is made to separate this "sulphur" from the shale and clay. The Third Vein District Agreement between the Illinois Coal Operators Association and the United Mine Workers of America provides in Article VII that "no sulphur shall be put in the building or march without the company's permission. When the rock is loaded out the sulphur shall be loaded with it. When no rock is loaded out the sulphur shall be left along the roadside, except that where the company so elects, the miner shall load it properly and receive therefor 15 cents per car, if the average coal capacity is less than 1,500 pounds, and 22 $\frac{4}{10}$ cents per car where larger cars are used." In spite of this agreement considerable sulphur is thrown in the gob.

STRIPPING MINES

The stripping system is used where the overburden can be removed economically from the coal by a steam-shovel or other mechanical means, thus exposing the coal which is then quarried.

In the Danville district the removal of overburden from coal lying at depths of 20 to 30 feet below the surface has been practiced for a longer time and more extensively than it has in any other district in Illinois. Beginning in 1866 with the primitive method of exposing the coal by removing a very shallow overburden by means of scrapers dragged by horses the process developed slowly, horse scrapers being replaced about 1900 by the drag-line steam shovel. Later, standard shovels were substituted for the drag-line and they in turn, were replaced by revolving steam-shovels in 1910.

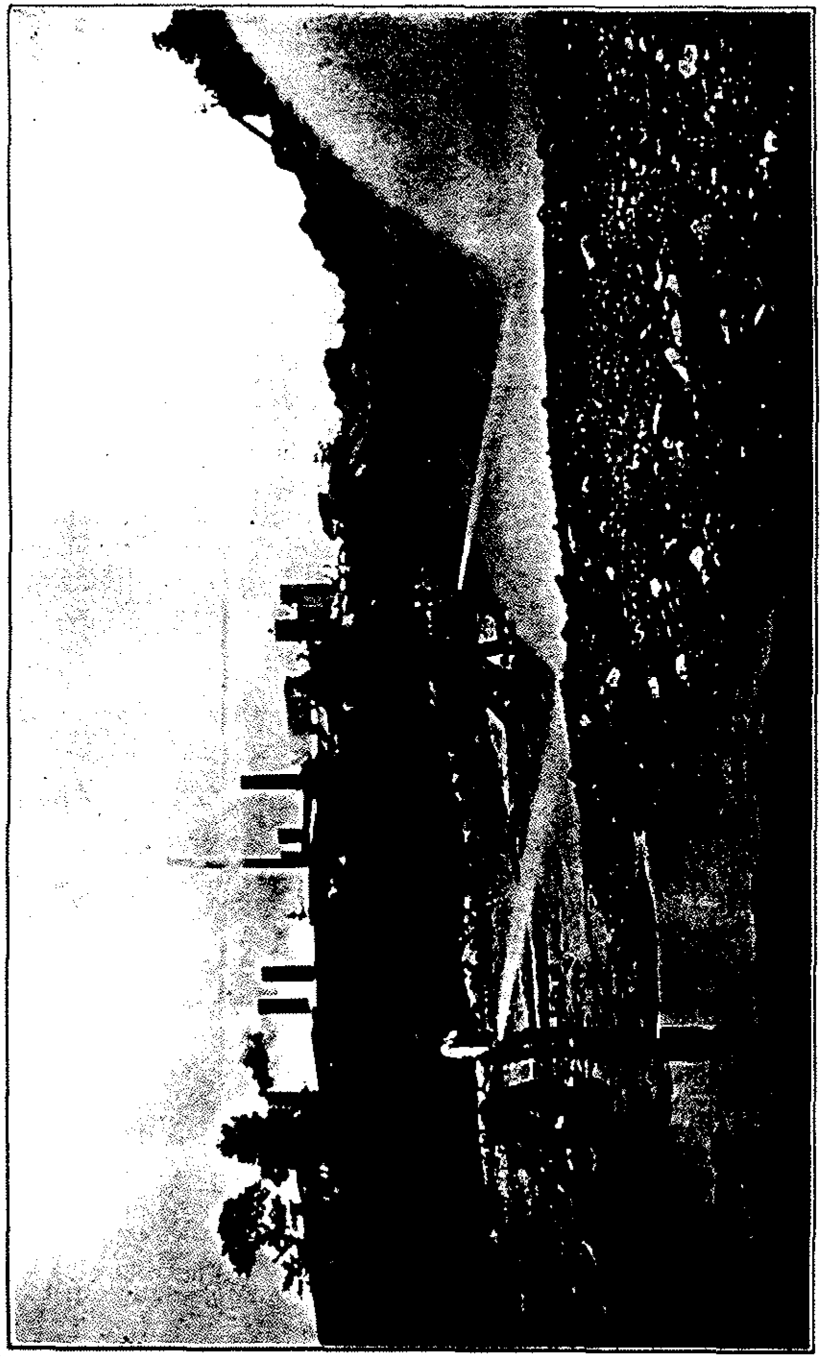


Fig. 28. Removing top soil with hydraulic monitors

The methods of stripping now employed in the district differ in the path which the shovel follows while digging, in the manner in which the top soil is removed from the shale overlying the coal, and in the disposal of the spoil. In one method the shovel makes a continuous cut about 50 feet wide in a circle around the area to be stripped and the coal exposed

Fig. 29. Steam-shovel digging shale overburden

behind the shovel is mined. The shovel having completed the first circle begins a second just inside the first and continues to move in circles with constantly decreasing diameters.

In the second method, the shovel instead of traveling in a circle goes forward and back across the property in parallel straight lines, a haulage-way for disposing of the material mined being maintained at one side of the property.

Fig. 30. Stripping-mine coal face.

Where the shale overlying the coal is to be used for the manufacture of brick or for other purposes and is overlaid by soil, the soil is first removed by hydraulicing. As fast as the coal is mined, the top soil for 50 feet from the edge of the bank of the cut is washed off into the pit left by the removal of the coal. For washing off the top soil hydraulic monitors under a pumping-head are used as shown in fig. 28. The amount of top soil washed per eight-hour shift varies with the material removed; in tight ground 100 cubic yards may be the total for eight hours; in loose ground, 2,000 cubic yards may be washed off. Fig. 29 shows the shovel digging the shale overburden and exposing the coal after the top soil has been washed off. In blasting stripped coal, holes 2½ inches in diameter are drilled 12 feet apart at a distance of 5 to 9 feet from the face. These holes are drilled with a hand auger or with an air drill, the air being furnished by a portable compressor. The average charge of powder is 1½ pounds per hole, and the average gain per 25-pound keg of powder is 250 tons.

At one stripping mine in the district the steam-shovel digs a permanent haulage-way along one side of the area to be stripped. At the end of this haulage cut a "thorough-cut" about 50 feet wide is made along the boundary of the property. The exposed coal is mined behind the shovel as shown in fig. 30. When the thorough-cut reaches the property line the shovel turns around and digs the overburden from another strip about 50 feet wide depositing the spoil in the pit made by the removal of the coal exposed by the thorough-cut.

Fig. 31 shows a steam-shovel which elevates the spoil by a belt-conveyor and deposits it along the side of the shovel-cut. This has been replaced by a revolving steam shovel with a very long beam.

The total cost of mining coal by stripping the overburden varies on a daily output of 300 tons per day from 40 to 50 cents per ton loaded on the cars.

Stripping is also done in District VI near Duquoin where the overburden is removed with horse-scrapers. In Districts I and VII steam-shovels are used for stripping.

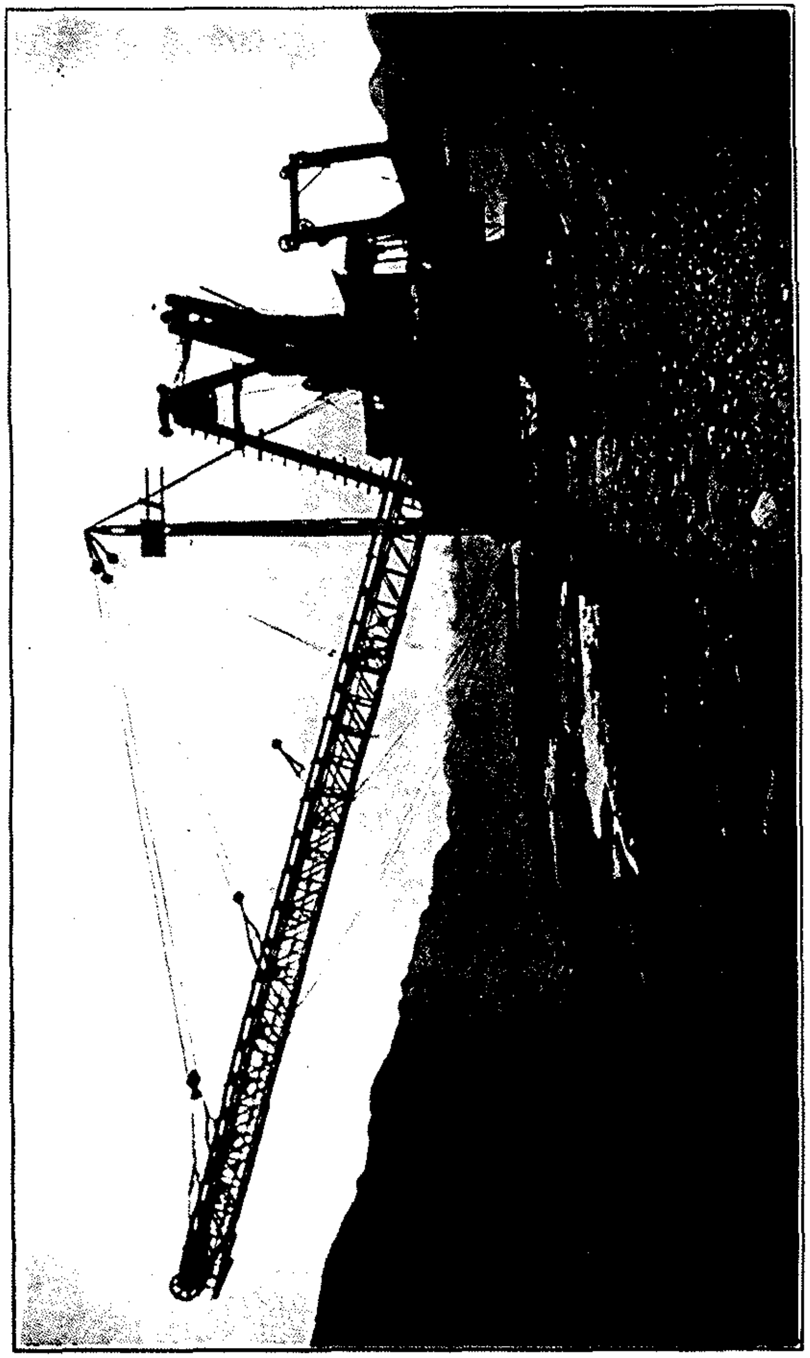


Fig. 31. Steam-shovel with belt-conveyor spoil-elevator.

DRAINAGE

Coal mines in Illinois are not troubled with large quantities of water. Generally the shallowest mines are the wettest because surface water seeps through the roof or, where the cap rock is lacking as in some places in Districts II and IV, sand and water flow into the mine through caves to the surface. The most water recorded in Illinois is in a mine in District II where approximately 1,000,000 gallons per 24 hours flow into the mine through caves. This water is pumped out through drill holes by two automatically-started electric turbine pumps of 250 gallons per minute capacity; two stationary electric pumps of 180 gallons per minute capacity; and five portable electric pumps discharging 70 gallons per minute. Water flows into some mines through channels in the floor under the coal. Often the only sources of water in Illinois mines are the hoisting and air shafts and sometimes the faces of rooms. If the water collects in swamps in entries and it is necessary to install pumps inby they are usually operated by electricity, seldom by air. The main pumps at the shaft bottom are usually operated by steam but sometimes by electricity, air, or gasoline.

The source of the water at the shaft sump can usually be told by its character. Where the water is acid it has been derived principally from seepage and its acidity is caused by the solution of iron sulphate; where it is neutral chemically it is surface water which has seeped through the shaft directly into the sump. At one mine it is sufficiently pure to give to the mules which are stabled underground.

BLASTING

At the present time almost one-half of the coal output of Illinois is produced by the dangerous and wasteful method of shooting off the solid. The charges of powder in the drill-holes are far in excess of the amount allowable for mining coal safely and the tonnage of slack coal produced by overcharged shots is needlessly high.

In District I (Longwall) powder is used at the face only occasionally, hence only mines other than longwall are considered under this caption.

No difference is apparent in blasting practice between mines operated on the unmodified room-and-pillar system and those operated on the panel system.

In local mines blasting methods are usually bad and shooting off the solid prevails wherever blasting is done. Holes 12 feet deep in a 5 foot seam are not uncommon. In a few shallow mines especially in District III no shooting is done, and the coal is brought down by wedge and sledge. Vertical cuts about 18 inches wide and 2 feet deep are made in the coal at 15 foot intervals and an undercut about 3 inches high and 2 feet deep is made along the face. Steel wedges are driven between roof and coal at 3-foot intervals and the coal breaks away in large blocks. The longwall system can not be used at these mines because where the coal is removed under any considerable area of roof, caves extend to the surface and sand and water pour into the mine. For this reason no attempt to draw pillars is made at these mines.

Shooting off the solid in shipping mines is done in every district although less in District VI than in others. The general custom throughout the State in mines where shooting off the solid is practiced is to shoot off the weak rib, that is, off the rib presenting the greater area of free surface. Three to seven shots constitute a round. At a mine in District III shooting in rooms is done off the solid but one-half of the face is kept about eight feet in advance of the other half. The small amount of powder required per ton of coal to gain the rear half of the face is offset by the amount neces-

TABLE 12.—*Blasting practice in mines shooting off the solid*

District	No. seam	No. mine	Size of powder	Tons of coal per keg of powder	Powder cost in cents per ton of coal	Length of holes in feet	Diameter of holes in inches	Shots fired by	Per cent of coal over 1¼ inches[1]
III	1 and 2	17	F and FF	18	9.7	8	2½	....	75
		18	FF	18	9.7	7	2½	Fuse	75
		19	F and FF	16	10.9	8	2½	Fuse	..
		24	FF	18	9.7	8	2½	....	70
IV	5	25	F,C and CC	17	10.3	6	2¼	Fuse	68
		26	C	18	9.7	6	2½	Fuse	70
		28	F	18	9.7	6	2¼	....	75
		29	F	16	10.9	7	2	....	71
		32	FF	21	8.3	6	2½	Fuse	68
		33	C	18	9.7	5	2½	Fuse	75
		34	C and CC	19	9.2	6	1½	Fuse	67
		35	C and CC	21	8.3	7	2½	Fuse	..
		36	C	24	7.3	6	2¼	Fuse	67
		37	C	19	9.2	6	1½	....	65
		38	C	31	5.7	6	2½	Fuse	..
		39	F	20	8.8	6	1¾	Fuse	70
		40	C	21	8.3	6	2¼	Fuse	71
		41	CC	18	9.7	7	2½	Fuse	70
V	5	47	F	22½	7.8	7	1¾	Fuse	55
		49	C	18	9.7	8	2½	Fuse	75
VI	6	55	FF	30	5.8	7	1¾	Squibs	..
		64	FF	24	7.3	7	1½	Squibs	45
		65	FF	25	7.0	7	2¾	Fuse	60

[1]Figures supplied by operators.

Table 12.—Continued

District	No. seam	No. mine	Size of powder	Tons of coal per keg of powder	Powder cost in cents per ton of coal	Length of holes in feet	Diameter of holes in inches	Shots fired by	Per cent of coal over 1½ inches[1]
VII	6	67	C	20	8.7	6	2¼	Fuse	65
		69	C	17	10.3	7	2	Fuse	60
		75	CC	24	7.3	7	3	Fuse	67
		80	CC	25	7.0	6	2½	Fuse	
		81	F	32	5.4	7	2½	Fuse	60
		85	C and CC	25	7.0	8	2½	Fuse	70
VIII	6 and 7	91	C	25	7.0	7	2¼	Fuse	40
		92	C	25	7.0	7	2¼	Fuse	70
		94	C	26	6.7	6	2¼	Fuse	60
		95	C	44	4.0	6	2½	Squibs	55
		97	C	20	8.8	8	1½	Fuse	50
Averages by districts									
III	1 and 2			18	9.7	7¼	2½		71
IV	5			20	8.8	6	2¼		70
V	5			20	8.8	7½	2⅛		65
VI	6			26	6.7	7	2¼		52
VII	6			24	7.3	7	2½		64
VIII	6 and 7			26	6.7	7	2		55
Average of 34 mines				22	8.3	6½	2¼		65

[1] Figures supplied by operators.

sary to bring down the tight coal of the advanced half. Shooting off the solid should be abandoned in Districts V and VI where the combination of explosive gas and dust renders the practice especially dangerous.

At the mines examined 22 tons of coal were gained per keg of powder as against 101 tons per keg after mining machines. Table 12 gives data for the practice in solid shooting mines. The percentage of coal undercut by machines is increasing too slowly. Table 13 gives comparative data on coal cutting and blasting conditions in Illinois since 1900. This table does not show the decrease in amount of powder that should be expected from the increased use of coal cutting machines.

Table 13.—*Coal cutting data since 1900*[1]

Year	Total production	Per cent mined by machines	No. mining machines	Tons of coal per keg of powder
1900	25,153,929	22.2	430	40.7
1910	48,717,853	37.3	1289	35.7
1912	57,514,240	44.4	1581	38.9
1913	61,846,204	48.8	1689	40.9
1914	60,715,795	51.8	1828	42.3

[1] Shipping mines only. Compiled from Thirty-first Annual Coal Report of Illinois.

Electric chain, air puncher, and few pneumelectric undercutting machines are used in the State. Puncher machines are usually found at mines of moderate production where mules are used on the main haulage. At mines equipped with electric haulage electric mining machines are usually installed. The chain-breast machine is commonest in Illinois, but the chain short-wall is rapidly growing in favor. At the mines examined the average number of tons of coal undercut per day per machine is 113. The puncher machine usually undercuts from 40 to 90 tons per day and the chain-breast machine from 135 to 200. The average chain machine will supply coal for 15 loaders. Table 14 gives blasting data for mines undercutting the coal by machines.

The usual method of supplying air to puncher machines is as follows: From the surface 9-inch mains run down the pipeway in the shaft to a receiver placed 300 feet from the bottom of the shaft. From the receiver a 6-inch line is run to the face of the main entries and this 6-inch line is tapped by a 3-inch branch running to each pair of cross-entries to the rooms.

Fig. 32 shows a typical method of placing shots after a puncher machine.

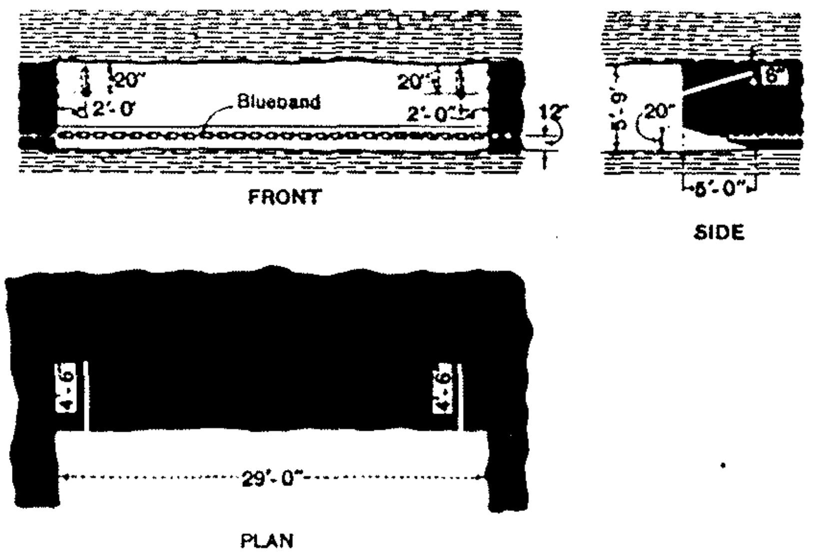


FIG. 32. A method of placing shots after puncher undercutting machine

The face which is undercut by chain machines is supposed to be snubbed for a depth equal to one-half the depth of the undercut. Snubbing usually is only 18 inches deep, however, and the height of face snubbed varies from 18 to 24 inches. In No. 6 seam the face is snubbed to the blue band. Fig. 33 shows a common method of placing holes after chain machines where black powder is used and fig. 34, where permissible explosives are used. The position of drill holes and their number vary between wide limits. The usual practice with chain machines is to use one-third pick bits and two-thirds chisel bits. In District IV seam No. 5 has always been

considered hard and in this district only chisel bits are used in the chain.

In a mine in District VI where entries are driven on two benches, shooting is done with size F black powder, and the

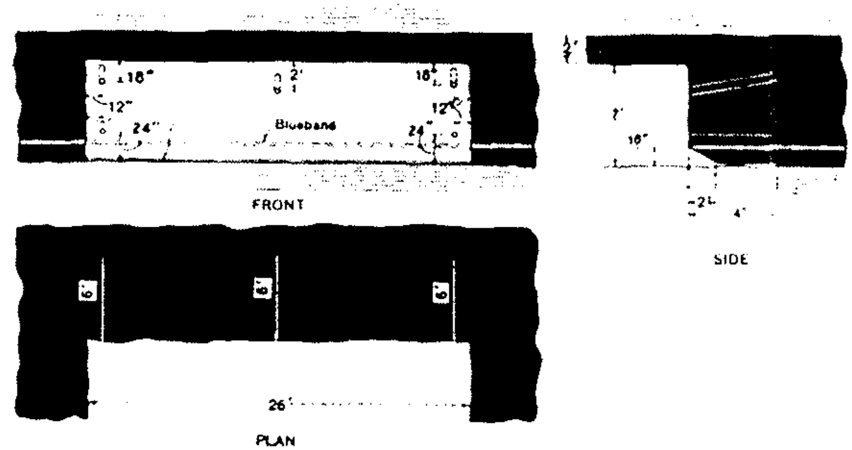


FIG. 33. Method of placing holes where black powder is used

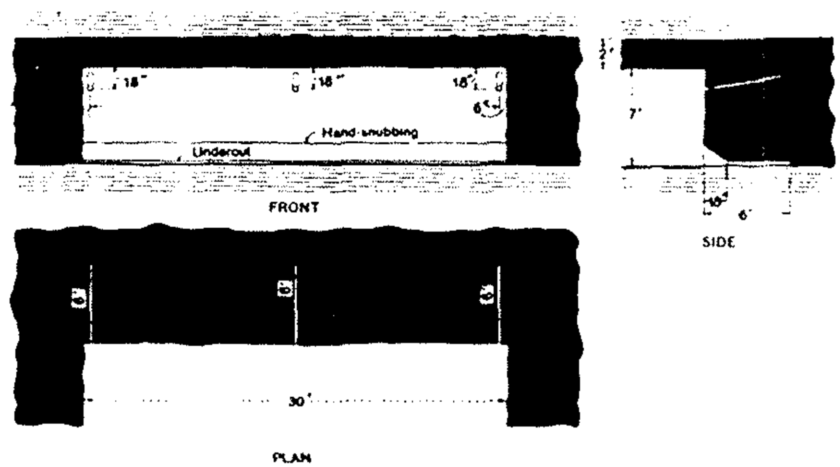


FIG. 34. Method of placing holes where permissible explosives are used

holes are arranged as shown in fig. 35. At another mine in this district all holes are drilled with air-drills. Unless the miner desires to point his own holes all holes are pointed by

TABLE 14.—*Blasting practice in mines using undercutting machines*

District	No. seam	No. mine	Kind of undercutting machine	Depth of cut in feet	Tons of coal per machine per shift	Height of snubbing	Size of powder	Tons of coal per 25-pound keg of powder	Powder cost in cents per ton of coal	No. holes per round	Length of holes in feet	Diameter of holes in inches	Shots fired by	Per cent of coal over 1½ inches[1]
II	2	12	Puncher	4	35	18	FF	100	1.8	3	4	2¼	Squibs	70
		13	Chain	6½	150	18	FF	115	1.5	3	6	2¼	Squibs	50
		14	Puncher	5	...	18	FF	150	1.2	3	4¾	2	Squibs	..[2]
		15	Puncher	4½	...	18	FF	125	1.4	3	5½	2	Squibs	60
IV	5	27	Chain	6	...	18	F	56	3.2	...	6	2¼	Fuse	70
		31	Chain	6	...	18	FF	40	4.4	...	6	2¼	Fuse	67
V	5	43	Chain	6	112	24	F	108	1.6	...	5	2¼	Squibs	70
		44	Chain	6	200	18	FF	125	1.4	...	6	1½	Squibs	70
		45	Chain	6	150	15	FF	116	1.5	...	5	2	Squibs	..
		46	Chain	6	...	18		100	1.8	...	5½	2¾	Fuse	..
		48	Chain	6	112	18	FF	107	1.6	...	5½	1¾	Fuse	70
VI	6	50	Chain	6	150	24	Black Diamond	175[3]	1.4	3	5	2	Fuse and caps	80
			Puncher	5	50	18	....	...	...	...	...	...		
							....	...	...	...	...	...		
		51	Puncher	4½	60	24	Mineite	113[3]	2.2	3	6	2	Fuse and caps	62
		52	Chain	7	125	..	F and C	56	3.1	5	6	1½	Squibs	60
				..	...	18	Black Diamond	100[3]	2.4	...	...	...	Fuse and caps	..
		53	Chain	6	...	18	Carbonite	100[3]	2.4	3	6	2¼	Fuse and caps	..
		54	Chain	6	165	18	FF	100	1.8	3	6	1½	Squibs	60
		56	Chain	5	125	18	F	48	3.6	5	4½	2¼	Squibs	41

[1] Figures supplied by operators.
[2] 55 over 1½ inches.
[3] Per 25-pound box of permissible explosives.

TABLE 14.—*Continued*

District	No. seam	No. mine	Kind of undercutting machine	Depth of cut in feet	Tons of coal per machine per shift	Height of snubbing	Size of powder	Tons of coal per 25-pound keg of powder	Powder cost in cents per ton of coal	No. holes per round	Length of holes in feet	Diameter of holes in inches	Shots fired by	Per cent of coal over 1½ inches[1]
VI		57	Chain	6	125	18	FF	75	2.3	4	5½	2	Squibs	65
		58	Chain	6	150	18	Carbonite	110[2]	2.2	3	5½	2	Fuse and caps	..[3]
		59	Chain	6½	150	18	FF	75	2.3	3	6	2¼	Fuse	60
		60	Chain	6	125	18	FF	60	2.9		6	2¼	Fuse	60
		62	Puncher	5½	70	24	F	65	2.9	3	5½	2	Squibs	..
		63	Puncher	5	...	24	F	80	2.2	5	4½	2¾	Squibs	..
VII	6	66	Puncher	5½	65	..		...	...		5½	..		
			Chain	7	140	30	F	175	1.0	3	7	2	Squibs	..[4]
		68	Puncher	5½	80	12	F	157	1.1	4	5	2	Squibs	73
		70	Puncher	5½	65	24	C	111	1.6	4	5	2	Squibs	70
		71	Chain	5½	150	18	C	110	1.6	6	5	2	Fuse	70
		72	Chain	7	127	18	C	132	1.3		6	1½	......	75
		73	Chain	7	195	18	C	190	0.9	3	6	2¼	......	72
		74	Chain	7	150	15	C	100	1.8	5	6	2¼	Squibs	75
		76	Chain	6	150	18	C	90	2.0		5½	1¾	......	74
		77	Chain	6	125	18	F and C	100	1.8	3	6	2	Squibs	71
		78	Puncher	5½	80	18	F	110	1.6	5	5	1½	......	75
		79	Chain	6	120	18	F and C	114	1.5	3	6	2	Squibs	71
		82	Puncher	5½	70	18	F	124	1.4	4	5	1½	Fuse	72
		83	Puncher	5½	70	20	FF	70	2.5	3	4½	1¾	Squibs	70
		84	Puncher	5½	70	20	FF	112	1.5	3	5	1½	......	72

[1] Figures supplied by operators.
[2] Per 25-pound box of permissible explosives.
[3] 58 per cent over 2 inches.
[4] 79 per cent over ¾-inch.

TABLE 14.—*Continued*

District	No. seam	No. mine	Kind of undercutting machine	Depth of cut in feet	Tons of coal per machine per shift	Height of snubbing	Size of powder	Tons of coal per 25-pound keg of powder	Powder cost in cents per ton of coal	No. holes per round	Length of holes in feet	Diameter of holes in inches	Shots fired by	Per cent of coal over 1½ inches[1]
VII		86	Chain	6	...	18	C	50	3.5	4	8	2	Squibs	..
		87	Chain	6	100	18	C	100	1.8	3	5	2	Squibs	70
		88	Puncher	5	70	18		50	3.6	...	...	...		
			Chain	6	130	20	F	100	1.8	2	4½	1½	......	65
		89	Chain	6	...	30	F	89	2.0	3	5	1¼	Fuse	65
		90	Puncher	5	...	20	F	38	5.1	3	4½	2¼	Fuse	70
VIII	6 and 7	93	Chain	6	...	18	F	120	1.5	...	6	2½	Fuse	65
Averages by districts														
II	2			5	93	18		123	1.5	3	5	2¼		63
IV	5			5¾		18		48	3.8	...	6	2½		68
V	5			6	144	19		111	1.6	...	5	2		70
								120[2]	...	...	...	...		...
VI	6			5¾	120	19		70	2.4	4	5½	2		61
VII	6			6	110	19		108	1.9	4	5¾	1¾		71
VIII	6 and 7			6		18		120	1.5	..	6	2½		65
Average of 43 mines.				5½	118	19		101	2.1	3	5½	2¼		67

[1] Figures supplied by operators.
[2] Per 25-pound box of permissible explosives.

the drill-runner. The operator of this mine states that on account of the differential in wage scale he finds no advantage in the use of power drills.

Hydraulic mining machines have been tried in one or two districts but the machines did not perform successfully on account of the strength of the coal and the lack of cleat.

There are used in blasting coal annually in Illinois about 32 million pounds of black powder and about one million pounds of permissible explosives. The standard sizes of black powder according to the Revised Mining Statutes of Illinois are the following:

Name	Size in inches
CCC	Through 40/64; over 32/64
CC	Through 36/64; over 26/64
C	Through 27/64; over 18/64
F	Through 20/64; over 12/64
FF	Through 14/64; over 7/64
FFF	Through 9/64; over 3/64
FFFF	Through 5/64; over 2/64

The larger the grain, the slower combustion proceeds and the slower does the force of the explosion develop. The sizes in ordinary use in Illinois range from CC to FF. In a comparatively soft material like coal it is obvious that FF, a "quick" powder will have a greater shattering effect than the coarse-grained CC which rends more than it shatters. With a quick powder too much slack coal is made, but since the gross-weight law went into effect FF is the favorite powder with the miners. The waste of lump coal resulting from its improper use in too large quantities has been very great. This is especially true in undercut coal where the size of the powder is usually too small and the weight of the charge too great. With explosive gas in quantities large for Illinois and with an explosive dust the use of a long-flame explosive in Districts V and VI should be abandoned. Nearly every mine in these districts has had one or more fires and explosions caused by the flame of black powder igniting feeders of gas near the face. As tested in an unyielding steel cannon the flame of black powder will extend more than three times as far into the open air as the flame of an equivalent shot of permissible explosive, and in coal, owing to the quick action of the permissible, the drill hole will be enlarged and in many cases the flame will not emerge from the hole. In order to ignite inflammable gas and dust mixtures a high temperature acting through a certain length of time is necessary. The flame temperatures of all explosives are higher than is necessary to ignite these inflammable mixtures, and the duration of black powder flame is much longer than the minimum for an ignition. The flame of permissible explosives in proper charges properly detonated is of such short duration that it does not ignite these mixtures. The quantity of permissible used for a shot should not exceed 1½ pounds.

In Illinois only nitroglycerin powders are used. They contain free water or an excess of carbon for the reduction of flame temperature and usually contain salts that decrease their strength and shattering effect. They detonate easily and are very little affected by moisture. The explosive is usually purchased in cartridges 6 to 8 inches long and 1¾ inches in diameter. In one mine a test showed that 25 pounds of a permissible gained 180 tons of coal and 25 pounds of black powder 91 tons. Permissible explosives are, therefore, cheaper for the miner, as 25 pounds of black powder cost $1.75 and 25 pounds of a permissible explosive $2.45. It is generally supposed that a permissible explosive with its greater shattering effect gives a larger per cent of slack coal. This depends in a great measure upon the manner in which it is used and the physical characteristics of the coal. Used properly a permissible does not make more slack.

The use of permissibles is fortunately increasing in Districts V and VI. The amount used in Illinois during the last four years is, as given in the Coal Reports of Illinois:

Year	No. pounds of permissible explosives used
1911	243,099
1912	328,075
1913	603,420
1914	930,596

A Co-operative Bulletin by J. R. Fleming, U. S. Bureau of Mines on "The Use of Permissible Explosives in the Coal Mines of Illinois," will soon be published.

In 90 per cent of the examined mines which shoot off the solid shots are fired with fuse but in mines undercutting the

coal 60 per cent of the shots are fired with squibs. In District IV shots formerly were fired by squibs in the mines examined but as numerous accidents occurred through miners or shot-firers returning too soon to the face to discover the cause of missed shots fuse was substituted.

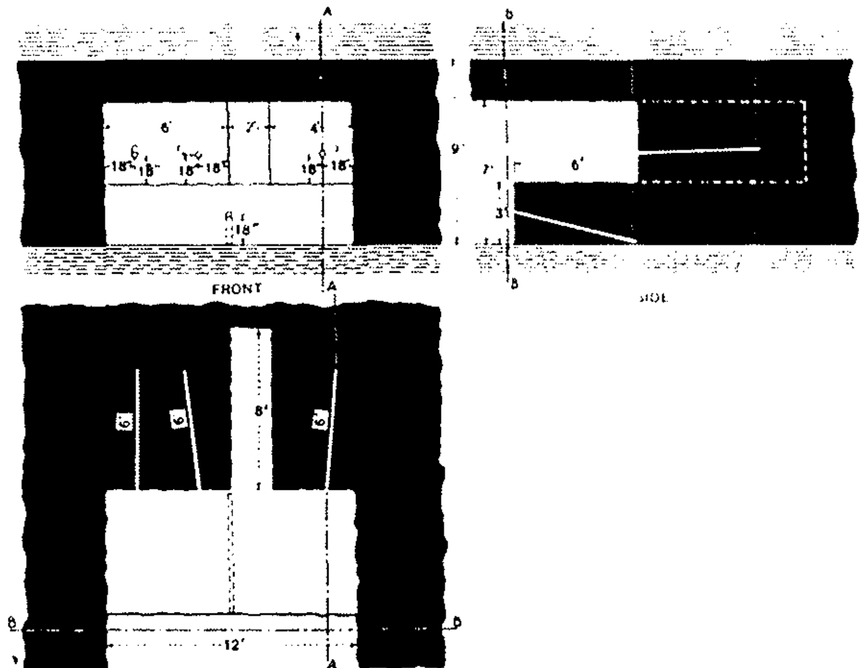


FIG. 35. Method of shooting with two benches

With fuse and squibs in black powder and with fuse and caps in permissibles about 1 per cent of the holes misfire.

Fireclay makes good tamping but it is easier to use bug dust, that is pick or machine cuttings, for filling dummies than to dig clay from the floor. Bug dust is often used for tamping although its use is forbidden by the State law. The usual custom throughout the State is to use 2½ feet of tamping in holes charged with black powder or permissibles.

To blast without shot-firers or in mines not free from gas in Illinois requires the restriction of the weight of a charge of black powder to two pounds. In many cases this restriction is not observed. By relying on large quantities of powder per round the miners are becoming less skillful in placing their shots. At one mine where two men were killed by a blown-out shot a drill hole was measured eleven feet in length and three inches in diameter. At many mines the number of tons of coal gained per keg of powder has decreased from 25 to 16 since the introduction of shot-firers. The miners drill longer holes and put in heavier charges when they do not fire their own shots and when consequently they are not exposed to the danger resulting from blown-out shots. The excess of powder above that necessary to bring down the coal shatters it producing an unnecessary amount of slack, cracks the roof increasing the danger of accident from roof-fall, and causes fires at the face.

Carelessness in filling cartridges is common. The men can see better with their lamps on their caps than when their lamps are at the required distance from the cartridge. Occasional explosions of powder while the miner is opening the metal keg with a pick emphasize the danger of this general custom. In District VI much of the powder is purchased in paper kegs but in other districts the metal keg is preferred.

For the transportation of powder from the top to the partings, special cars have been built at some mines. Several explosions of powder during transport in the last two years resulting in loss of life and partial wrecking of the mines emphasize the need of specially protected cars for the delivery of powder to the face.

Fires at the face after shooting are frequent in Districts V and VI at mines where black powder is used and at these mines fire-runners are employed to inspect the blasted coal after shooting. In some mines 20 to 30 fires start after each shooting. There are no fires after shooting with permissibles.

TIMBERING

The difference in mining methods between the longwall and room-and-pillar systems makes it impossible to compare timbering in District I and the other districts consequently timbering in District I (Longwall) will be discussed separately.

TIMBERING IN LONGWALL MINES

The continued settling for a considerable period of time of the strata overlying the coal in longwall mines makes tim-

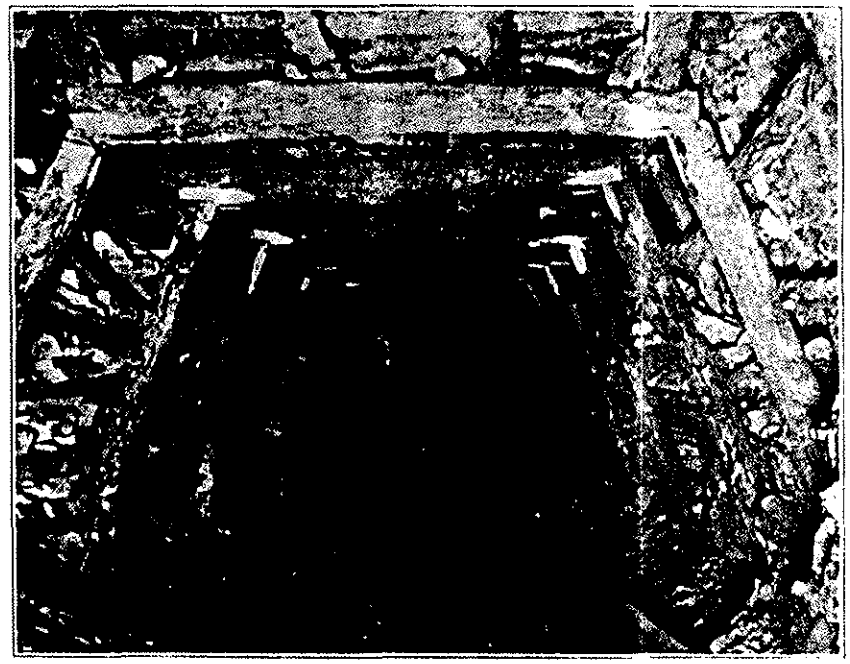


FIG. 36. Entry closely timbered in longwall mine

bering of roadways difficult and expensive. Permanent timbering can be extended only to that point where the first rapid and violent settling has ceased, and it is not usual to extend permanent timbering to any point until the face has been advanced beyond it for at least two years. Roof breaks destroy the cohesion of the shale and large masses of rock must be supported by timber so that the collars of the three-piece gangway set must be heavier than those ordinarily used in room-and-pillar entries. For usual timbering with ordinary roof conditions an 8-inch cross bar is supported by 6-inch legs. The legs are battered 1½ inches for each vertical foot between rail and cross bar. Under bad roof the entry is usually closely timbered as shown in fig. 36. The frames in this illustration have white oak legs 8 inches in diameter and 10-inch white oak cross bars. These frames are spaced on 6-foot centers, and the top and sides of the entry are lagged with split and round props 4 to 5 inches in diameter.

When it is necessary to support the increased area of roof resulting from turning off a cross entry from the main entry, or from turning rooms from a cross entry, cogs called "branch cogs" are built with props. These cogs are filled to two-thirds of their height with waste rock and mining dirt. They are not completely filled because it is necessary to allow for settling of the overlying strata which crushes the cog as the weight comes on it. A cog built 4 feet high above the floor will in 18 months be crushed to a height of but 18 inches above the floor. If cogs were entirely filled with waste rock and dirt they would offer too much resistance to roof subsidence and the roof would "cut" at the cog. This roof caving would increase the danger of accidents from roof falls and would add to clean-up expense.

Article V of the Third Vein District Agreement states: "The price for turning a room where the company does the brushing and builds the cog shall be $5, and where the miner does the brushing and builds the cog the price shall be $8.747, the company to have the option of method." Besides the branches at entry and room junctions two other wide roof areas must be supported, that is, the shaft bottom and the lyes, called partings in room-and-pillar mines. In this district the timbering of the bottoms does not generally differ from the timbering of the bottoms in room-and-pillar mines. The roof is supported by props alone, by timber-sets, by

masonry, or by steel I-beams. In one mine in which pillar coal was removed, after roof and floor met the bottom was widened and timbered with 10 by 12-inch frames spaced on 4-foot centers and lagged with 3 by 12-inch planks. No trouble from roof cutting has ever been experienced in this mine.

In a few mines the inner lyes are in abandoned rooms but generally the lye is formed by widening the entry at the desired location. The usual width of a lye, as shown in fig. 37, is 14 feet. Ten-inch collars and legs are used for the tim-

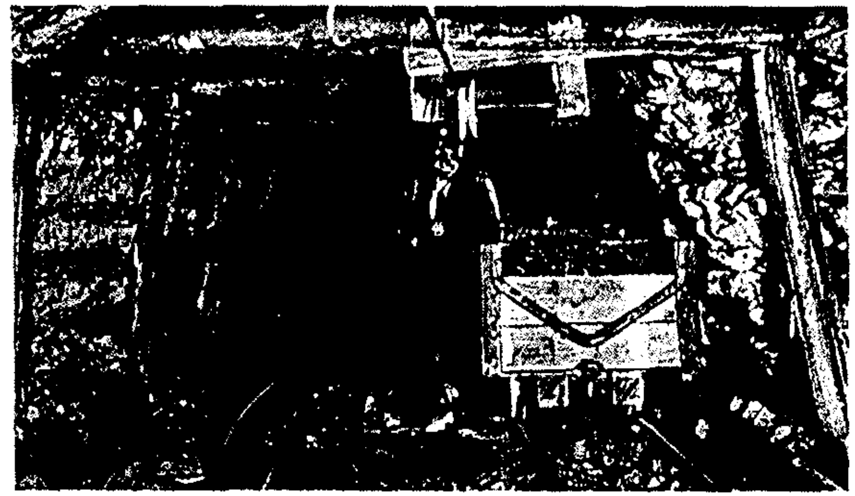


FIG. 37. A typical lye in a longwall mine

ber sets which are spaced 6 feet apart. The lye in fig. 37 is 75 feet long and provides storage for 13 cars on each track.

Where a soft wet fire clay several feet thick underlies the coal it is sometimes necessary to build short cogs as a foundation for the legs of the frames in the lyes. A cog of 4-inch props is usually constructed 3 feet high and 4 feet square. On the top of this cog, a 3 by 12-inch plank 4 feet long is placed. The bottom of the leg rests in a notch cut in this plank. As the roof weight settles on the frames the cog is pushed into the clay and the settling is gradual and continuous.

The high temperature of the return air current in longwall mines is very favorable to fungus growth. The heavy and expensive entry timbers on the return fail through decay in from 2 to 4 years. In one mine preservative treatment is given to the timber used on the main roads. At this mine the life of an untreated white-oak collar averages two years on the intake and less than one year on the return. Treated timbers have already been in service on the return for three years without sign of decay. The timbers to be treated are peeled and sun-seasoned. Before taking them underground they are painted with a heavy coat of carbolineum. The cost of labor and carbolineum for treating two legs 7 feet long and 6 inches in diameter, and one collar 6 feet long and 7 inches in diameter, is 16 cents. The cost of the untreated timbers is 45 cents.

The cost of timbering in longwall mines where conditions of roof and floor are so widely different varies with each mine. Total cost of timbering varies from 5 to 8 cents per ton of coal mined. At that mine in which the total cost of timbering was 8 cents, the cost of face props was 6 cents per ton of coal mined. A mine producing 1,450 tons a day employed 8 day-timbermen and used daily 1,500 props, 70 cross bars 7 feet in length, 50 bars 8 feet in length, and 2 bars 10 feet in length. Props 3½ or 4 inches in diameter are usually bought. From ½-cent to 1 cent per linear foot is paid for props and the number used per ton of coal mined varies from 1½ to 3.

TABLE 15.—*Cost of mine timbers in District I*

Length Feet	Diameter Inches	Average cost Cents
6	8	15
7	8	16
8	10	80
10	10	125
14	12	190

The expense of cross bars increases rapidly with increased diameter and length of span. Table 15 gives average cost in the longwall district of mine timbers of various diameters and lengths. These figures do not include the cost of placing in position but refer only to the timbers as piled on the surface.

ROOM-AND-PILLAR TIMBERING

Timbering in unmodified room-and-pillar and panel mines in Illinois is characterized by excessive waste in spite of the steadily decreasing timber supply and constantly increasing cost of mine timber. Generally no attempt is made to save room props by pulling them after rooms have holed through and props are abandoned even though they could easily be

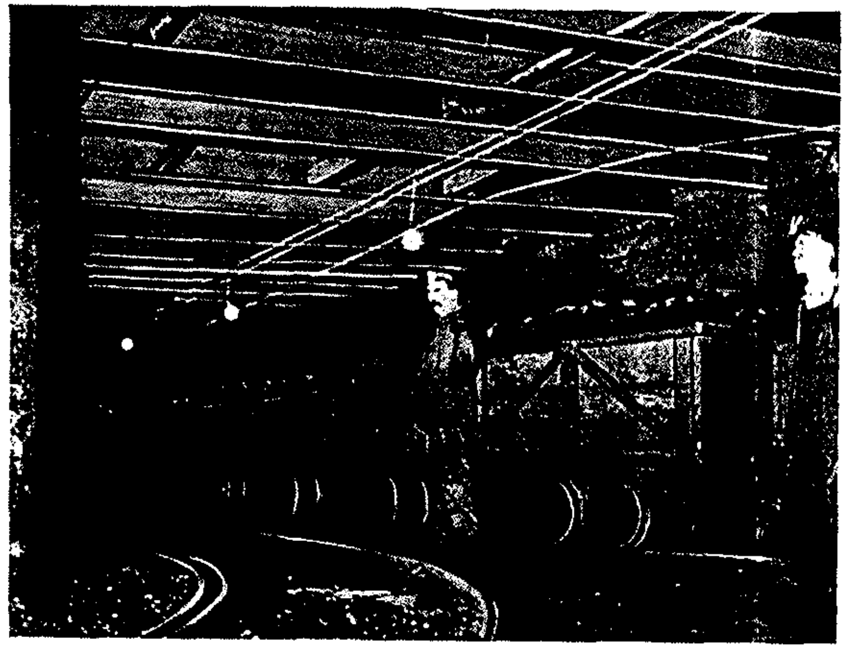


FIG. 38. Shaft bottom with roof supported by steel I-beams set on concrete walls (photo by R. Y. Williams, U. S. Bureau of Mines)

pulled at small cost. The high cost of white-oak props of standard 4½-inch diameter for lengths up to 5 feet has led to the false economy of buying props of poor quality and smaller diameter. This is especially true in District V where many operators buy shipments in which less than one per cent of the props are white-oak, the remainder consisting of red oak, water oak, elm, hickory, sassafras, and hemlock with an average prop diameter of only 3½ inches at the small tip.

At very few mines is preservative treatment given permanent timbers, and these mines are principally in District IV. At one time in this district where loss by decay has been heavy timbers are treated with one gallon of creosote per cubic foot. Untreated round, white-oak timbers with a small end diameter of 10 inches cost 10 cents per running foot. The treated timber at the pit mouth costs 17 cents per running foot. At two mines in District IV carbolineum is used; at one where crossbars have broken after decay the timbers of all new sets are treated with it; at the other, it is being used on new shaft sets.

In the newer large mines in the State where there is a heavy roof load with frequent failure of timber crossbars steel I-beams are substituted for timber. Steel is not used to any extent for roof support in Districts II and III but it is used extensively in District VI, in several mines in Districts IV and VIII, and in a few in Districts V and VII. The standard I-beam of structural steel which combines a high degree of resistance to bending with minimum weight of metal has proven well fitted for use in mines. Steel I-beams can often be purchased at second hand from the wrecking companies in the large cities for a cent a pound. An average estimate for new I-beams in place is 3 cents per pound including labor cost. Where much rock work must be done the cost is higher. At a mine in District IV where considerable rock work was necessary in placing sets an entry-set composed of a 10-inch 35-pound steel I-beam 16 feet long on 8-inch white-oak legs costs approximately $20.00 in place. The cost of setting timber and steel collars is about the same. The standard relation in Illinois between span and diameter of round white-oak crossbars or size of steel I-beams is:

Span in feet	Diameter of round white-oak timbers in inches	Size and weight of Steel I-beams
8	6	10½ pound; 4-inch or 18 pound; 8-inch
10	7 or 8	17¼ pound; 6-inch or 18 pound; 8-inch

Span in feet	Diameter of round white-oak timbers in inches	Size and weight of Steel I-beams
12	9	18 pound; 8-inch
14	10	40 pound; 8-inch
16	12	40 pound; 8-inch or 52 pound; 12-inch
18	14	52 pound; 12-inch or 70 pound; 18-inch

With this relation frames are usually spaced on 2½-foot centers. Eight-inch diameter rough white-oak legs are used with spans of 8 and 12 feet and 10-inch legs are used for

FIG. 39. Inby end of concrete-lined bottom

greater spans. It is not certain that for entry timbering steel legs are economical. The cost in place of a 4-inch 28-pound steel leg 6 feet long is approximately $5.00. An 8-inch round white-oak leg 6 feet long costs about 80 cents at the pit mouth. Inasmuch as sets fail in the crossbars when not subjected to lateral presure and the labor cost of replacing a leg is small the use of steel legs may entail an unnecessary expense.

Old railroad and streetcar rails are used as crossbars in Districts IV, VI, VII and VIII. Old rails have been purchased in one district for $12 per ton. When bought for roof support their weight varies from 50 to 75 pounds per yard. In District VIII 60-pound rails used as crossbars failed under the roof weight. No rail lighter than 70 pounds per yard should be used under heavy roof presure and even heavy rails are inferior to I-beams because their carbon content is high causing them to break more easily than the I-beam and their section is not adapted to the purpose.

Shaft bottoms at many mines in all districts are crudely timbered usually with 16 to 24-inch framed 3-piece sets carry-

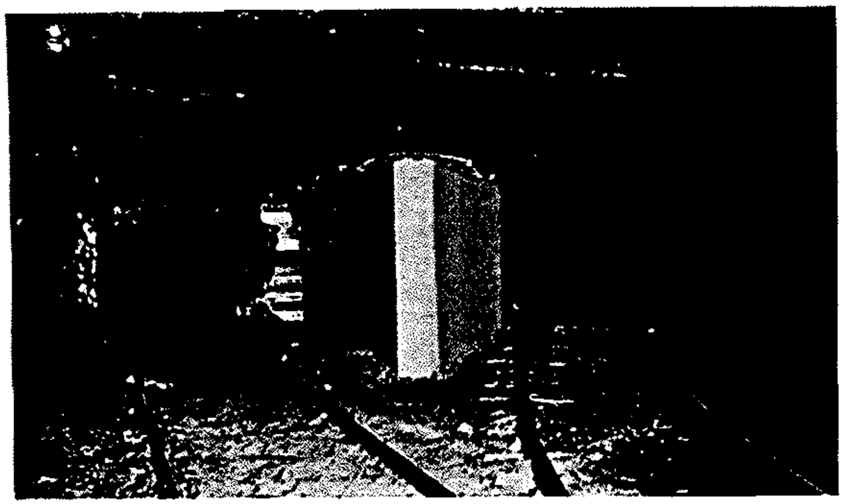


FIG. 40. Solid concrete pier at branch

ing 2-inch lagging or with round timber legs and crossbars. Steel in nearly all new mines is being used for roof-supports at shaft bottoms.

Concrete in all large mines is coming into general use as a substitute for close or massive timbering as at shaft bottoms or at pillar points at partings. Fig. 38 shows a shaft bottom at a mine in District VI where the roof is supported by steel I-beams resting on concrete walls and fig. 39 shows the inby end of a shaft bottom in District VIII which is lined throughout with concrete. The walls of the lining are 24 inches thick at the bottom and the thickness of concrete is

gradually reduced till at the crest of the arch it is 12 inches. A gob filling is packed between the arch and the roof. The length of concrete bottom on each side of the shaft is 165 feet. The concrete was made in the following proportions: 1 Portland cement; 1 sand; 4 washed gravel. Proportions for concrete which are frequently used for massive work are: 1 Portland cement; 1 washed sand; 4 sifted cinders. Fig. 40 shows the point of the pillar at a cross entry in a mine in District VI. The coal pillar is cut back 20 feet and the roof at the point is supported by a solid concrete pier. The chief object in removing the coal at pillar points and building brick

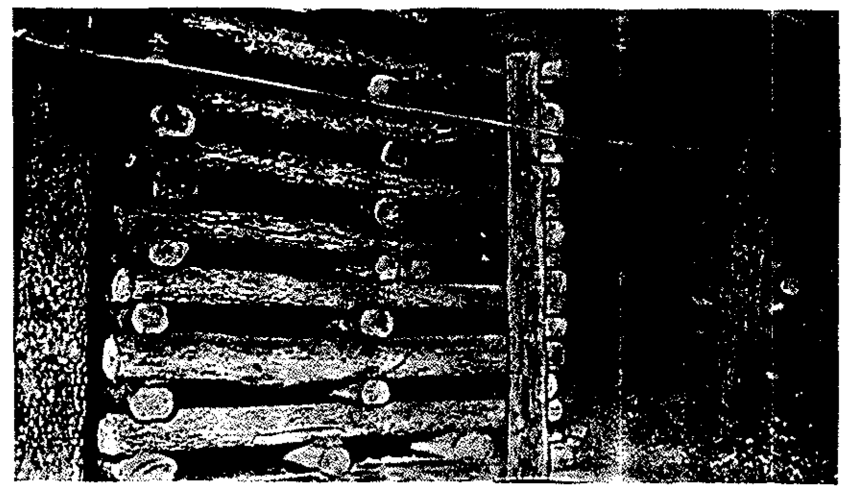


FIG. 41. Cog timbering at parting

or concrete piers is to provide a substantial roof support which will not be knocked away if hit by a trip which happens to leave the track when rounding the curve.

In a few large mines other than longwall timber is used instead of concrete where a large bearing surface is desired. At one mine where wide partings are built the roof is supported by cogs 8 feet square built of 6-inch props, as shown in fig. 41. These cogs are not filled with gob and are weaker than filled cogs used in longwall mining in Illinois.

In entries in nearly all mines the support under bad roof is the 3-piece entry set, either with two long legs, with one leg short and the other long or with two short legs resting in latches cut in the ribs. Where a curve occurs in the entry the short-legged frames are commonly used because a trip which jumps the track is likely to break the legs of long-legged frames and bring down bad falls. Fig. 42 shows the methods of leg arrangement in the three-piece entry set. In District V hundreds of feet of entry with bad roof are supported by props alone and sets are seldom used at any of the mines examined. The quality of timber is poor and the three-piece gangway set when used is generally constructed of split room-props of small diameter.

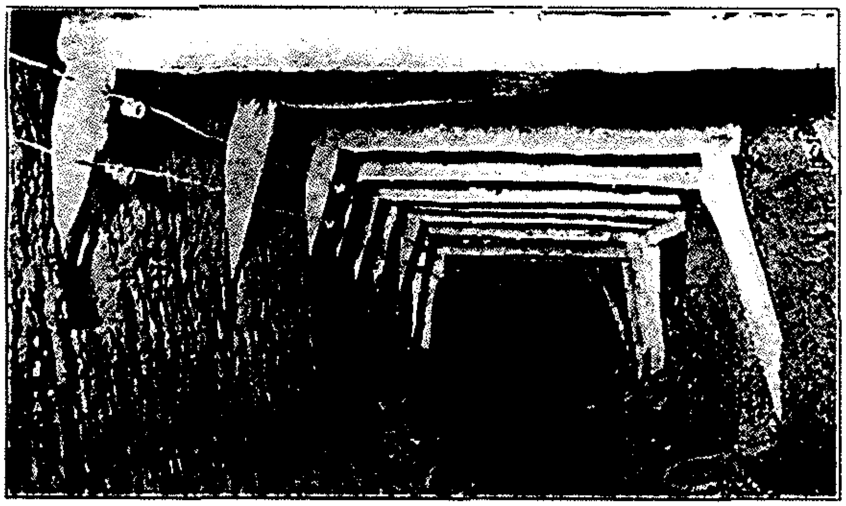


FIG. 42. Timbering in haulage entry

It is to be expected that where roof conditions are so varied as in the eight districts of Illinois different types of timbering will be found. The roof may require no timbering or there may be an alternation of "rock top" and clod as shown in fig. 43. Where the transition from limestone roof to clod is abrupt it is productive of many accidents from roof falls. At a mine in District VII there is a thick shale deposit overlying the coal and the roof on both sides of the shaft caved to a height of 42 feet from the floor. This cave extended 110 feet along the main entry. Fig. 44 shows the method of timbering the entry in the caved area. The frames shown were set on 4¾-foot centers.

In many of the mines examined in Districts II, IV, VI, and VII top coal was left where the immediate roof over the coal was thick black shale. Top coal prevents variations of temperature and humidity from affecting the shale of the roof proper, which spalls badly when exposed to the air. As a rule where no top coal is left the shale falls with the coal or is drawn. Where there is less than four inches of shale between the coal and the cap rock it is drawn. Where the shale is over 4 inches thick it is propped in some mines, but in others it is drawn unless it is over 2 feet thick.

FIG. 43. Alternation of good and bad roof

In District II where the two benches of the bed are united and the coal is over 6 feet thick, top coal is left up in entries and the roof is arched. In this district no timber is used in entries under top coal except where it is broken by slips. Where the lower bench only is mined the roof is supported by three-piece timber sets having 8-inch crossbars and 6-inch legs. White oak is generally used for entry timbering.

In rooms in Illinois the variations in propping are as wide as are those in entry timbering. The roof may be limestone or hard shale requiring no propping or top coal may be left or the roof may be clod with such slight cohesion that it breaks at the prop or it may be black shale so difficult of support that it requires cross-bars on props.

A mine prop is supposed to have one inch of diameter for each foot of length but this relation seldom obtains, the diameter usually being less than in this ratio. The cost of props increases rapidly with increasing length and the prevailing prices in Illinois are:

Length in feet	Cost in cents per prop
4½	4½
5	5
5½	6½
6	10
6½	13
7	17
8	25
9	30

At each mine examined several rooms were chosen as typical and inspected carefully. The width of a room was measured and the number of props in place counted in a measured length. From these data the number of props per 100 square feet of roof was calculated. Table 16 gives figures concerning props in rooms for each mine and average number and cost of props per 100 square feet of roof for each district.

Dicipline at the face is lax and in every mine examined rooms under dangerous roof were found in which the nearest prop to the face was 20 feet distant from it and in many mines the distance was over 50 feet. No man under shale roof should be allowed to work 20 feet ahead of his last prop. Many miners will not use sufficient care in propping unless compelled to do so and the greatest need for safer mining is more face bosses. In Districts V and VIII this need is especially apparent. It is difficult to understand the opposition to a provision in the State Mining Law for a fixed number of face bosses for each hundred men employed.

In rooms in District V the number of props is inadequate for safe roof support and the miners are not compelled to keep their props close to the face. In District VIII the necessity for close propping is obvious because the numerous

TABLE 16.—*Data on props in rooms*

District	No. mine	No. per 100 sq. ft. of roof	Cost in cents per 100 sq. ft. of roof
	12	6.6	26.4
II	13	4.8	33.6
	14	7.5	33.8
	15	5.5	38.5
	17	Few props except at clay veins	
	18		
III	19		
	22		
	24		
	25	3.7	16.7
	26	5.4	25.2
	27	3.7	17.2
	28	...	....
	29	...	....
	31	6.5	30.0
	32	4.0	20.0
	33	2.8	16.8
IV	34	...	....
	35	...	....
	36	2.6	26.0
	37	2.8	18.2
	38	1.6	8.8
	39	1.1	10.0
	40	2.4	14.4
	41	...	....
	42	...	....
	43	5.7	51.3
	44	2.5	20.0
V	45	1.6	9.2
	46	2.4	12.0
	47	2.3	20.7
	48	2.7	16.5
	49	5.1	30.6
	50	2.3	32.2
	51	2.2	17.3
	52	4.0	29.0
	53	0.9	7.9
	54	5.5	41.3
	55	2.7	24.3
	56	4.7	34.1
VI	57	No props in rooms	
	58	2.8	21.0
	59	4.0	34.0
	60	2.2	29.7
	62	2.0	16.0
	63	3.0	21.0
	64	2.5	21.9
	65	2.4	21.0
	66	6.0	72.0
	67	2.7	27.0
	68	2.7	42.3
	69	2.0	16.0
	70	6.0	54.0
	71	5.0	50.0
	72	...	....
	73	...	....
	74	...	....
	75	1.8	25.2
	76	...	....
	77	4.0	64.0
VII	78	4.0	42.0
	79	2.4	33.6
	80	...	....
	81	...	....
	82	7.2[1]	70.3
	83	5.0	40.0
	84	5.0	70.0
	85	1.3	11.7
	86	1.9	10.5
	87	5.0	32.5
	88	5.0	30.0
	89	2.8	19.6
	90	2.6	18.2
	91	3.1	20.9
	92	8.1	44.6
VIII	93	3.1	24.8
	94	7.6	41.8
	95	5.0	37.5
	97	6.3	44.1
Average by districts			
II		6.1	33.0
III		...[2]	....
IV		3.4	18.5
V		3.2	22.9
VI		2.9	25.0
VII		3.8	38.4
VIII		5.5	35.6
All mines examined		3.7	29.3

[1] Including cross bars.
[2] Few props except at clay veins.

"niggerheads" or "sulphur-balls" which protrude from the roof have little cohesion to the roof shale.

The cost of props per ton of coal and the total timbering cost per ton of coal are difficult to ascertain on account of the

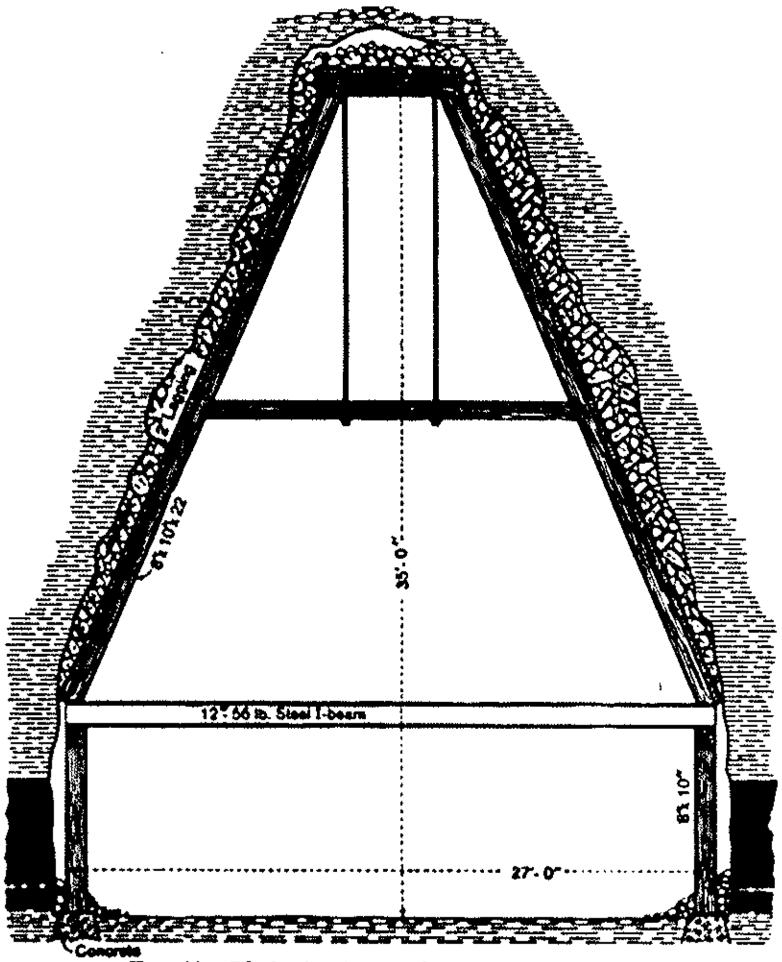


FIG. 44. Timbering in caved area in District VII

different segregations of cost items at mines in the State. The number of props purchased per ton of coal varies from 2 to 12 depending upon roof conditions. The figures as supplied by operators for cost of props vary from ½-cent to 2

cents per ton and the total timbering cost from 1.5 to 6.5 cents.

Depth of cover and system of mining in mines other than longwall seem to have no effect in the amount of timbering necessary. The character of the immediate roof is the chief factor in determining whether little or much timbering shall be done.

ACCIDENTS

In the year ended June 30, 1912, only 7 accidents at coal mines in Illinois occurred on the surface. Dangerous roof insufficiently supported, the presence of explosive gas, non-enforcement of the State Mining Law, insufficient oversight of working places, and failure to clean the roadways are all reflected for each district in the number of accidents per 1,000 employees (Table 17). In District V there is explosive

TABLE 17.—*Accidents per 1000 employees*

	DISTRICT							
	I	II	III	IV	V	VI	VII	VIII
Fatal	1.0	0.0	3.6	1.2	5.8	2.6	2.3	4.5
Non-fatal	16.8	10.7	5.4	2.8	13.4	11.5	10.2	14.7
Total	17.8	10.7	9.0	4.0	19.2	14.1	12.5	19.2

gas with insufficient inspection of working face and a treacherous roof with scanty timbering. In District VIII the chief factors in the high accident record are the dangerous roof and failure to keep props close to the face. In District I miners do not put enough sprags under their coal or enough props under the roof at the face.

District IV has the best accident record in Illinois because it has a good roof and very little explosive gas.

In Table 18, District I with its very low production per underground employee and its high accident ratio produces the fewest tons per accident.

The causes of accidents to employees as given in Table 19 compiled from the Illinois Coal Report show the source of danger in each district. From an analysis of this table it is evident that the miner's place in all districts and especially in Districts I and VIII should be inspected more frequently each day to insure the proper placing of props and sprags; that a more efficient and frequent examination for gas should be made in Districts V and VI and in some parts of District VII; that the operators should be compelled to

TABLE 18.—*Tonnage per accident by districts*

	DISTRICT							
	I	II	III	IV	V	VI	VII	VIII
Tons per accident..........	24,194	62,513	51,218	170,478	44,642	73,350	64,711	43,824
Tons per fatal accident.......	419,362	......	128,044	568,260	148,275	316,564	362,172	187,469
Tons per non-fatal accident...	25,471	62,513	85,363	243,540	63,872	95,472	78,788	57,194

TABLE 19.—*Causes of accidents to employees*[1]

	PERCENTAGE BY DISTRICTS								
	I	II	III	IV	V	VI	VII	VIII	State
Causes of fatal accidents									
Fall of rock or coal..................	58.3	0.0	50.0	33.3	42.9	52.7	54.8	77.7	54.4
Pit car	16.6	0.0	25.0	33.3	10.7	23.7	24.2	5.5	18.8
Use of explosives....................	16.6	0.0	0.0	6.7	7.1	10.5	6.5	5.5	7.2
Gas explosions	0.0	0.0	0.0	0.0	32.1	2.6	3.2	0.0	6.9
Undercutting machines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Causes of non-fatal accidents									
Fall of rock or coal................	67.8	35.7	83.3	34.3	43.2	33.4	34.7	47.5	45.5
Pit cars	21.9	25.0	0.0	45.7	18.5	27.8	29.5	27.1	26.3
Use of explosives....................	1.0	0.0	0.0	5.7	4.6	1.6	3.1	5.1	2.6
Gas explosions	0.0	0.0	0.0	5.7	9.2	7.2	1.4	0.0	2.9
Undercutting machines	0.0	0.0	0.0	2.9	9.2	3.2	1.7	0.0	2.8

[1] Compiled from the Thirty-first Annual Coal Report of Illinois.

clean up the gob lying alongside the tracks which is a contributory cause of the numerous accidents from pit-cars in all districts, and especially in Districts IV, VI and VII.

There seems to be no relation between percentage of coal undercut and number of accidents.

The causes of accidents in Illinois are much the same as in other coal mining states. Attention has been called repeatedly to them in the reports of the State Mine Inspectors and they are covered by provisions of the Illinois Mining Law and the agreement between the operators and miners but throughout the State the enforcement of the State Mining Law is lax and its provisions are frequently disregarded. Hay is taken to the underground stables in open

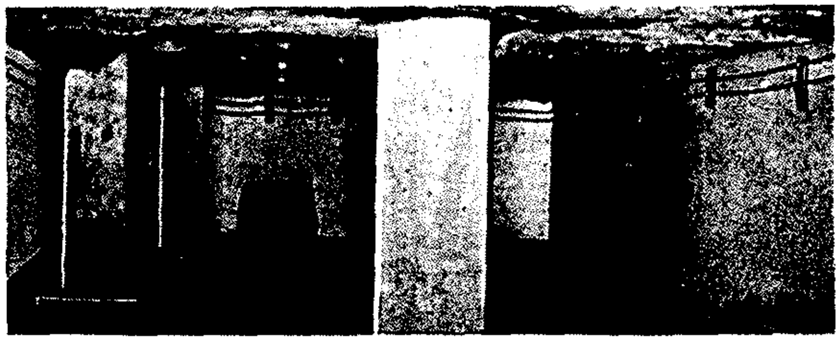
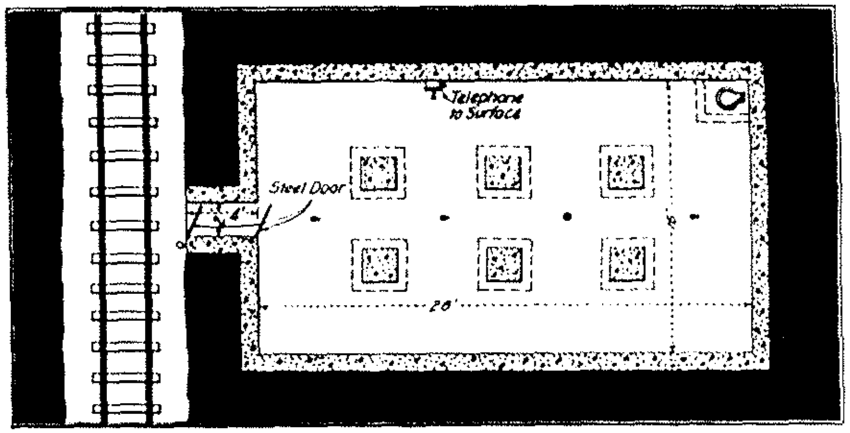


Fig. 45. Photograph of underground refuge chamber

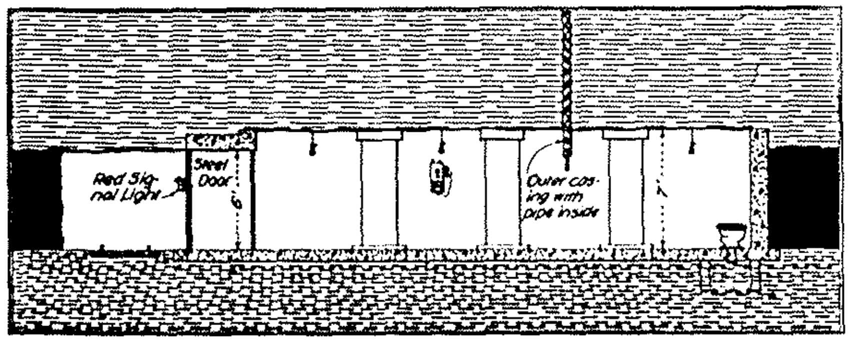
cars, open lights are taken into the stables, powder is handled carelessly in transportation and is stored underground in greater quantity than is allowed by law, powder kegs are opened with picks, cartridges are filled while the miner's open lamp is on his cap, dummies are filled with "bug-dust," and gob is kept so close to the track that in some places the hubs of the pit-car wheels touch it in transit. The injuries and fatalities in Illinois will not lessen until stricter enforcement of the common-sense provisions of the State Mining Law is compelled by mine inspectors, operators, and miners.

The Peabody Coal Company in its Peabody mine at Sherman in District IV has prepared an underground refuge chamber in its mine so that if the miners are imprisoned

through any cause they may have a safe place of retreat where communication with the surface can be maintained. This refuge chamber, shown in fig. 45, a photograph of the interior, and in fig. 46, a sketch showing the method of con



Plan



Longitudinal Section through Center

Fig. 46. Sketch of underground refuge chamber

struction, is lined with concrete and closed by an air lock protected with steel explosion-proof doors. A hole 8 inches in diameter is drilled from the surface into the chamber which is 7 feet high, 28 feet long, and 16 feet wide. The shale roof of the chamber is supported by six concrete pillars two feet square. An empty powder can placed in the mouth of the drill hole shows its position in fig. 45. Through the drill hole fresh air can be pumped to the chamber and supplies can be lowered. Refuge chambers in coal mines are an admirable precaution and at least two should be built in every mine, particularly in mines in southern Illinois in which explosive gas and dust are found.

The state of Illinois has provided three Mine Rescue Stations at which crews are maintained for rendering assistance in case of explosions or mine fires. A number of mining companies also maintain rescue and first aid crews and equipment.

PER CAPITA PRODUCTION OF EMPLOYEES

The factors which enter into the total amount of labor necessary to produce the tonnage of each district are: Nationality of employees, thickness of seam, system of mining, percentage of tonnage undercut, character of roof, daily tonnage of mines, and the extent of preparation of coal for market.

In analyzing Table 20 which contains data on daily per capita production of employees it is noticeable that District I, the longwall district, produces only 2.1 tons per day per employee and only 2.8 tons per day per face worker. This low production is due partly to the method of mining but principally to the thin seam which in this district averages 3 feet, 2 inches in thickness. Longwall mines in District IV in a seam 4 feet, 8 inches thick average 3.5 tons a day per employee and 4.2 tons a day per face worker. It takes the same amount of labor at the face in longwall mining to gain a slice of coal 3 feet, 2 inches thick as to gain one 4 feet, 8 inches thick.

In Districts II and III the mines are all small and the average number of tons a day per face worker is high because in District II almost all the coal is undercut and in both districts the labor is chiefly American, English, and Scotch and the coal is easily mined. In Districts IV, V, VI, VII, and VIII, in which the mines are of larger capacity, the percentage of undercut coal is the chief factor in high per capita production although the number of men employed in rescreening plants and washeries, thickness of seam, and the nationality of employees are minor factors in Districts VI, VII, and VIII.

The coal mining industry is now in a critical condition in Illinois. The principal cause of the present depression is that it has been too easy to open a mine. The Mining Investigation Commission of the State of Illinois in its report to Governor Charles S. Deneen, March, 1911, said:

"The number of shipping mines in Illinois is greatly in excess of the number required to supply the maximum demand for Illinois coal. This has resulted in the actual annual aver-

TABLE 20.—*Daily per capita production of employees*[1]

District	Production in tons for the year	Total no. employees	Underground employes per each surface employe	Tons a day per each surface employee	Tons a day per each underground employee	Tons a day per each face worker[2]	Tons a day per each employee	Per cent of production mined by machine
I	5,032,346	11,631	10.7	26.9	2.4	2.8	2.1	0.0
II	500,102	750	6.7	33.0	4.9	7.3	4.3	95.9
III	512,178	1,119	6.9	26.7	3.9	7.6	3.4	1.9
IV	8,523,903	12,835	10.6	48.9	4.7	5.9	4.2	7.5
V	4,151,702	4,822	10.6	59.2	5.6	8.1	5.1	90.2
VI	12,029,450	14,562	9.2	50.4	5.5	7.6	5.0	53.3
VII	22,454,672	27,847	10.8	60.5	5.6	7.3	5.1	60.3
VIII	3,374,443	4,007	12.2	60.1	4.9	6.0	4.6	20.2
State as a whole	57,514,240	79,411	10.3	50.9	4.9	6.1	4.5	44.4

[1] Compiled from the Thirty-first Annual Coal Report for the year ended June 30, 1912.
[2] Shipping mines only.

age running time of all mines operating in Illinois for several years past being materially less than two hundred days per year. With a more reasonable adjustment of mining capacity to the greatest possible maximum demand (which is entirely feasible in so far as the commercial or physical considerations are concerned) it should be possible for the mines to be operated an average of at least two hundred and fifty days per year. The result of this condition is that all of the mine employees in Illinois (now about seventy thousand) are idle on an average at least sixty days per year more than need be if there were a reasonable adjustment of mining capacity to the fullest trade requirements.

Stated in another way, the entire force of mine employees is idle one-fourth of the time they should be able to work after making all allowance for unavoidable idle time. This has the same effect as though one-fourth of them were idle all the time. In other words, fifteen thousand men, in effect, are idle throughout the entire year, but held in the industry by the attraction of the excessive number of mines nominally in operation. This is an enormous economic waste."

On account of the lack of a uniform system of accounting it is difficult to make comparisons between the cost of similar operations in different districts and to adjust selling quotations for the different fields according to actual costs. The books of many operators do not segregate the cost items for different phases of mining operations so that the profit leaks can be discovered.

VENTILATION

The causes of mine-air pollution are: respiration of men and animals; gases from the use of explosives; fumes from miners' lamps; absorption of oxygen by coal and pyrites; exudation of gas from the seam; emanations from excrement; decay of timber; coal dust from mining operations, etc. These factors often combine to impoverish mine air and render it injurious to the health of the miners. The problem of preventing excessive pollution of the air is, therefore, very important.

The fundamental difference between the longwall system and the unmodified room-and-pillar and panel systems necessitates separate discussions of ventilation in longwall mines and in mines other than longwall.

VENTILATION OF LONGWALL MINES

The ventilation of mines operated on the longwall system presents few difficulties, and the problem of supplying air to the men at the working face is easy of solution. In room-and-pillar mining, the faces of the rooms, that is, the working places of the miners, are outside the direct flow of the air current except when the face of a room is at the point where a cross-cut is driven through the room-pillar. In

TABLE 21.—*Comparative temperatures in longwall and room-and-pillar mines*

Location	Mining system	Number of weeks of daily readings	Average temperature at bottom of intake air shaft, degrees F.	Average temperature at bottom of intake air shaft, degrees F.	Degrees of heating in passage through mine
Oglesby	Longwall	39	52.2	74.0	21.8
La Salle	do	47	58.3	76.9	18.6
Benton	Room-and-pillar	40	53.9	64.9	11.0
Glen Carbon	do	44	56.9	68.0	11.1
Average for longwall	Longwall	43	55.3	75.5	20.2
Average for room-and-pillar	Room-and-pillar	42	55.4	66.5	11.1

longwall mines the air current always flows along the working face, as shown by fig. 20. More physical discomfort is suffered by the longwall miners, however, because the temperature at the face of the longwall mines is greater than at the face of room-and-pillar mines. This is shown in Table 21 which gives return air temperature for mines under both systems.

This table shows that during passage through the workings of a longwall mine of average size the ventilating current undergoes an average rise in temperature of 20.2 degrees above that at the bottom of the downcast shaft. In a room-and-pillar mine of ordinary extent of workings the air current has its average temperature raised 11.1 degrees F. while passing through the mine. This average difference throughout the year of 9.1 degrees between the temperatures of longwall and room-and-pillar mines is largely because in the former a much smaller quantity of air with lower velocity passes over more men and lamps. Sometimes the gob fires in longwall mines increase the temperature. When mining is done in the clay under the coal few gob fires occur because then not much coal finds its way into the gob. Gob fires are more frequent where undermining is done in the coal because every condition necessary for spontaneous combustion is then found in the gob about 15 feet from the face. The necessary factors are:

Fine particles of coal.

Finely divided iron pyrites.

Moisture.

Air confined in the interstices of the gob.

Initial heat produced perhaps by roof pressure on the gob.

Where the gob is not heated to the point of combustion its temperature may be raised considerably by the oxidation of coal and pyrites. Because the presence of air is necessary for this process gob fires do not occur much farther behind the face than twenty feet as beyond this point the settling of the roof has packed the gob so tightly that air is excluded. That sufficient heat is developed by a few gob fires to bring about the increased temperatures at the longwall face is shown by a temperature reading of 84 degrees F. taken at the face 10 feet from a gob fire after the air current has passed the sealed-off fire, and by a reading of 73 degrees F. taken at the face 100 feet distant from the fire before the current has passed over it.

The cost of removing sulphur from the mine varies from ¾ to 1¾ cents per ton of coal mined. Fires in the gob of longwall mines are easily sealed off. The usual method is to build around three sides of a fire a solid wall of roof rock leaving the gob which has been packed by roof settling as the fourth side. A lining of fine sand is placed inside of the wall.

The sand is usually brought into the mine for this purpose and stored underground to be ready for immediate use when needed. Including cost of sand the expense of sealing off a small gob fire approximates $25. In some mines road dust instead of sand is used for sealing off fires and serves the purpose as well because road dust consists principally of inert shale pulverized by car wheels on the track and by the feet of men and animals on the roadways. If a fire occurs from 5 to 20 feet from the face between two rooms, it is reached in some mines by digging through the burning gob which is then loaded out if possible before sealing off is begun. This method of walling off is regarded as very efficient because the sand or road dust packs remain effective for at least two months and before the end of this period the fires are extinguished.

Very little marsh gas is found in longwall mines, although occasionally pockets are discovered in small sand deposits immediately above the shale roof. Wherever it thus occurs it is quickly diffused in the air and becomes so dilute that no cap is shown by a testing lamp.

Roof falls caused by the expansion and contraction of roof material on account of temperature changes are numerous, because cracks extend several feet into the immediate roof. Two of the mines examined heat the intake air in winter to keep the temperature more constant and also to prevent the formation of ice in the intake shaft. The amount of roof fall is in this way lessened. In one of these mines the exhaust steam from the fan engine is put into the down-

cast air shaft through a 4-inch pipe and as a precautionary measure against a temperature so low that exhaust steam could not keep the shaft free from ice, a 1½-inch pipe for live steam also runs into the shaft. It is seldom necessary, however, to use this live steam. In the other mine the live steam is sent down the intake shaft through a 3-inch pipe, which leads to a cylindrical radiator 7 feet in diameter placed at the bottom.

The necessity for artificial humidification to prevent coal-dust explosions has not been apparent in longwall mines. Inasmuch as all the coal is removed from the seam as the face advances and as the excavation is filled with waste rock the only sources of supply for coal dust are the daily working face of fresh coal and the spillings from the pit cars. In room-and-pillar mines the ribs of the entire workings and sometimes also the roof and floor are of coal and the spalling of this coal furnishes a cumulative supply of dust that becomes constantly drier and more explosive. The coal dust from mining at the face in longwall mines is covered with shale and clay within a few days after it is made so that there is no accumulation of it. The dust brushed from the ribs of longwall mines is not inflammable. The analyses of samples thus taken show that the dust consists principally of shale or other inert matter. Table 22 gives the average of analyses and of pressures developed in the explosibility apparatus for 14 samples of longwall rib dust collected in the haulage ways.

TABLE 22.—*Comparison of longwall and room-and-pillar rib dust on haulage ways.*

Mining system	Number samples	Proximate analysis of coal—First: "As received" with total moisture. Second: "Dry" or moisture free.				Pressure in pounds per square inch developed in explosibility flask at 2192° F.
		Moisture	Volatile matter	Fixed carbon	Ash	
Average longwall......	14	3.45	14.68	6.77	75.12	0.175
		Dry	15.19	7.01	77.80	....
Typical room-and-pillar mine in southern Illinois	3	5.54	34.89	39.21	20.37	4.760
		Dry	39.94	41.51	21.56	....

The high average temperature of the air in longwall mines decreases the relative humidity and considerable moisture is absorbed from the dust of ribs and roads so that, unless additional moisture is supplied by seepage water or by sprinkling, the dust of the roadways becomes very dry. In a few longwall mines the haulage roads are sprinkled at intervals varying from one week to three months.

A co-operative bulletin on the character of the dust in Illinois mines will soon be published.

VENTILATION OF MINES OTHER THAN LONGWALL

Explosive gas is found in every district in Illinois but in Districts II, III, IV, and VIII gas is found in active workings usually only in roof caves and at slips and in small quantities in abandoned areas. In these districts an occasional accident occurs by ignition of small bodies of gas in these areas. In Districts V and VI and in the northeast part of District VII, however, the subject of ventilation is a vital one inasmuch as there have been serious explosions of gas and dust in many mines resulting in much loss of life and destruction of property. The disastrous explosion at the Zeigler mine in 1905 and the fire in 1908 and the explosion at the North mine, Royalton, in 1914, will be recalled by those familiar with Illinois mining history. Frequent explosions of less magnitude in other mines, many of them resulting in loss of life and all of them entailing great expense in recovering the mine or a portion of it, have caused these districts to be regarded properly as dangerous. The mines less than 100 feet deep seem to be comparatively free from explosive gas. As the rock strata of the shallow cover are broken and in places eroded, the spaces left by rock removal being filled with sand and clay, much of the gas in the bed has escaped. Where the bed lies at depths greater than 100 feet it is usually undrained and contains the greater part of the gas originally formed in it. Mallard states that gas impregnates a coal bed just as water impregnates a porous substance and that its escape results directly from a difference of pressure between the interior and the exterior of the mass. The highest pressure of gas in the solid coal which was recorded by Darton in this district was 33 pounds per square inch although the pressure is probably higher in certain areas. However,

a difference in pressure of a few pounds only is sufficient to set up a steady flow of gas from the coal into the workings. The actual volume of gas found in the return air current at any time will depend chiefly upon the number of active working places in the mine unless the bed contains large storage basins of gas, that is, it will depend upon the area of fresh coal face exposed daily. This statement is borne out by Darton's findings. In one mine 418 feet deep with a daily production of 2,300 tons he records 181 cubic feet of methame per minute in the return air current when the mine was operating

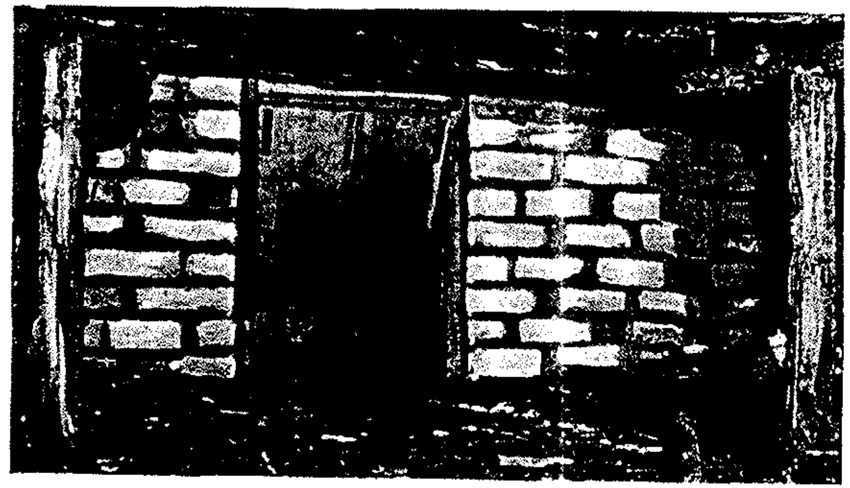


FIG. 47. Explosion-door in concrete-block stopping in District V

and 78 cubic feet per minute after a suspension of 5 to 15 days. "In the flat-lying undisturbed Illinois beds, depth over 200 feet does not seem to be a factor in the amount of gas in the bed.[1]"

The presence of large volumes of gas can not be predicted for any area unless it is known by previous workings that the area is one in which the coal is broken by structural movement so that it acts as a reservoir for a considerable surrounding area of the bed. In the deeper mines of this district, however, there is a continuous emanation of gas from the fresh coal and

[1]Darton, N. H., Occurrence of Explosive Gases in Coal Mines, U. S. Bureau of Mines, Bulletin 72.

such reservoirs may be broken into at any point. Although different exposures of fresh coal do not give off uniform quantities of gas, some exuding none and some large quantities, the aggregate emanation is considerable. The return air in the upcast shaft at one mine contained 0.28 per cent methane. The irregularity of emanation in different sections is well illustrated at one mine where the upcast air contained 0.20 per cent methane and a cross-entry, on which there were 23 working places, near its intersection with the main entry contained 1.08 per cent. In another mine with 0.26 per cent methane in the main return, samples taken in two rooms at the face showed 5.53 per cent in one and 10.35 per cent in the other.

FIG. 48. Typical gob stopping

In almost every mine examined in Districts V and VI gas is found in development entries and in the face of all workings driven to the rise. Inasmuch as naked lights are allowed throughout these districts the safety of the miners depends upon the thoroughness of the examination of the mine examiner. A single dereliction of duty may result in great loss of life and the wrecking of the mine. In many mines the use of naked lights should be abandoned unless the quantity of air

supplied to the face is very materially increased. In a few mines the use of safety lamps in certain sections is insisted upon, but mixed lights are dangerous and in other states have frequently caused serious explosions.

Wherever workings in a gassy mine have been abandoned they are usually sealed off by stoppings of various materials. A large amount of methane soon collects in these abandoned areas. In one mine in which a squeezed area has been sealed off by a concrete stopping, air samples drawn through a 3-inch relief pipe in the stopping showed 38.17 per cent methane. It is reported that since the data on which this bulletin is based were collected all sealed-off areas in Franklin County have been opened up and ventilated.

Details of a study of gas in mines in southern Illinois will be found in Co-operative Bulletin 72, U. S. Bureau of Mines, Occurrence of Explosive Gases in Coal Mines, N. H. Darton.

Face samples of the coal when ground to 200-mesh, dried and tested in the laboratory in Urbana, show that the unadulterated coal dust of every district is explosible. The average pressures developed in the explosibility apparatus are given for each district in Table 23.

TABLE 23.—*Pressure developed by dust of face samples in explosibility apparatus*

District	No. samples	Pressure in pounds per square inch at 2192° F.
I	11	8.400
II	5	5.880
III	5	7.805
IV	17	7.700
V	7	7.105
VI	16	5.950
VII	24	7.175
VIII	6	8.925

In Districts II, III, IV, VII, and VIII the dust found on the ribs of entries is not very explosible because it has such a high moisture and shale content. Shale dropping from the roof is ground up by car wheels and by the feet of men and mules and the inert dust thus produced is mixed with the coal dust on the ribs and acts as a diluent. However, although the coal dust may not be sufficiently explosible to initiate an explosion when an explosion is once initiated in mines in these districts by ignition of gas or by a blown-out shot the dust will propagate the explosion as violently as any other.

The rib dust of Districts V and VI, which are gassy districts, is dry and in District VI is not likely to be adulterated with shale because the constant dropping of top coal adds to the supply of pure dust. Every precaution should be observed in these districts for the prevention of dust explosions and for checking them if they are initiated. At a few mines in these districts, notably at those in which there have been

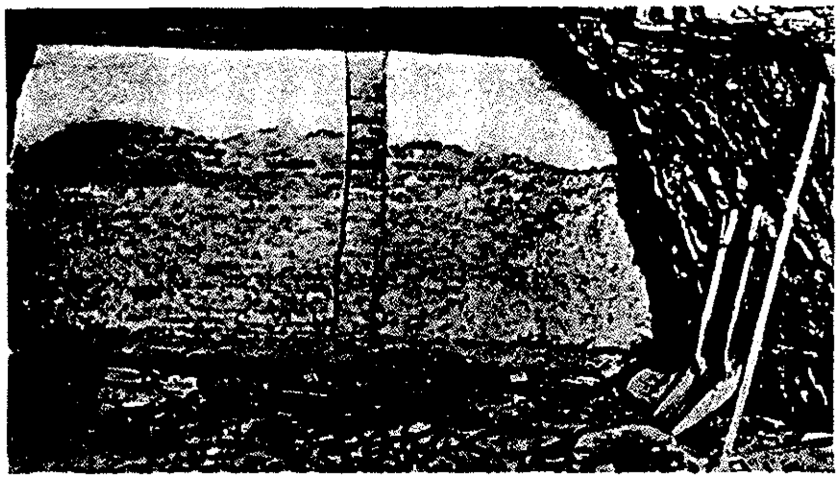


FIG. 49. Efficient brick stopping

explosions, attempts are made to lessen the danger. In District V in one mine where road dust is thick calcium chloride is put on the floor of entries. Calcium chloride being a hygroscopic salt absorbs moisture. Coal dust when covered with it becomes moistened and remains damp as long as the calcium chloride continues to absorb moisture. The finest coal dust is thus prevented from being thrown into suspension in the air current. At this mine it was found that by using 1¼ pounds of granulated calcium chloride per square yard of floor, fine coal dust lying one inch thick was kept moist for six months. The use of this salt has been so satisfactory at

this mine that a much greater floor area will be covered in the future. In the small quantity bought for experimentation calcium chloride cost $13. per ton. This cost will be considerably less if the salt is bought in large quantity. Provision is made at another mine in this district for the expansion of an explosion wave, the idea being to prevent the propagation through the main entries of a local explosion in a room or entry. An explosion door (fig. 47) is built into every eighth stopping along the main entries. This door is built of two thicknesses of one inch shiplap boards, and swings vertically on a one-inch iron rod. Uprights and casings are built into the stopping. The width of the door, 4 feet 3 inches, is the same whatever the width of the crosscut, but the height varies with the stopping.

In District VI at one mine water is piped to the face of every room and the ribs, roof, and props of every room are hosed before shooting. In a few other mines the ribs of entries are hosed every two weeks. In another mine the haulage roads are ballasted with ashes. It takes 76 cubic feet of ashes to cover 40 linear feet of road. When the road bed becomes covered with coal dust more ashes are sprinkled on it. The roads are sprinkled with water nightly. In this mine an explosion which killed 8 men died out for lack of explosive dust after traversing a short stretch of entry in which ash ballast had been used.

A bulletin dealing with the explosibility of coal dust in Illinois mines is in press and will soon be ready for distribution.

The subject of humidity of air in Illinois mines has been covered in Co-operative Bulletin 83, U. S. Bureau of Mines, The Humidity of Mine Air, by R. Y. Williams. The humidity of return air in Illinois mines throughout the year averages 96 per cent and the temperature averages 64 degrees F. The average humidity of the outside air in Illinois is 72 per cent and the average temperature 52 degrees F. The moisture gained by the air current is extracted from the ribs and where there is no seepage of water the moisture is obtained from the dust on the ribs. Humidification of mine air is attempted at a few mines. At two mines in

District IV the intake air is heated; at one by passing it over a coil of one-inch pipe 695 feet long through which live steam is passed at a pressure of 80 pounds per square inch; at the other by jets of steam exhausted into the air shaft from the fan engine. At these mines it is stated that in the coldest weather the intake air at the bottom of the air-shaft has a temperature above freezing. Clean-up expense in this district can be lessened materially by heating the intake air and every mine in the district could profitably install a steam coil or drum. The initial expense would be small and the expense of operation slight compared with the

FIG. 50. Latch in rib dug to receive stopping

saving in clean-up cost. The shale roof spalls off badly in spring and summer in many mines and in some continues to fall till the limestone or sandstone cap rock is exposed. In several mines in this district in new entries driven during winter the roof begins to fall with the advent of summer and caves to the cap rock. The cause of the falling is chiefly the expansion of the black shale with the rise in temperature of the intake air current. Maintaining the air current at a more nearly constant temperature by means of preheating with steam coils would decrease the roof falls by decreasing the seasonal range of temperature.

In District VI in three mines exhaust steam from the fan engine is turned into the intake air-shaft in winter to prevent the formation of ice in the shaft. At one of these mines the exhaust steam is carried over a radiator heated by live steam. The radiator is made of 1,000 feet of 1½-inch pipe. One of the mines using exhaust steam reports that it causes roof to fall badly.

In District VIII exhaust steam was turned into the air-shaft at one mine to prevent the formation of ice.

At the mines examined in other districts the only water introduced into the mine is in sprinkling the haulageways for the purpose of laying the dust. This procedure aids very little in humidification of the air but adds to the efficiency of the mules by temporarily lessening the amount of dust thrown up by the passage of cars and by the feet of men and animals.

At most mines in Illinois the fans are always run as blowers but in a few they exhaust in summer and blow in winter, and in the vicinity of Pana they always exhaust. The quantity of air delivered by the fans usually is small in some mines the amount being less than 25,000 cubic feet per minute. The average mine with about 1,500 tons daily output usually has a ventilating current of approximately 50,000 cubic feet per minute. There are only a few mines in Illinois at which the ventilating current supplies 200,000 cubic feet per minute and these mines are nearly all in the gassy District VI. The fan at one of the mines examined in District V has a capacity of 200,000 cubic feet.

Although at most mines enough air is delivered by the fan to provide the legal amount in proportion to the number of men and mules underground stoppings are often so inefficient that only a comparatively small amount of air reaches the last cross-cut on the entries or arrives at the working face. At many mines a large percentage of the air blown by the fans into the air-shaft short-circuits through the leaky stoppings into the return air. In one mine with lumber stoppings, a careful study by J. T. Ryan, U. S. Bureau of Mines, showed only 12½ per cent ventilating efficiency. Frequently only 20 per cent of the air supplied by the fan reaches the last cross-cut. A co-operative bulletin by R. Y. Williams, "The Efficiency of Mine Stoppings" will soon be issued by the U. S. Bureau of Mines. At nearly all of the smaller mines in Illinois stoppings are built of gob, sometimes loosely packed, more often tamped. Fig. 48 shows a typical gob stopping. In a few mines gob stoppings are plastered with mud and in some with mud and wood-fibre. Besides gob the materials of which stoppings are made are: powder cans and mud mortar, old ties and fine gob, lumber and wood-fibre, expanded metal and wood-fibre, pressed gypsum blocks called Pyrobar, brick, concrete blocks, and monolithic concrete with various aggregates.

FIG. 51. Mixer and mould for making concrete blocks

In one instance noted stoppings had been built of ⅜-inch-mesh expanded metal nailed on props with one side of the expanded metal plastered with wood-fibre ½-inch thick. The metal rusted and the stoppings fell in six months. They were replaced by concrete monoliths. Berkytt lath nailed to props and covered with wood-fibre ½-inch thick is used extensively for stopping material in District VI. This stopping is efficient for a short time. Two men can build three of these

stoppings a day. One 100-pound sack of wood-fibre costing $10. per ton f. o. b. mine will cover one stopping 8 by 10 feet. Berkytt lath bought in lengths to fit a mine car costs $15.50 per thousand board feet. At a mine in District VII stoppings are built of shiplap with shale, slack, and fireclay banked on each side of the lumber stopping.

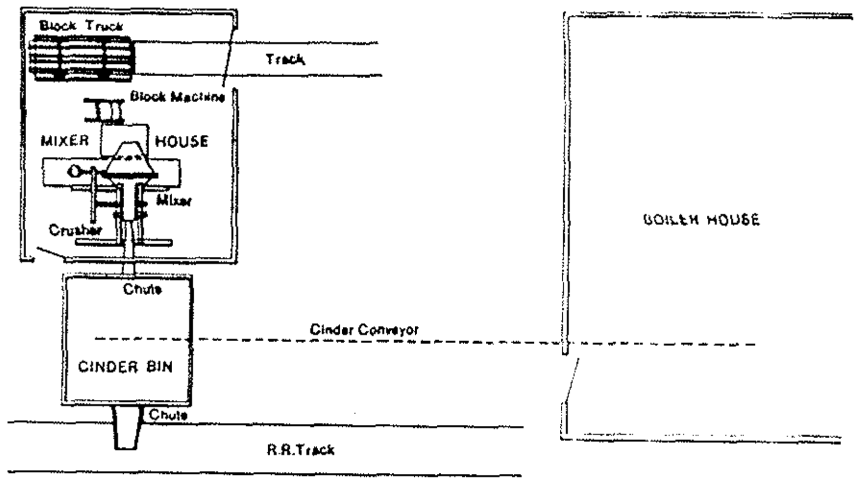


FIG. 52. Arrangement of plant for making concrete blocks (After Ross.)

Pyrobar stoppings are found in several mines. Pyrobar is a gypsum block made in two sizes; 12 by 30 by 4 inches and 12 by 30 by 15 inches, and to decrease the weight three longitudinal core holes are made in the blocks. The block 4 inches thick has a compressive strength of 154 pounds per square inch and the block 5 inches thick a strength of 162 pounds, the greater compressive strength of the block five inches thick being due to greater thickness of its walls. The four-inch block weighs 12 pounds per square foot of surface and the five-inch block, 13½ pounds. The price of the four-inch block

TABLE 24.—*Total cost of completed stopping*

	Per square foot of surface	Per block
Cost of manufacture in cents	5.58	4.96
Cost of building in cents	5.04	4.48
Total laid cost in cents	10.62	9.44

TABLE 25.—*Material and initial cost of stoppings*

District	Material of stopping	Proportions of concrete	Thickness of stopping in inches	Cost in cents per square foot in place	Size of blocks in inches	REMARKS
II	Concrete blocks	1 Portland cement; 6 cinders	5	....	5 by 8 by 20	Blocks cost 6 cents each at pit mouth
III	Gob	....	48	8	...	....
IV	Pyrobar	....	4	9	4 by 12 by 30	
V	Concrete blocks	1 cement; 2 sharp washed sand; 4 crushed lime stone	12	21.6	8 by 12 by 24	Unnecessary aggregate. Blocks weigh 180 pounds. Labor costs 8 cents per block
	Berkytt lath and wood fibre	....	1¼	6.0	...	....
	Concrete	1 Portland cement; 2 sand; 7 sifted cinders	6	....	6 by 10 by 20	Blocks cost 4 cents each at pit mouth
VI	Concrete	1 cement; 6 sifted cinders	6	11.4	...	To replace expanded metal and wood fibre
	Concrete	1 cement; 2 sand; 5 slack from floor	14	15.0	...	....
	Brick coated with cement	....	4	16.6	...	Brick cost $9 per M. delivered. One man builds one stopping 7 feet by 12 feet in 2 days
	Tamped gob	....	72	5.4	...	Cost of transportation of gob not included
VII	Tamped gob	....	144	7.0	...	Cost of transportation of gob not included
	Concrete blocks	1 Portland cement; 6 crushed cinders	8	10.6	8 by 8 by 16	....
VIII	Concrete	1 cement; 5 unsifted cinders	8	25.1	...	....

is four cents per square foot, f. o. b. Fort Dodge, Iowa. The Pyrobar block is well adapted to mine stoppings and fire seals in dry mines where it is not subjected to heavy roof settlement. The blocks can be sawed into desired sizes with a hand saw. The mortar used in building stoppings with this material has a gypsum base and costs $6.50 per ton. Two men can build three 6 by 12-foot stoppings in eight hours. In this district a 6 by 12-foot stopping in place costs $6.50; about nine cents per square foot of surface. Fire seals can be built easily and quickly with these blocks which are fire resistant.

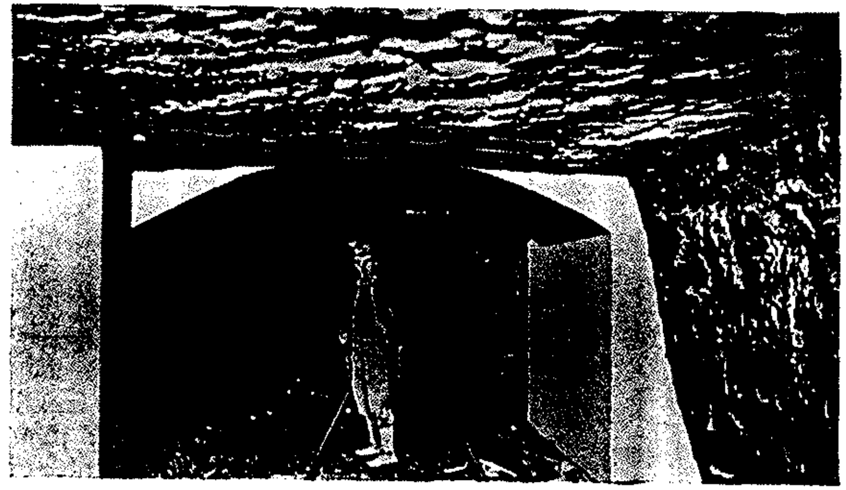


FIG. 53. Concrete overcast

Fig. 49 shows an efficient brick stopping in a mine in District VI. This stopping has one course of brick laid on the broad side. The rib, roof, and floor are cut away for a depth of 6 inches to provide a tight joint. In the center a stiffener course is laid at a right angle to the other bricks. Mortar is made of 1 part Portland cement and 3 parts sand. After the bricks are laid, both sides of the stoppings are plastered ½-inch thick with this mortar. A 7 by 12-foot stopping is said to cost $12.

In another mine in District VI stoppings are built of concrete with unusual ingredients. One part Portland cement is mixed with 2 parts sand and 5 parts slack shoveled from the floor. The larger pieces of coal in the slack are picked out by hand. Stoppings with this mixture in good condition were noted which have been in place 11 years.

Monolithic concrete is extensively used for stoppings in the larger mines. Concrete stoppings are not always inserted deeply enough in the ribs, roof and floor and consequently sometimes allow air to short-circuit around them. Fig. 50 shows a stopping in District V with blocks set in cuts deep enough to provide a good joint. The cut is made about 2 inches wider than the bearing side of the blocks, and the joint in rib, roof, and floor is packed with cement mortar with the proportions, 1, Portland cement; 3, sharp washed sand. The rib cut is 14 inches deep.

The usual aggregates for concrete blocks or monolithic concrete are: graded gravel, sand and crushed limestone, sand and uncrushed cinders, crushed cinders. At the No. 1 mine of the Superior Coal Company at Gillespie the system for making concrete blocks is very efficient. The blocks which are made on the surface are proportioned as follows: 1 Portland cement; 4 crushed cinders. The mould makes with one filling a block 8 by 8 by 16 inches and another 8 by 8 by 8 inches. Two men can make 300 moulds per day, which is equivalent to 450 blocks 8 by 8 by 16 inches, as the 300 smaller blocks are equal to 150 of the larger. The mixer and mould are illustrated in fig. 51. The arrangement of the plant is shown in fig. 52. A cinder crusher delivers cinders under 1¼-inch mesh and a 6 H.P. Westinghouse motor operates the crusher and the mixer which handles 1/5 of a cubic yard per batch. The cost of manufacturing concrete blocks at this mine and delivering at the pit mouth is in cents per block: Labor 1.08, material 3.88, total 4.96. Each block has 0.888 square feet of face and, therefore, the cost per square foot of face is 5.58 cents.

To obtain a proper set the blocks are ripened on the surface for two weeks. To estimate the cost of a stopping in place, costs of material transportation from the top to the required location in the mine and of stopping construction

TABLE 26.—*Ventilating equipment of mines producing less than 1000 tons daily*

District	No. seam	No. mine	Tons per day	Depth of air shaft in feet	Size in feet of air shaft in clear	Type of fan[1]	Fan: Diameter in feet	Fan: Width of blade in feet
		2	900	465	8 by 12	Capell	10	4
		3	750	398	5 by 9	Paddle-wheel	8	4
		4	550	546	8 by 10	Paddle-wheel	20	10
		5	400	135	6 by 12	Paddle-wheel	20	6
		6	900	100	10 ft. diam	Crawford & McCrimmon	16	4
I	2	7	800	200	8 by 16	Paddle-wheel		
		8	700	300	6 by 6	Paddle-wheel	10	
		9	200	....	6 by 7	Crawford & McCrimmon	19	4
		12	150	125	8 by 10	Paddle-wheel	16	4
II	2	14	300	135	4½ by 7½	Paddle-wheel	16	4
		15	800	160	8 by 12	Robinson	6	2½
		17	500	210	6 by 12	Paddle-wheel	18	4
		18	850	69	8 by 10	Robinson	10	4
III	1 and 2	19	850	70	8 by 12	Paddle-wheel	12	3½
		22	30	60	4 by 5	Paddle-wheel	6	2½
		24	350	40	6 by 8	Paddle-wheel	6	4
		26	900	196	8 by 15	Sturtevant	6½	4
		27	550	170	6 by 14	Paddle-wheel	12	4
		28	950	150	5 by 10	Paddle-wheel	20	7
		32	550	68	6 by 9	Paddle-wheel	10	4
IV	5	34	650	200	5 by 10	Paddle-wheel	12	4
		35	275	162	6 by 8	Paddle-wheel	12	6
		40	700	270	....	Jeffery	6	3½
		41	325	365	4½ by 7	Stevens	10	2
		42	750	570	6 by 8	Duncan	15	3½
V	5	48	800	76½	5 by 10	Paddle wheel	10	3
		48	800	76½	5 by 10	Paddle wheel	18	4
		69	500	290	5 by 10	Paddle wheel	16	4
		78	800	140	7 by 16	Paddle wheel	20	5
		81	800	200	7 by 14	Paddle wheel	16	4
VII	6	83	800	140	6 by 16	Paddle wheel	14	4
		87	800	707	6 by 8	Paddle wheel	12	4
		89	400	85	6 by 8	Paddle wheel	15	3
		90	500	160	6 by 12	Capell	6	12

[1] Paddle-wheel refers to straight blade type of fan.

TABLE 26.—*Continued*

District	No. seam	No. mine	Tons per day	Depth of air shaft in feet	Size in feet of air shaft in clear	Type of fan[1]	Fan: Diameter in feet	Fan: Width of blade in feet
VIII	6 and 7	92	150	240	6 by 14	Capell	10	4
		94	800	90	7 by 14	Capell	12	6
		95	50	40	4½ by 4½	Paddle-wheel	3	1½
		97	300	223	6 by 10	Capell	14	6½
Averages by districts								
I	2		650	280	7¼ by 10¼		15	5¼
II	2		417	140	6¾ by 9¾		12¼	3¼
III	1 and 2		433	90	6¾ by 9½		10½	3½
IV	5		628	239	5¾ by 10		11½	4½
V	5		600	88	5½ by 8			
VII	6		657	246	6 by 12		14	5¾
VIII	6 and 7		360	148	6 by 10½		10	4½
Average of 38 mines			573	199	6½ by 10		12½	4½

must be considered. The cost items of erecting such a stopping, 8 by 10 feet, containing 90 blocks are: Delivery from surface to location in mine 71 cents; preparing ribs and building stopping requiring the labor of 2 men for 4 hours, $2.62; 2 sacks of cement, 60 cents, and sand, 10 cents, to be used for mortar. The total cost of transportation of blocks and erection of stopping is $4.03. The building cost is 5.04 cents per square foot or 4.48 cents per block. Table 24 gives total cost for stopping in place.

A tight stopping 8 inches thick is provided at a total cost of 10.6 cents per square foot.

Table 25 gives cost and material of stoppings by districts.

Overcasts for carrying the intake air over the return airway are built of lumber, concrete, lumber and concrete, old rails or steel I-beams and concrete, brick, brick and lumber, brick and steel, and Pyrobar. The cost of an overcast varies from 40 to 250 dollars depending upon its material and substantiality. It is false economy to build an overcast of

material which is not permanently air tight because loss of air and repair cost make a leaky overcast expensive. Fig. 53 shows a permanent air tight overcast which has no repair expense. This overcast cost about $150 and is built of concrete reinforced with steel I-beams. The concrete has the proportions: 1 Portland cement; 2 river sand; 2 unsifted cinders. At a few mines in District VIII overcasts are lined with ½-inch tongue-and-groove. Lining the overcast prevents its filling with an accumulation of small roof falls which chokes the ventilating current.

At a few mines the crossing of air is made by an undercast. An undercast collects water reducing its available cross-section and is expensive to keep open.

No two operating companies segregate the same items into ventilation cost so that figures for total cost of ventilation are not available. At a mine in District VI with 2,400 tons daily production the total ventilating cost excluding cost of steam used by the fan engine but including that of trappers, examiners, brattice cloth and labor on brattices is ½-cent per ton of coal. At a mine in District III the total ventilating cost is 3.9 cents per ton of coal. In determining ventilation cost at this mine wages of foreman, assistant foreman, pumpers, trappers and water bailers are apportioned in the segregation of items and ventilation is charged with its proportionate amount.

Fan engines are operated by steam at all except one or two mines where the fan is driven by electricity. Ventilating equipment varies in a general way with the size of the mine. Tables 26, 27, and 28 give ventilating equipment for the mines examined segregated by tonnage. At mines producing more than 2000 tons per day the average air shaft and ventilating fan are much larger than at mines with less than 1000 tons output.

TABLE 27.—*Ventilating equipment of mines producing 1000 and less than 2000 tons daily*

District	No. seam	No. mine	Tons per day	Depth of air shaft in feet	Size in feet of air shaft in clear	Type of fan[1]	Fan: Diameter in feet	Fan: Width of blade in feet
I	2	1	1450	413	9 by 12	Capell	14	8
		10	1000	480	8 by 12	Capell	16	6
		11	1200	530	5 by 9	....	20	6
II	2	13	1300	114	9 by 20	Robinson	10	3
IV	5	25	1200	185	8 by 8	Paddle-wheel	15	3½
		29	1100	185	8 by 16	Paddle-wheel	16	4
		31	1200	60	9 by 15	Duncan	22	6
		33	1600	285	6 by 12	Robinson	12	6
		38	1400	245	6 by 12	Jeffrey	10	4
V	5	44	1400	270	11 by 20	Paddle-wheel	20	6
		45	1600	320	6 by 8	Paddle-wheel	12	5
		46	1100	450	8 by 12	Paddle-wheel	20	5
		49	1100	337	6 by 10	Paddle-wheel	14	4
VI	6	51	1200	494	9 by 13	Capell	20	7
		54	1600	380	8 by 12	Paddle-wheel	15	5
		55	1200	180	6 by 8	....	16	4
		56	1400	580	9 by 13	Robinson	16	5
		57	1600	318	9½ by 15	Capell	10	5
		64	1350	120	10 by 14	Blakslee	20	5
		65	1600	65	8 by 10	Paddle-wheel	20	7
VII	6	67	1250	320	5 by 10	Paddle-wheel	20	6
		70	1250	92	8 by 16	Paddle-wheel	22	5
		79	1700	127	6 by 8	Paddle-wheel	12	4
		80	1000	145	7 by 12	Capell	20	5
		85	1200	440	4 by 6	Paddle-wheel	22	6
		86	1800	536	7½ by 9½	Stevens	10	3
		88	1050	85	7½ by 11	Capell	20	6
VIII	6 and 7	91	1250	217	8 by 12	Capell	16	4
Averages by districts								
I	2		1216	474	7½ by 11		16⅔	6⅔
II	2		1300	114	9 by 20		10	3
IV	5		1300	192	7½ by 14		15	5
V	5		1300	344	8 by 12½		18½	5
VI	6		1422	305	8½ by 12		19	5½
VII	6		1322	249	6½ by 10		18	5
VIII	6 and 7		1250	217	8 by 12		16	4
Average of 28 mines			1325	285	7½ by 12		16½	5

[1] Paddle-wheel refers to straight blade type of fan.

MINE FIRES

Many mines are troubled with small fires originating from various causes but principally occurring at the face after shots with black powder and in the gob in damp rooms where the gob contains a mixture of fine coal and iron pyrites. Nearly all fires are discovered before they attain serious proportions and are quenched with water or loaded out. To extinguish them costs from 5 to 150 dollars. Many fires, however, require sealing off. One fire which started at the face after shooting in a mine in District VI affected 1300 feet of both of a pair of cross-entries and was sealed off by a wall of cement-and-cinder concrete 2 feet thick. Concrete is a favorite material for seals and the usual seal costs from 25 to 200 dollars in place. Seals are built of lumber, gob, brick, concrete, or Pyrobar. In Districts IV, V, VI, and VII gob fires are frequent. At the No. 1 mine of the Peabody Coal Company at Nokomis on account of the heavy shale over the coal it was the intention to drive wide entries and to allow the shale below the upper limestone to fall. As the entry progressed the carbonaceous shale was displaced by a thin bed of dirty coal. To prevent the mine fires which would have occurred if this coal were mixed with the gob it became necessary to narrow the entries and to hold up all of the shale by heavy timbering.[1]

Stable fires are quite frequent in Districts V and VII and are usually caused by cap lamps. In these districts extreme carelessness is tolerated in the use of naked lamps in underground stables. At many mines proper care is not observed in the transportation of hay from the surface to the underground stables and it is often taken into the mine in open cars and sometimes is allowed to lie for several hours on the stable floor after unloading. The Illinois mining laws regarding the protection of stables from fire are unusually stringent and if obeyed should make stable fires impossible.

In District VI the provisions of the State law with regard to the transportation of hay to stables where mules are kept

[1]Bulletin 11, Illinois Coal Mining Investigations, Coal Resources of District VII, by F. H. Kay.

TABLE 28.—*Ventilating equipment of mines producing 2000 tons daily and over*

District	No. seam	No. mine	Tons per day	Depth of air shaft in feet	Size in feet of air shaft in clear	Type of fan[1]	Fan: Diameter in feet	Fan: Width of blade in feet
IV	5	36	2450	200	7½ by 15	Stevens	12	4
		37	2700	235	10 by 14	Buffalo-Forge	16	5
		39	2400	204	10 by 12	Capell	13½	7½
V	5	43	2500	160	8 by 8	Clifford-Capell	13	5½
VI	6	50	2000	726	10 by 15	Capell	20	7
		52	2400	640	9 by 13	Capell	11	5
		53	2500	417	12 by 12	Robinson	18	8
		58	2500	515	9 by 13	Paddle-wheel	13½	6
		59	3000	220	10 by 14	Paddle-wheel	21	6
		60	2250	112	....	Crawford & McCrimmon	20	8
		62	2325	190	8 by 12	Blakslee	20	6
		63	2600	140	10 by 12	Robinson	20	6
VII	6	66	4000	332	8 by 14	Miller	18	6
		68	2500	387	7 by 12	Duncan	22	6
		71	2500	205	8 by 18	Sullivan	10	6
		72	4000	287	9 by 12	Capell	20	8
		73	3750	318	8 by 18	Duncan	21	6
		74	2800	330	8½ by 17	Paddle-wheel	22	5
		75	2000	310	8¼ by 5⅜	Crawford	16	2
		76	2120	370	11 by 22	Capell	15	6
		77	2500	462	9 by 16	Sullivan	10	5
		82	3000	192	7 by 10	Paddle-wheel	20	5
		84	2000	320	6 by 8	Paddle-wheel	15	8
VIII	6 and 7	93	2600	186	8 by 12	Capell	24	7
Averages by districts								
IV	5		2517	213	9⅛ by 13⅜		14	5½
V	5		2500	160	8 by 8		13	5½
VI	6		2447	370	9¾ by 13		18	6½
VII	6		2834	319	8¼ by 14		17	5¾
VIII	6 and 7		2600	186	8 by 12		24	7
Average of 24 mines			2641	311	9 by 13		17	6

[1] **Paddle-wheel refers to straight blade type of fan.**

underground is attended with more care than in any other district in Illinois. In almost every mine examined in this district the provisions of the State law with respect to the transportation of hay to underground stables are scrupulously observed. The hay, which is baled, is carried in a specially constructed car. Fig. 54 shows a steel hay car in an under-

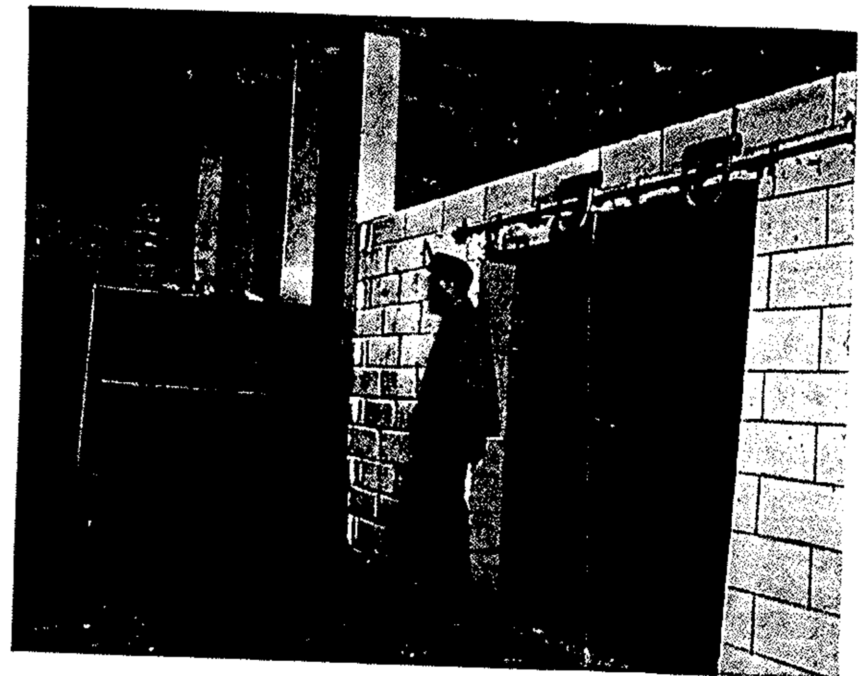


FIG. 54. Steel hay car and concrete hay room. (Photo by R. Y. Williams, U. S. Bureau of Mines.)

ground stable in which a concrete-walled room is provided for the storage of small quantities of hay.

At a great majority of the mines in Illinois mules are stabled underground, but at many mines the mules are stabled on the surface. At one mine having 24 mules on the secondary haulage they are hoisted out each night. It requires thirty minutes to hoist and the same time to lower them and the total expense of these operations is $0.000888 per ton of coal hoisted.

In many mines an unnecessary liability of fire is added by allowing comparatively large quantities of lubricating oil to be stored in the run-around or at other points near the shaft. In one mine two full barrels of oil and four empties were kept within 25 feet of the main hoisting shaft, while 200 feet away were stored two full and three empty barrels. In the newer mines danger of underground fire is reduced to a minimum by prohibiting the storing of oil in the run-around. The daily supply taken below is stored in a small room driven in the rib near the shaft and closed by a fireproofed door. The oil is also heated here by steam coils. In District VIII at the Little Vermilion mine of the Bunsen Coal Company an unusual method of conveying oil to the shaft bottom was noted. On the surface at a distance of 100 feet from the hoisting shaft three oil tanks are sunk 5 feet deep in the ground. One tank of 400 gallons capacity contains black oil; one of 250 gallons capacity contains engine oil; and a third of 200 gallons capacity holds cylinder oil. Pipes from these tanks are carried down the pipe-way in the hoisting-shaft and the various oils are pumped direct to the bottom as needed. This method obviates the necessity of taking oil into the shaft in barrels or in cans and does away with storing oil in the run-around.

LIGHTING

Carbide lamps are used extensively by the miners. At one mine in District VI the management forbids their use and insists on the use of oil lamps. The smoky oil lamps pollute the air in rooms and in mines where they are used air at the working face is noticeably more impure than where carbide is used. The use of open lamps should be carefully regulated in Districts V and VI. The bottoms and main haulage entries of 207 mines in Illinois are lighted by electricity.

HAULAGE

The flat lying seams of Illinois offer every opportunity for the development of speed in haulage but it is only since 1906 that the introduction of locomotives and the opening of mines of large capacity have developed the present rapid transportation of coal from the face to the shaft bottom. Locomotives are rapidly superseding mules and rope haulage on the main haulageways. This is clearly shown in the following tabulation:

KIND OF HAULAGE IN ILLINOIS SHIPPING MINES[1]

Year	No. Mines Using on Main Haulage: Locomotive	Cable	Mules	Hand pushing
1907	75	25	303	5
1908	88	32	283	4
1909	96	16	268	4
1910	106	25	251	8
1911	137	24	219	7
1912	165	4	210	1
1913	185	13	168	0
1914	191	6	139	1

[1]Compiled from Thirty-first Annual Coal Report of Illinois.

Local mines do not need mechanical haulage and their output would not support it. In most of them cars are pushed by hand and in some are hauled by mules. In one mine in District III cars were hauled by dogs for many years as shown in fig. 55. In 1912 locomotives were used in 167 of the mines in the State, rope haulage was used in 21, mules in 339, and in 244 the cars were pushed to the bottom by hand About 80 per cent of the production is hauled by locomotives, 19 per cent by mules, and less than 1 per cent by cable.

Standard electric locomotives were used in 45 of the mines examined, rack-rail locomotives in 4, and gasoline locomotives in 7.

Tables 29 and 30 give data on performance of the three types of locomotives. Electric locomotives in the mines examined make the greatest number of ton-miles per day. The combination third and rack-rail locomotive is used only in mines of small outputs where rolls and pitches in the seam cause steep grades. The third-rail in coal mines is dangerous and leakage of power through it is serious where the floor is wet. At one mine in District VII power loss through the third-rail was so great that a trolley was strung and the locomotive fitted with a pole.

Gasoline locomotives are used chiefly in mines where formerly mules were used and where the haul from parting to bottom has become too long for profitable mule haulage.

TABLE 29.—*Ton mileage of standard electric locomotives*

District	No. seam	No. mine	Weight of locomotives in tons	Miles traveled per shift	Ton mileage per shift
I	2	8	..	....	....
		11	..	....	....
II	2	13	..	....	....
IV	5	25	10	....	....
		26	11½	39.8	1356
		28	10	37.9	1136
		31	12	34.1	1355
		33	7½	20.0	780
		36	12	31.1	1434
		37	15	30.0	1716
		38	10	38.6	1622
V	5	43	15	29.8	1509
		44	10	14.2	1167
		45	10	18.0	675
		48	6	21.8	575
		49	8	42.3	888
VI	6	50	15	18.9	796
		51	10	9.5	296
		52	12	30.7	1266
		53	..	....	....
		54	12	6.8	320
		56	10	22.8	592
		57	8	....	....
		58	13	34.1	1381
		59	15	37.9	2040
		60	13	27.3	851
		62	10	27.3	745
		63	..	....	....
		65	8	35.0	735

TABLE 29.—*Continued*

District	No. seam	No. mine	Weight of locomotives in tons	Miles traveled per shift	Ton mileage per shift
VII	6	66	15	34.1	1823
		67	7½	47.0	1598
		68	10	10.6	875
		70	7½	41.7	1337
		71	13	30.3	1560
		72	12	23.0	1127
		73	10	....	....
		74	12½	26.5	1432
		75	10	15.1	920
		76	10	22.7	977
		77	13	21.0	992
		82	12	36.0	4095
		84	12	15.9	730
		86	12	15.2	1045
		87	10	32.5	1366
VIII	6 and 7	93	13	38.4	1208
Averages by districts					
IV	5		11	33.1	1343
V	5		10	25.2	963
VI	6		11½	25.0	902
VII	6		11	26.6	1420
VIII	6 and 7		13	38.4	1208
Average of 45 mines			11	27.5	1198

Their great advantages are cheapness of installation and flexibility. The necessity of bonding rails is obviated, no surface plant is required, and the change from mule haulage can be made without stringing trolley wires. They are subject, however, to the usual defects of the gasoline engine when required to do variable work. Their limitations for use in mines are clearly shown by Prof. O. P. Hood, Chief Mechanical Engineer of the U. S. Bureau of Mines.[1] Prof. Hood says, "The size of a gasoline locomotive that may with safety be introduced into a mine depends upon the amount of air that can be

[1]Gasoline Locomotives in Relation to the Health of the Miners. Bulletin of the American Institute of Mining Engineers, October, 1914, p. 2607.

FIG. 55. Pit-car hauled by dog. (Photo by Mr. James Taylor)

TABLE 30.—*Ton mileage of locomotives other than standard electric*

Kind	District	No mine	Weight of locomotive in tons	Miles traveled per shift	Ton mileage per shift
Gasoline	III	19	5	28.4	512
		24	7	11.4	150
	IV	29	8	13.3	270
		39	12	33.1	1392
		64	8	27.3	458
	VI	79	6	12.7	468
		81	5	16.6	518
Rack-rail	I	2	2¼	33.0	528
	II	15	..	...	
	VII	88	5	40.0	1593
		89	4	35.0	1556
Average:					
Standard electric			11.0	27.2	1198
Third-rail electric			3.9	36.0	1226
Gasoline			7.3	20.4	538

mixed with the exhaust gases in the most unfavorable portion of the run of the locomotive. For each cubic foot of carbon monoxide possible to generate in the engine there should be available 2,000 cu. ft. of air to mix with the exhaust gases if this air is for continued breathing, while for short and infrequent intervals the proportion may rise to one part in one thousand." Table 31 gives data compiled by Prof. Hood.

TABLE 31.—*Amount of air required for ventilation with various sizes of gasoline locomotives*

Engine cylinder size, in	No. cylinders	Speed, rev. per min.	Piston displacement[1] (Cu. ft. per min.)	Maximum probable amount of noxious gases (Cu. ft. per min. at 60° F. and 30 in. barometer) produced with: Good carburation		Bad carburation		Amount of air (Cu. ft. per min.) required to dilute exhaust gases to 1 part CO per 1000 parts of air[2]	
				CO	CO_2	CO	CO_2	Good carburation	Bad carburation
4.75 by 5.25	4	800	172	2.61	6.80	9.91	3.65	2,610	9,910
5 by 5	4	600	136	2.06	5.37	7.84	2.88	2,060	7,840
5 by 5	4	800	182	2.76	7.18	10.48	3.86	2,760	10,480
5 by 6	4	800	218	3.30	8.60	12.56	4.62	3,300	12,560
5.5 by 5	4	600	165	2.50	6.51	9.50	3.50	2,500	9,500
6 by 6	4	700	275	4.17	10.86	15.85	5.82	4,170	15,850
6 by 7	4	500	229	3.47	9.04	13.19	4.85	3,470	13,190
6.5 by 7	4	500	269	4.07	10.63	15.50	5.70	4,070	15,500
6.5 by 8	4	650	399	6.04	15.76	23.00	8.46	6,040	23,000
7 by 7	4	500	312	4.73	12.33	17.97	6.62	4,730	17,970
7 by 7	6	500	468	7.08	18.49	26.97	9.92	7,080	26,970
8 by 7	4	500	407	6.16	16.08	23.45	8.62	6,160	23,450
8 by 7	6	500	610	9.24	24.10	35.14	12.93	9,240	35,140

[1]Area piston in square feet multiplied by stroke in feet multiplied by number of cylinders multiplied by revolutions per minute.
[2]Maximum amount of carbon monoxide which can be breathed for short and infrequent intervals without injurious effects.

The first gasoline locomotive used in Illinois mines was built by the Sangamon Coal Company and put in its mine at Springfield in 1904. This crude machine, fig. 56, pulled in a trip seven to nine pit cars each weighing loaded 4,000 pounds. The rails in the mine at that time weighed 16 pounds per yard. In Illinois gasoline locomotives in mines average 30.8 ton-miles per gallon of gasoline and about 700 ton-miles per gallon of engine oil. Their average travel per shift is about 20 miles.

Rope haulage is still used in a few mines and with limited outputs furnishes economical transportation of coal. In two mines hauling with main-and-tail rope cost of haulage from parting to bottom averages 2½ cents per ton.

Gathering is usually done with mules. Standard 5 or 6-ton electric locomotives are used for gathering in a few mines

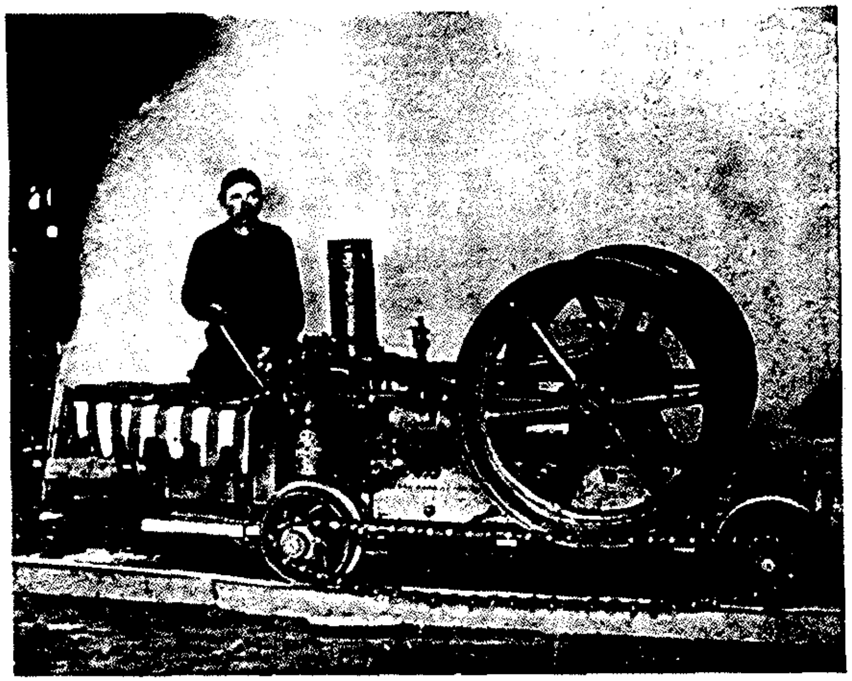


FIG. 56. First gasoline mine-locomotive in Illinois. (Photo loaned by Mr. Frank R. Fisher.)

and storage-battery locomotives in one. The storage-battery locomotives for gathering in mines without any steep grades are reported to be successful and cheap to operate.

Mules are kept in good condition in Illinois mines. Their useful life is decreasing because the increased production of the mines and the substitution of locomotives for mules on the long hauls have limited the work of the animals to gathering,

and as this must be done at high speed to keep the locomotives supplied with loads the life of a mule has consequently been shortened. In many mines in this district and throughout the State the limit of the average mule's work underground is 3 years. The expense per mule including feed, shoeing and harness repair is estimated to be 75 cents to one dollar a day. Figures on ton-mileage of mules are seldom available. In one mine on a 2 per cent grade in favor of the loads two mules weighing 1300 pounds each made seventy-five loaded trips of 700 feet with four cars weighing empty 1000 pounds apiece, each car having a capacity of 3500 pounds. With this load and haul the daily ton-mileage for each mule was 54.67. At one mine with a 2 per cent grade in favor of the loads a spike team of 3 mules hauls trips of 17 cars each weighing empty 1800 pounds and holding 2100 of coal, making a total weight of 3900 pounds per loaded car and approximately 33 tons for the trip. At a mine in District VIII where there is a 0.6 per cent grade against the loads mules travel 8.9 miles per day, averaging 64 ton-miles.

On account of incomplete segregation of cost items the cost of gathering can not be obtained with accuracy. It probably ranges from 4½ to 7 cents. Total cost of haulage in mines other than longwall varies from 6 to 15 cents. In one mine which was recently abandoned because it was worked out, haulage cost 25 cents per ton of coal.

In longwall mines the costs of haulage and maintenance of haulage ways are high per ton of coal because from ¼ to ⅓ of the entire tonnage hauled to the bottom is waste. Furthermore, the continuous settling of the roof, and in many mines, the heaving of the floor, add an expense for brushing roof and floor which is not an item in room-and-pillar mines. The roadways are usually maintained 4 feet high and 7 to 9 feet wide. The miners brush the roof at the face, but the settling as the face advances necessitates a further brushing which is done in the LaSalle field by the company. Fig. 57 shows the amount of "company brushing" necessary at one mine after subsidence. This brushing of roof and floor costs the operators in the LaSalle field approximately 15 cents per ton of run-of-mine coal. Labor for haulage costs approximately 12½ cents. Maintenance of mules and car repairing costs 5½ cents. The total cost items chargeable to haulage and maintenance of haulage roadways amount to about 33 cents in a typical mine with mule haulage on both main and cross entries.

The chief reasons for high haulage costs in mines other than longwall are failure to keep partings close enough to the working face to enable gathering mules to fill them with loads

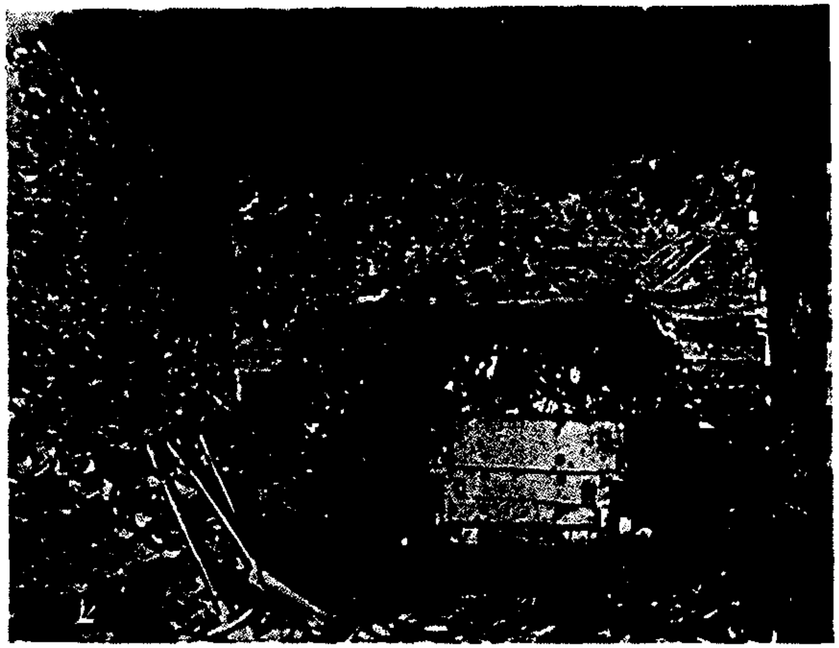


FIG. 57. Amount of "company brushing" necessary after settling

between trips of the locomotive, pit cars with high friction of running gear, light rails on main haulage, steep grades, sharp curves, and gob on the track. In nearly all mines haulage costs can be materially reduced. Pit cars are often leaky and spill coal along the track thus adding to the supply of dust on the ribs. On account of poor track and road-bed wrecks are frequent in many mines. At one mine in District VII with a daily production of 1050 tons it is necessary to clean up an

TABLE 32.—*Haulage equipment with mule haulage*

District	No. seam	No. mine	Track gage in inches	Rail weight in pounds per yard: Main entry	Rail weight in pounds per yard: Cross entry	Pit cars: Weight in pounds	Pit cars: Capacity in pounds	Ratio of coal to car weight	Per cent of car weight in total load
I	2	1	33	16	16	1800	2600	1.4	40.9
		3	42	16	16	900	2500	2.8	26.5
		5	36	16	16	425	1000	2.4	29.8
		9	37	24	12	850	1000	1.2	45.9
		10	42	16	12	1200	2650	2.2	31.2
II	2	12	36	16	16	1200	1800	1.5	40.0
		14	32	16	12	1100	2600	2.4	29.7
IV	5	27	36	16	16	1400	2800	2.0	33.3
		32	36	45	16	1000	2400	2.4	29.4
		34	36	16	12	1400	3000	2.1	31.8
		35	36	16	16	900	2300	2.6	28.1
		40	35	16	16	1500	3500	2.3	30.0
		41	24	20	12	740	2300	3.1	24.3
		42	38	16	16	1165	3000	2.6	29.0
V	5	46	42	30	16	1800	2100	1.2	46.2
		47	29	25	16	1200	2200	1.8	35.3
VII	6	69	24	16	16	1100	2800	2.5	28.2
		78	30	30	16	1000	3500	3.5	22.2
		83	30	20	12	1500	4000	2.7	27.3
		90	36	16	16	2200	3000	1.4	42.3

TABLE 32.—*Continued*

District	No. seam	No. mine	Track gage in inches	Rail weight in pounds per yard: Main entry	Rail weight in pounds per yard: Cross entry	Pit cars: Weight in pounds	Pit cars: Capacity in pounds	Ratio of coal to car weight	Per cent of car weight in total load
VIII	6 and 7	91	38	30	16	1800	5000	2.7	35.4
		92	38	16	16	1150	3000	2.6	27.2
		95	38	16	16	1200	2000	1.7	37.5
		97	36	16	16	1200	2000	1.7	37.5
Averages by districts									
I	2		38	18	14	1035	1950	1.9	34.9
II	2		34	16	14	1150	2200	1.9	34.9
IV	5		34	21	15	1159	2757	2.4	38.6
V	5		35	27	16	1500	2150	1.5	40.8
VII	6		32	20	15	1450	3325	2.5	30.0
VIII	6 and 7		38	20	16	1335	3000	21.8	34.4
Average of 24 mines			35.3	20	15	1239	2627	2.1	32.1

average of 20 tons from the haulageway each night because of the many wrecks and the loss of coal from pit cars in transit. At another mine which has low grades, easy curves and a good road-bed, the coal lost from pit cars through leaks and by overloading necessitates an average nightly clean-up of 24 tons.

Where large faults in District VI are met near the shaft the difference in elevation is usually overcome by an air lift or by an automatic chain car-haul as shown in fig. 58. In two mines the loads from the high side are lowered by a cable and drum down an incline.

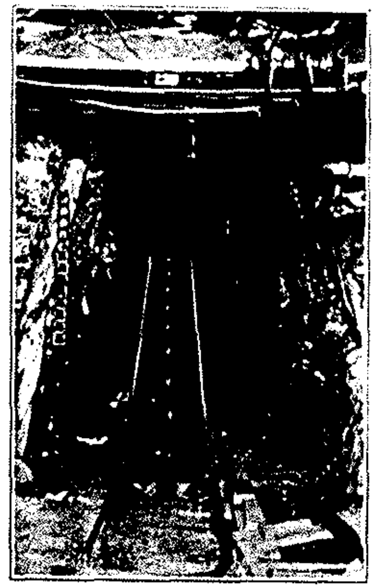


FIG. 58. Automatic chain car-haul

Equipment for haulage is excellent in all of the newly opened large mines and at many of them there are tight steel cars of large capacity, many of which have roller-bearing wheels. Tables 32 and 33 give equipment data for mines with mule and mechanical haulage on the main entry. In mines with mechanical haulage the average track gage is wider and the rail weight heavier than with mule haulage, and the ratio of coal carried to weight of empty car is greater,

TABLE 33.—*Haulage equipment with mechanical haulage*

District	No. seam	No. mine	Kind of Locomotive	Weight in tons and number of each weight[1]	Track gage in inches	Rail weight in pounds per yard		Pit cars		Ratio of coal to car weight	Per cent of car weight in total load
						Main entry	Cross entry	Weight in pounds	Capacity in pounds		
I	2	2	Third-rail	Two 2½	37	16	12	840	2200	2.6	27.6
		4	Cable	....	26	40	16	900	1700	1.9	34.6
		6	Cable	....	24	20	12	825	2000	2.4	29.2
		7	Cable	....	32	16	16	500	1000	2.0	33.3
		8	Electric	....	36	30	16	1100	2700	2.5	28.9
		11	Electric	....	36	35	16	1100	2600	2.4	29.7
II	2	13	Electric	....	42	30	16	2400	4300	1.8	35.8
		15	Third-rail	....	30	30	16	2200	3000	1.4	42.3
III	1 and 2	17	Cable	....	29	60	20	800	2000	2.5	28.6
		18	Cable	....	36	20	16	1600	3000	1.9	34.8
		19	Gasoline	One 5	36	30	16	1500	3000	2.0	33.3
		24	Gasoline	One 7	36	25	12	1200	2000	1.7	37.5
IV	5	25	Electric	One 10; three 6; one 3	36	30	12	1200	2600	2.2	31.6
		26	Electric	One 12; one 7; one 6	42	40	16	1500	3700	2.5	29.6
		28	Electric	Two 10	36	30	16	900	3000	3.3	23.1
		29	Gasoline	One 8	36	30	16	1300	4200	3.2	23.6
		31	Electric	Two 12; one 6	36	45	20	1300	3700	2.8	26.0
		33	Electric	Two 7½; two 5	42	35	16	1900	4000	2.9	32.2
		36	Electric	Two 12	36	30	16	1500	4400	2.9	25.4
		37	Electric	One 15; two 13	42	35	16	2200	6000	2.7	26.8
		38	Electric	One 10; two 8	36	35	16	1000	2800	2.8	26.3
		39	Gasoline	Three 12	42	30	20	1700	5000	2.9	25.4
V	5	43	Electric	Three 15	36	40	16	1800	4500	2.5	28.5
		44	Electric	One 10; six 6	42	30	20	2600	8000	3.1	24.5
		45	Electric	One 10; three 7	40	30	30	1000	4000	4.0	20.0
		48	Electric	One 6	42	16	16	1800	4500	2.5	28.5
		49	Electric	One 8	40	30	16	1300	3000	2.3	30.2
VI	6	50	Electric	One 15; two 13; three 6	42	35	20	2400	6400	2.7	27.3
		51	Electric	Two 10; one 6	42	30	16	1000	4200	4.2	19.2
		52	Electric	Two 12; one 6½	42	30	16	2250	6500	2.9	25.7
		53	Electric	....	42	60	25	3700	8000	2.2	31.6
		54	Electric	Two 12	36	40	16	1600	4125	2.6	28.0
		55	Cable	....	38	40	16	1300	3300	2.5	28.2
		56	Electric	Three 10	42	40	16	2200	6000	2.7	26.8
		57	Electric	Four 5; one 8	42	30	30	2400	6000	2.5	28.6
		58	Electric	Two 5; one 10; six 6; one 7½; one 13	42	40	20	2400	6000	2.5	28.6
		59	Electric	Three 15; one 10; two 6	42	55	16	2400	4700	2.0	33.8
		60	Electric	Three 13	42	25	16	2200	6000	2.7	26.8
		62	Electric	Four 10	42	30	20	1750	5600	3.2	23.8
		63	Electric	....	42	30	16	2200	7000	3.2	23.9
		64	Gasoline	One 8	36	30	16	1700	5000	2.9	25.4
		65	Electric	One 8; two 6	36	35	16	2000	5000	2.5	29.6

[1] Figures refer to weight of locomotive.

TABLE 33.—*Continued*

District	No. seam	No. mine	Kind of Locomotive	Weight in tons and number of each weight [1]	Track gage in inches	Rail weight in pounds per yard: Main entry	Rail weight in pounds per yard: Cross entry	Pit cars: Weight in pounds	Pit cars: Capacity in pounds	Ratio of coal to car weight	Per cent of car weight in total load
		66	Electric	One 15; one 12; one 6; one 5	42	40	20	2100	6500	3.1	24.4
		67	Electric	Two 13	36	40	18	1300	2800	2.2	31.7
		68	Electric	Two 10	42	30	16	2710	6300	2.3	30.1
		70	Electric	One 7; one 5	24	30	16	1200	4000	3.3	23.1
		71	Electric	Two 13	42	40	20	2150	6000	3.0	26.4
		72	Electric	Three 12	42	35	20	2000	5800	2.9	25.6
		73	Electric	Two 10	42	30	20	1900	5600	2.9	25.4
		74	Electric	One 12; one 5	42	35	20	3000	6000	2.0	33.3
		75	Electric	Four 10	42	30	18	1700	4700	2.8	26.6
		76	Electric	Three 10; two 5	38	35	16	1800	5000	2.8	26.5
VII	6	77	Electric	One 13; ten 5	48	40	20	4000	7700	1.9	34.2
		79	Gasoline	One 6	42	30	20	1050	4300	4.2	19.6
		80	Electric	One 6	32	25	16	1400	4000	2.9	25.9
		81	Gasoline	One 6	30	20	16	1000	3000	3.0	25.0
		82	Electric	Three 12; two 5	42	40	20	3000	7000	2.3	30.0
		84	Electric	Two 12; one 7; three 5	36	30	20	2000	6200	3.1	24.4
		85	Electric	....	26	30	12	1500	4500	3.0	25.0
		86	Electric	One 12; one 10; two 6; seven 5	42	30	20	2000	7000	3.5	22.2
		87	Electric	Two 10; one 8; one 3	26	35	16	1400	2800	2.0	33.3
		88	Third-rail	One 3	30	20	12	1100	2350	2.1	31.9
		89	Third-rail	One 4	36	20	16	2200	3500	1.6	38.6
VIII	6 and 7	93	Electric	Two 13; two 10	38	30	16	2200	5000	2.3	28.6
		94	Cable	....	36	16	16	1800	2500	1.4	41.9

[1] Figures refer to weight of locomotive.

TABLE 33.—*Continued*

District	No. seam	No. mine	Kind of Locomotive	Weight in tons and number of each weight [1]	Track gage in inches	Rail weight in pounds per yard: Main entry	Rail weight in pounds per yard: Cross entry	Pit cars: Weight in pounds	Pit cars: Capacity in pounds	Ratio of coal to car weight	Per cent of car weight in total load
Average by districts											
I	2				32	26	15	877	2033	2.3	30.6
II	2				36	30	16	2300	3650	1.6	39.1
III	1 and 2				36	34	16	1275	2500	2.0	33.7
IV	5				38	34	16	1450	3940	2.8	27.0
V	5				40	29	20	1700	4800	2.9	26.0
VI	6				41	36	18	2100	5588	2.7	27.0
VII	6				37	27	18	1929	5002	2.7	28.0
VIII	6 and 7				37	23	16	2000	3750	1.9	35.3
Average of 65 mines					37.6	32.3	17.3	1753	4450	2.5	28.6

[1] Figures refer to weight of locomotive.

which shows that less money is expended in hauling excess weight of cars. The percentage of car weight in total load of car and coal is about 28. This is the relation which obtains between weight of modern steel railroad cars and total weight of car and load. The pressed-steel railroad cars with a capacity of 100,000 pounds weigh empty from 38,000 to 46,000 pounds.

To keep locomotives in good repair there are well equipped machine shops underground in a few mines (See fig. 59) where locomotives are examined daily for defective parts and poor adjustments. The locomotives are consequently kept up to the highest possible mechanical efficiency.

FIG. 59. Underground machine shop

Mixed ties with dimensions 4 inches by 4 inches by 5½ feet are usually bought for the haulage roads. Mixed ties can be bought at Mulkeytown in District VI at 10 cents f. o. b. They are elm, hickory, water-oak, white-oak, and sassafras. The average shipment in Illinois contains about 10 per cent of white-oak ties, which are the most desirable. Mixed ties cost the middleman 7 cents each, of which amount 4 cents is paid for cutting and trimming in the woods and 3 cents for hauling to the shipping point. When white-oak ties are specified the purchaser pays 15 cents each f. o. b. shipping point, and the middleman 12½ cents. About 1000 ties can be cut from an acre of timber.

HOISTING

In Illinois in the year ended June 30, 1912, the coal was reached by a slope at 93 mines, by a drift at 214 and by a shaft at 572. Hoisting, according to the Illinois Coal Report for that year, was done by steam at 555 mines, by horses at 59, and by hand at 151. A few mines did not report hoisting methods. At a few mines hoisting at the present time is done by electricity.

Hoisting speed is remarkable in the mines of large production. In District VII at the No. 3 mine of the Superior Coal Company at Gillespie, where the bottom of the shaft is 346 feet below the dumping shoes in the tipple, 5,195 tons were hoisted in eight hours on June 3, 1915. At this mine the daily tonnage for a month was 4530. In Mine No. 1 of the New Staunton Coal Company at Livingston 1673 hoists in eight hours were made through a shaft 287 feet deep, an average of 3.48 hoists per minute. From July 1, 1914 to April 30, 1915, the number of tons hoisted daily at this mine averaged 4514.

Automatic caging is provided for in nearly all of the largest mines but there are some large mines where caging is done by hand.

Shaft bottoms often are too short and have not sufficient storage space for loads and empties to provide for hoisting very long after an accidental interruption of haulage.

The standard self-dumping cage is in common use except in District I where there are many platform cages often designed to hold two pit cars tandem. At one mine in this district and at two in District II an adaptation of ore skip is used which was designed by Mr. Robert E. Lee. Pit cars from the face on reaching the shaft bottom have their contents dumped, as shown in fig. 60, into a two-compartment hopper 9 feet deep lying below the floor. Each compartment of the hopper has a capacity of two pit cars and automatically discharges its contents into the skip. The skip is provided with a vertically-sliding door which is automatically lifted into the tipple discharging the contents of the skip on to the screens.

TABLE 34.—*Hoisting equipment for mines producing less than 1000 tons daily*

District	No. seam	No. mine	Average daily tonnage	Self dumping cage?	Hoisting shaft: Depth in feet	Hoisting shaft: Size in feet	Engine: First motion	Engine: Cylinder size in inches	Drum: Diameter in feet	Drum: Length in feet
I	2	2	900	No	465	8½ by 12	Yes	24 by 36	6½	8
		3	754	No	398	9 by 12	Yes	20 by 32	8	8
		4	550	[1]	546	7 by 12	Yes	13½ by 42	5	7
		5	400	No	135	6 by 12	Yes	18 by 36	8	4
		6	900	No	100	13[2]	Yes	14 by 20	3½	4
		7	800	No	200	7 by 16	Yes	16 by 30	5	6
		8	700	Yes	300	7 by 16	Yes	32 by 42	8	..
		9	200	Yes	....	6 by 8	No	14 by 20	6	5
II	2	12	150	Yes	125	6 by 14	Yes	12 by 16	4½	8
		14	300	No	135	7 by 12	Yes	18 by 36	4¾	8
III	1 and 2	15	800	Yes	160	7 by 16	Yes	16 by 32	6	6
		17	500	[1]	210	14 by 14½	No	14 by 24	..	..
		18	850	[1]	69	10 by 14	No	14 by 24	..	..
		19	850	No	70	8 by 16	No	13 by 16	..	..
		22	30	No	60	6 by 12	No	....	..	..
		24	350	No	40	7 by 14	No	9 by 12	..	..
IV	5	26	900	[3]	..	....	....	....	..	..
		27	550	Yes	170	6½ by 18	Yes	18 by 36	6	7
		28	950	Yes	150	8 by 16	No	14 by 20	6	8
		32	550	....	68	6 by 12	No	12 by 15	..	..
		34	650	Yes	200	7 by 14	Yes	16 by 32	6	7½
		35	275	No	187	8 by 16	No	12 by 15	5½	4½
		40	700	Yes	270	8 by 16	Yes	18 by 36	6	2
		41	325	No	365	6 by 16	Yes	16 by 24	6	8

[1] Skip.
[2] Diameter; circular shaft.
[3] Drift.

TABLE 34.—*Continued*

District	No. seam	No. mine	Average daily tonnage	Self-dumping cage?	Hoisting shaft: Depth in feet	Hoisting shaft: Size in feet	Engine: First motion	Engine: Cylinder size in inches	Drum: Diameter in feet	Drum: Length in feet
V	5	42	750	No	570	8 by 16	Yes	20 by 36	8	7
		47	400	....	90	7 by 4	No	12 by 24	5½	8
		48	800	....	76½	12½ by 8½	Yes	16 by 32	4½	4
VII	6	69	500	No	290	5½ by 11	Yes	16 by 30	6	2¾
		78	800	Yes	160	7 by 14	Yes	18 by 36	6½	4½
		81	800	Yes	200	7 by 14	Yes	24 by 36	6	6
		83	800	Yes	140	8½ by 16	Yes	20 by 36	6	3
		87	800	No	707	6 by 14	Yes	18 by 32	3	7½
		89	400	Yes	85	8 by 12	Yes	16 by 24	4	8
		90	500	No	160	7 by 14	No	12 by 24	5½	8
VIII	6 and 7	92	150	No	240	7 by 12	Yes	16 by 32	5½	4
		94	800	Yes	90	6 by 14	Yes	16 by 32	5	2
		95	50	No	..	5 by 8	[1]	....	5	4
		97	300	Yes	223	....	Yes	16 by 32	5	4
Average by districts										
I	2		650		306	7¼ by 12½		19 by 32	6½	6
II	2		417		140	6½ by 14		15 by 28	5	7½
III	1 and 2		433		90	9 by 14		12½ by 19	..	..
IV	5		628		248	8 by 15½		16 by 28	6	5
V	5		600		84	9½ by 6½		14 by 28	5	6
VI	6		657		249	7 by 13½		18 by 31	5	5½
VIII	6 and 7		360		178	6¼ by 12		15 by 25	5	4½
Average of 38 mines			573		213	7½ by 13½		16 by 28	5½	5½

[1] Horse whim.

The skip can be adjusted to hoist men. Weighing is done at the bottom. In the larger mines of District I the steam ram and transfer table are used in the tipple.

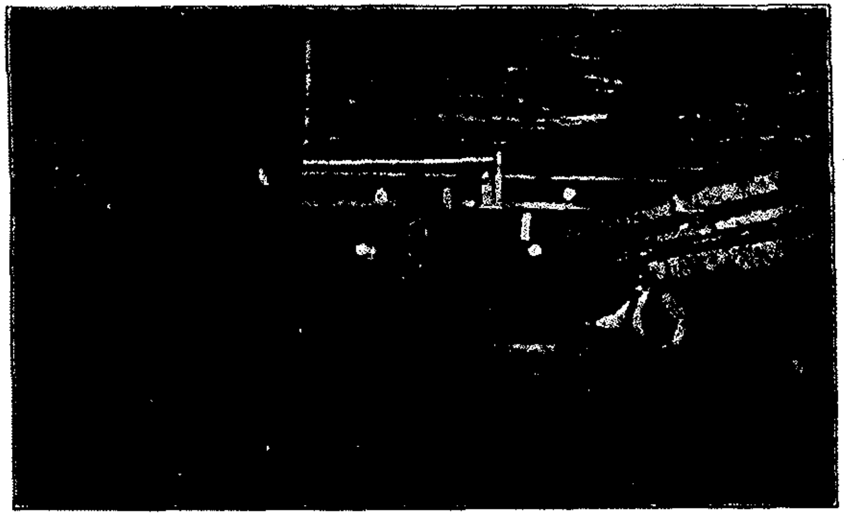


FIG. 60. Hopper for receiving coal at bottom of shaft

A skip is also used at one mine in District VI. Here the shaft was sunk 33 feet below the bottom of the coal. A bin was then built with its sloping bottom extending from beyond the tracks to the shaft. The pit cars, which are bottom-dumping, unload when a dog on the bottom of a car strikes a cam between the rails. The coal from the bin discharges into a skip 11 feet deep holding 7 tons. The shaft has three compartments; two 6¼ by 7 feet each for coal hoisting, and one 4 by 7 feet, for hoisting men by cages. Weighing is done at the shaft bottom of this mine. On account of the great weight of skip and load the hoisting engine is second motion.

The Peabody Coal Company at Nokomis has self-dumping cages holding two cars side by side.

The pneumatic signalling device is found at all but small mines. At these, signalling from shaft bottom to engine room is done by pulling a wire which rings a bell in the engine room.

TABLE 35.—*Hoisting equipment for mines producing 1000 and less than 2000 tons daily*

District	No. seam	No. mine	Average daily tonnage	Self-dumping cage?	Hoisting shaft: Depth in feet	Hoisting shaft: Size in feet	Engine: First motion	Engine: Cylinder size in inches	Drum: Diameter in feet	Drum: Length in feet
I	2	1	1,450	No[1]	413	12 by 12	Yes	24 by 42	8	7
		10	1,000	No[1]	480	12 by 16	Yes	24 by 42	8	8
		11	1,200	No	530	9 by 12	Yes	24 by 42	8	8
II	2	13	1,300	Yes	114	9 by 20	Yes	18 by 36	7	5
IV	5	25	1,200	Yes	185	8 by 16	Yes	18 by 36	5	6
		29	1,100	Yes	185	8½ by 15½	Yes	18 by 36	6	6
		31	1,200	...	90	7 by 8	No	....	..	..
		33	1,600	Yes	285	8½ by 16	Yes	24 by 40	8	3½
		38	1,400	Yes	245	7 by 14	Yes	20 by 36	6	2
V	5	44	1,400	Yes	270	10 by 20	Yes	24 by 36	6	3½
		45	1,600	Yes	320	8 by 14	Yes	22 by 36	6	5
		46	1,100	Yes	450	9 by 13½	Yes	20 by 36	..	..
		49	1,100	Yes	337	9 by 13½	Yes	22 by 36	6	8
VI	6	51	1,200	Yes	494	9½ by 12	Yes	24 by 36	6	5
		54	1,600	Yes	380	8 by 16	Yes	20 by 36	8	3½[2]
		55	1,200	No	160	7 by 16	Yes	16 by 36	6½	3
		56	1,400	Yes	580	7½ by 10	Yes	26 by 48	10	5
		57	1,600	Yes	320	9 by 15	Yes	24 by 36	7	10
		64	1,350	Yes	120	10½ by 14½	Yes	16 by 32	4½	6
		65	1,600	Yes	90	....	Yes	24 by 36	5	4

[1] Tandem platform.
[2] 2 drums.

TABLE 35.—*Continued*

District	No. seam	No. mine	Average daily tonnage	Self-dumping cages	Hoisting shaft: Depth in feet	Hoisting shaft: Size in feet	Engine: First motion	Engine: Cylinder size in inches	Drum: Diameter in feet	Drum: Length in feet
		67	1,250	Yes	320	8 by 12	Yes	20 by 32	7	4½
		70	1,250	Yes	92	8 by 13	No	12 by 20	5	8
		79	1,700	Yes	127	7 by 15	Yes	20 by 36	7	6
VII	6	80	1,000	Yes	145	7 by 14	Yes	18 by 36	5	8
		85	1,200	Yes	440	7½ by 16	Yes	22 by 30	7	3½
		86	1,800	Yes	536	9½ by 14½	Yes	24 by 42	8	4
		88	1,050	Yes	85	7½ by 11	Yes	16 by 32	6	6
VIII	6 and 7	91	1,250	Yes	217	8 by 12	Yes	24 by 36	7	2½
Averages by districts										
I	2		1,216		474	11 by 13½		24 by 42	8	7½
II	2		1,300		114	9 by 20		18 by 36	7	5
IV	5		1,300		198	8 by 14		20 by 37	6½	4½
V	5		1,300		344	9 by 15¼		22 by 36	6	5½
VI	6		1,422		307	8½ by 14		21½ by 37	7	5½
VII	6		1,322		249	7¾ by 3½		19 by 33	6	2½
VIII	6 and 7		1,250		217	8 by 12		24 by 36	7	2½
Average of 28 mines			1,325		286	8½ by 14		21 by 36	6½	3½

The compensating conical drum is generally preferred in the deeper mines and the first-motion hoisting engine is general, the geared engine being found only at the old mines. Tables 34, 35, and 36 give different hoisting data for mines of different daily tonnage. Tonnage is the chief factor in determining equipment for hoisting because at the deepest mine in Illinois the hoist is only 1004 feet.

At slope mines hoisting is often done by a partly balanced rope on a two-track incline where the weight of the descending empties assists in hoisting the loaded cars.

The State Mining Law by a provision passed in 1913 specified that all shafts sunk subsequent to the passage of the law shall be fireproofed. Since 1913 one or two shallow masonry-lined shafts have been sunk but nearly all new shafts are lined with concrete. One of the earliest concrete-lined shafts built in this country is at the No. 6 mine of the Big Four Wilmington Coal Company at Coal City. Two circular shafts were sunk, one of which, the air shaft, 10 feet in diameter, was finished in May, 1903. The hoisting shaft, 13 feet in diameter, as shown in fig. 61, was completed in June, 1903. Both of these shafts were lined with concrete 14 inches thick from rock 40 feet deep to a point 8 feet above the surface level, making a total of 48 linear feet of concrete lining. Fig. 62 shows the plan and section of a hoisting shaft in District V. The excavation was made through the top soil and sandstone and the lining was built up from the bottom beginning with the water seal at solid rock. The concrete is reinforced vertically with ⅜-inch by 2-inch iron bars and horizontally by ¾-inch twisted rods. The proportions of the concrete used are: 1 Portland cement; 2 sharp washed sand; 4 crushed limestone. The linings of both shafts were built with great care and are excellent examples of fireproof shaft construction under the new State law. Below the concrete the shafts are limestone except the last 91 feet which is gray shale. The buntons below the seal are placed in hitches cut in the rock. The yellow pine guides are made up to 6 by 8 inches. Where the shaft at a depth of 100 feet from the surface passes through bed 7 it is bricked by a wall 9 feet high and 12 inches thick.

Table 36.—*Hoisting equipment for mines producing 2000 tons and over daily*

District	No. seam	No. mine	Average daily tonnage	Self-dumping cage?	Hoisting shaft: Depth in feet	Hoisting shaft: Size in feet	Engine: First motion	Engine: Cylinder size in inches	Drum: Diameter in feet	Drum: Length in feet
IV	5	36	2,450	Yes	238	9½ by 19	Yes	24 by 36	8	6
		37	2,700	Yes	235	10 by 16	Yes	24 by 36	7	5
		39	2,400	Yes	204	10 by 20	Yes	22 by 36	7	3
V	5	43	2,500		160	14 by 12	Yes	18 by 32	6	5
VI	6	50	2,000	Yes	726	10 by 18	Yes	28 by 48	10	5
		52	2,400	Yes	640	9½ by 17½	Yes	26 by 48	10	4⅝
		53	2,500	[1]	450	7 by 18	No	18 by 30	10	10
		58	2,500	Yes	516	9½ by 17	Yes	24 by 42	8	4
		59	3,000	Yes	220	8 by 12	Yes	24 by 42	10	5
		60	2,250	Yes	112	10 by 20	Yes	20 by 36	7½	..
		62	2,325	Yes	190	9 by 17½	Yes	24 by 36	7	2
		63	2,600	Yes	140	10 by 16	Yes	24 by 36	6	5
VII	6	66	4,000	Yes	332	8 by 14	Yes	24 by 36	8	3
		68	2,500	Yes	387	8 by 15	Yes	24 by 36	8	3½
		71	2,500	Yes	194	8 by 18	Yes	20 by 36	6	7
		72	4,000	Yes	287	8½ by 14½	Yes	24 by 36	8	..
		73	3,750	Yes	318	8 by 17	Yes	24 by 36	8	8¾
		74	2,800	Yes	330	9½ by 18	Yes	24 by 36	8	..
		75	2,000	Yes	310	8½ by 14	Yes	24 by 36	8	6
		76	2,120	Yes	370	11 by 22	Yes	24 by 36	7	6
		77	2,500	Yes	462	9 by 16	Yes	24 by 40	9	5
		82	3,000	Yes	192	9 by 18	Yes	24 by 36	7	8
		84	2,000	Yes	320	8 by 16	Yes	24 by 36	7	5

[1] Skip.

Table 36.—*Continued*

District	No. seam	No. mine	Average daily tonnage	Self-dumping cage?	Hoisting shaft: Depth in feet	Hoisting shaft: Size in feet	Engine: First motion	Engine: Cylinder size in inches	Drum: Diameter in feet	Drum: Length in feet
VIII	6 and 7	93	2,600	Yes	186	9 by 14	Yes	24 by 36	7	2½
Averages by districts										
IV	5		2,517		226	9¾ by 18⅓		23 by 36	7½	4¾
V	5		2,500		160	14 by 12		18 by 32	6	5
VI	6		2,447		374	9 by 17		23½ by 39¾	8½	5
VII	6		2,834		318	9 by 16½		24 by 36	8	5¾
VIII	6 and 7		2,600		186	9 by 14		24 by 36	7	2½
Average of 24 mines			2,641		313	9¾ by 16½		24 by 38	8¾	5

With but few exceptions the shafts sunk prior to 1913 are timber lined. The development of the cement gun has provided a means of fireproofing these shafts. The timber lining can be given a concrete cover by means of the cement gun which sprays under air pressure of about 40 pounds per square inch a cement mortar composed of about 1 part Portland cement and 3 parts coarse sharp sand. At a shaft in District VI the timber lining was covered with a 2-inch layer of "Gunite", as concrete applied by this method is called, at the rate of 190 square yards in 8 hours. The walls of the shaft were first covered with American Steel and Wire Company's No. 7A netting as a reinforcement for the concrete.

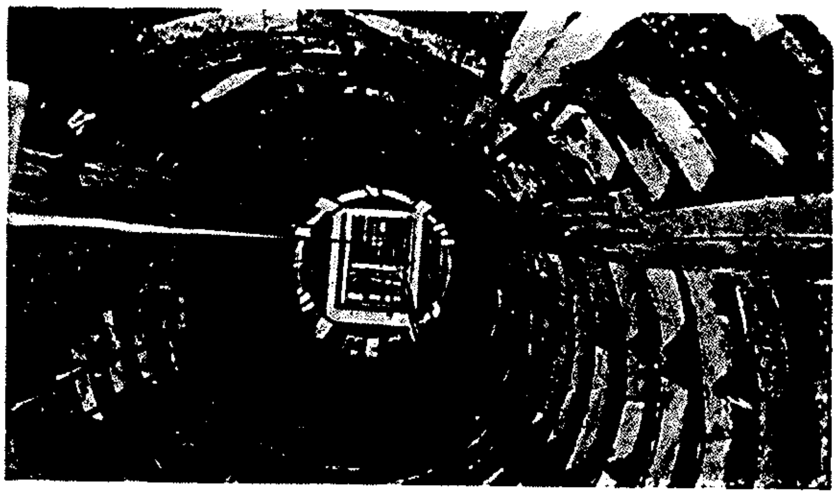


FIG. 61. Circular hoisting shaft

Gunite sets in 2½ to 3 hours. The cost of application varies from 16 to 24 cents per square foot depending largely upon the amount of water the shaft makes. With a dry and smooth timber lining the work should average about 20 cents per square foot.

The shafts of all mines in Illinois are of moderate size, the largest at the mines examined being 11 by 22 feet. No serious difficulties have been encountered in sinking them. Water flow has never been large. At one mine in District VI a considerable body of quicksand necessitated a reduction of shaft size but in general shaft sinking is comparatively cheap and speedy.

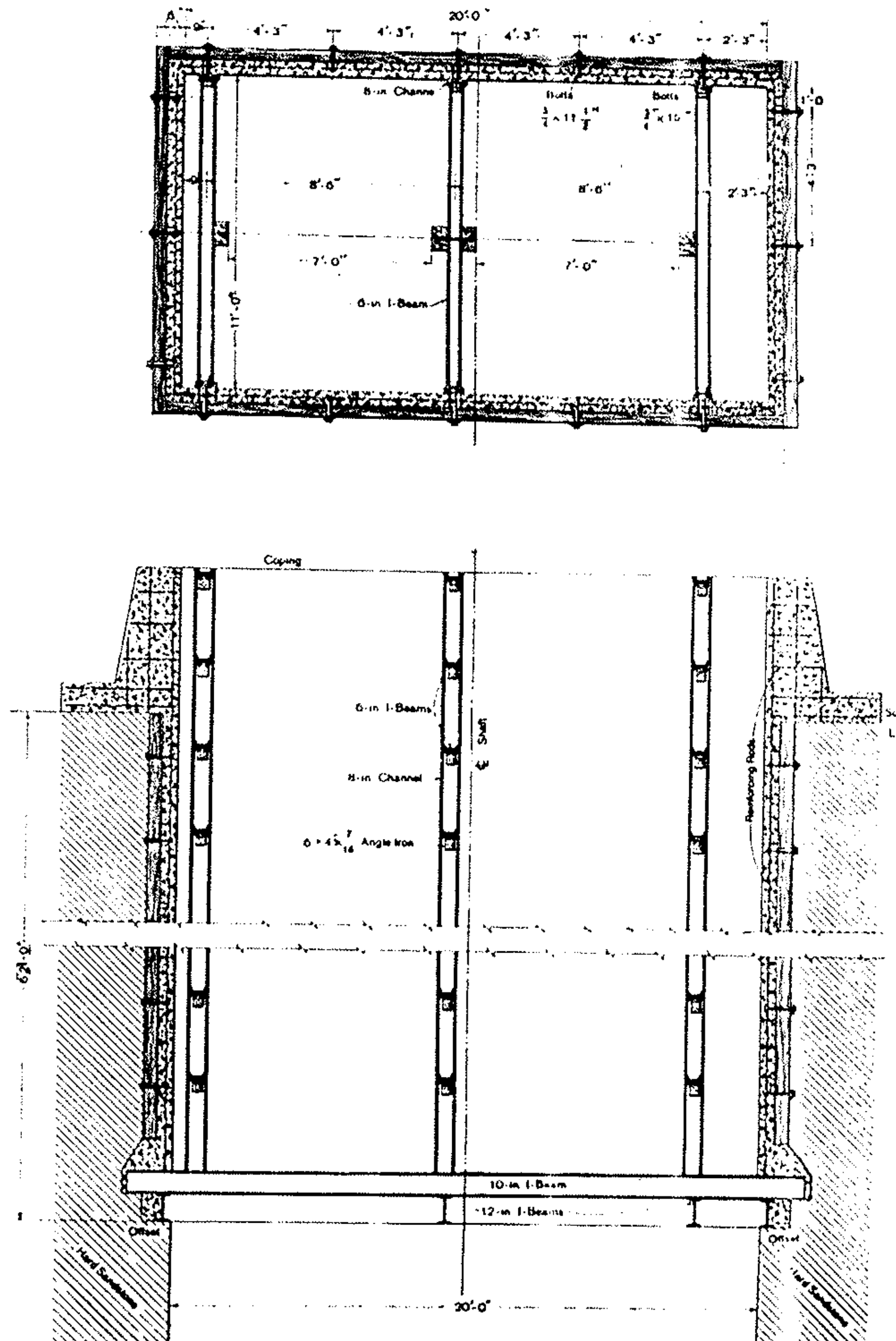


FIG. 62. Plan and section of concrete-lined shaft

PREPARATION OF COAL

About 20 per cent of the production of Illinois mines is sold as run-of-mine coal. This coal on reaching the tipple is dumped into chutes and loaded directly into cars without receiving any preparation. The remaining 80 per cent of the output receives treatment before shipment. Fig. 63 shows the equipment for preparation at a local mine. As regards the preparation of their coal for market the mines of the State may be divided into those at which the raw coal is sized on shaking screens only; those at which the product passing through the 2 to 3½-inch holes of the shaking screens is rescreened in revolving screens; and those at which the coal under 3 or 3½-inches is washed.

At mines where the coal receives no further treatment than separation into sizes on shaking screens four sizes are usually made at a time. These sizes vary widely in different districts and at different times of the year. They are called generally lump, egg, nut, and screenings but the same term does not mean the same size in different districts. The coal which passes over the largest sized holes in the screen is called lump whether the holes are 1¼ inches, 6 inches, or any intermediate size. Table 37 gives the variations in names and sizes. Six-inch lump is made in all districts and refers always to the oversize from screens with 6-inch holes.

Where the coal is rescreened but not washed a typical separation is:

Name	Size in inches	Per cent of total output
Lump	Over 6	15
Egg	Over 3½; through 6	19
No. 1 nut	Over 1¾; through 3½	16
No. 2 nut	Over 1 ; through 1¾	15
No. 3 nut	Over ¾; through 1	7
No. 4 nut	Over ¼; through ¾	7
No. 5 nut	Through ¼	21

At different mines and in different districts sizes vary somewhat but those given in the table may be taken as average. A bulletin dealing with the dry sizing of coal has been

prepared for the Engineering Experiment Station of the University of Illinois by Prof. E. A. Holbrook and will soon be published.

TABLE 37.—*Sizes of coal made in Illinois*

Name	District	Size in inches
8-inch lump	IV	Over 8
6-inch lump	I, II, III, IV, V, VI, VII, VIII	Over 6
4-inch lump	VIII	Over 4
3-inch lump	IV, VIII	Over 3
2¼-inch lump	II	Over 2¼
2-inch lump	III, IV, VII	Over 2
1½-inch lump	I, II	Over 1½
1¼-inch lump	I, II, III, IV, V, VI, VII, VIII	Over 1¼
Chunk	I	Through 6; over 3½
Egg	I, II, III, IV, V	Over 4; through 6 Over 3; through 6 Over 2; through 6 Over 1¼; through 6
Nut	II, III, IV, V, VI, VII	Over 2; through 3 Over 1½; through 3 Over 1¼; through 3 Over 1¼; through 2 Over 1⅛; through 1½ Over ¾; through 1½ Over ¾; through 1¼ Over ¼; through 1¼
Pea	III	Over ¼; through 1¼
Screenings	I, II, III, IV, V, VI, VII, VIII	Through 2¼ Through 2 Through 1½ Through 1¼ Over 1; through 1¼ Through 1⅛

F. C. Lincoln in Bulletin No. 69, Coal Washing in Illinois, Engineering Experiment Station, University of Illinois, says

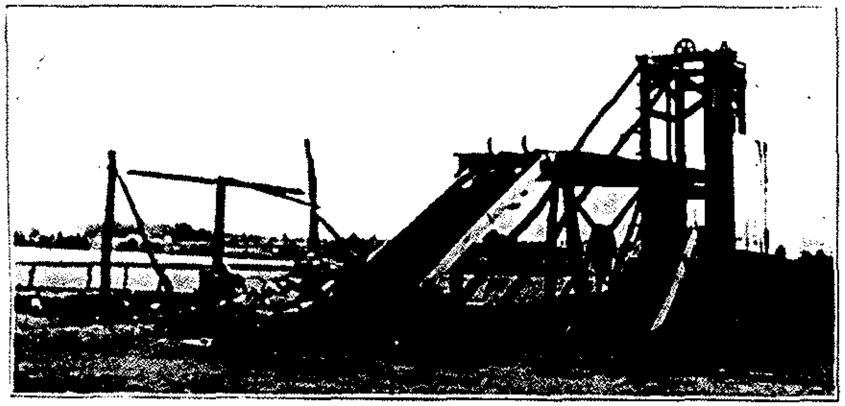


FIG. 63. Equipment for preparation at local mine. (From unpublished report by Prof. E. A. Holbrook.)

that no two washeries in Illinois make washed coals of exactly the same sizes. The range in inches is as follows:

	No. 1 extra	No. 1	No. 2 extra	No. 2	No. 3	No. 4	No. 5
Always under......	3¼	3½	2¼	2¼	1½	⅞	3/16
Always over......	2½	1¼	1⅛	⅞	⅝	3/16	0

The impurities in the coal which are shale, fireclay, and nodules of pyrites, are separated as far as possible at the face. Where fireclay is shot up with the coal the separation underground is comparatively easy on account of the contrast in color. A further picking is made at many mines on the screen and car; six pickers being employed at some mines.

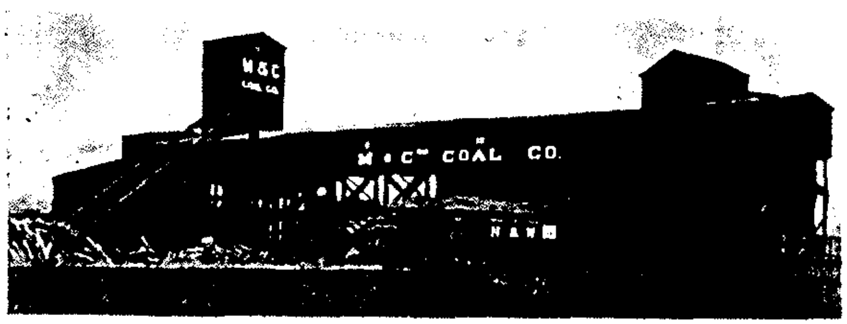


FIG. 64. Tipple designed for local trade and shipping

TABLE 38.—*Preparation of coal*

District	No. seam	No. mine	Material of tipple	Sizing screen: Type	Length in feet	Width in feet	Inclination, inches per foot	Shakes per minute	Is coal rescreened or washed?	Per cent of total output over 1¼ inches
I	2	1	Timber	Shaking	24	6	3	120	Neither	80
		2	Timber	Shaking	43	6	3	85	Neither	83
		3	Timber	Shaking	34	6	3	110	Neither	79
		4	Timber	Shaking	27	6	3	80	Rescreened	65
		5	Timber	Shaking	57	6	3	80	Washed	70
		6	Timber	Shaking	22	6	3	90	Washed	80
		7	Timber and steel	Shaking	24	6	3	120	Washed	73[1]
		8	Steel	Shaking	48	6	3	75	Neither	73[1]
		9	Timber	....	..	..	..	..	....	..
		10	Steel	Shaking	50	8	2½	60	Both	83[2]
		11	Timber	Shaking	..	5	2½	60	Washed	83
II	2	12	Timber	Shaking	32	6	3	90	Neither	70
		13	Timber	Shaking	40	8	4	84	Neither	50
		14	Timber	Shaking	16	6	4	60	Neither	55[1]
		15	Timber	Shaking	42	6	3	100	Washed	60
III	1 and 2	17	Timber	Shaking	18	12	4	80	....	75
		18	Steel	Shaking	12	7	4	85	....	75
		19	Timber	Shaking	34	6	4	90	....	..
		22	Timber	Gravity bar	12	6	4	..	....	80
		24	Timber	Shaking	32	5½	3	60		75

[1] Over 1½ inches.
[2] Over ¾-inch.

TABLE 38.—*Continued*

District	No. seam	No. mine	Material of tipple	Sizing screen: Type	Length in feet	Width in feet	Inclination, inches per foot	Shakes per minute	Is coal rescreened or washed?	Per cent of total output over 1¼ inches
IV	5	25	Steel	Shaking	25	6	4	76	Rescreened	68
		26	Steel	Shaking	37½	8	4	80	Neither	70
		27	Steel	Shaking	32	8	4	78	Neither	70
		28	Wood	Shaking	..	12	4	82	Rescreened	75
		29	Wood	Shaking	75	..	4	76	....	71
		31	Wood	Shaking	31	7	3	80	Neither	67
		32	Wood	Shaking	30	6	4	80	Neither	68
		33	Wood	Shaking	68	8	3	78	Rescreened	75
		34	Wood	Shaking	30	5½	4	79	....	67
		35	Wood	Shaking	36	6	3	80	Neither	..
		36	Wood	Shaking	..	12	..	80	Neither	67
		37	Wood	Shaking	55	12	3	80	Neither	65
		38	Wood	Shaking	38	6	4	76	Neither	..
		39	Steel	Shaking	45	15	3	80	Neither	70
		40	Wood	Shaking	46	4	3	80	Neither	71
		41	Wood	Shaking	..	6	4	75	Rescreened	70
		42	Wood	Shaking	..	7	4	..	Rescreened	68[1]
V	5	43	Wood	Shaking	14	7	4	75	Rescreened	70
		44	Steel	Shaking	48	5	3	90	Neither	70
		45	Wood	Shaking	38	7	4	90	Rescreened	..
		46	Wood	Shaking	30	8	4	75	Neither	45[2]
		47	Wood	Shaking	38	6	1½	70	Both	55
		48	Wood	Shaking	40	6	4	85	Neither	70
		49	Wood	Shaking	30	6	4	80	Neither	75

[1]Over 2 by 2½-inch holes. [2]Over 3 inches.

TABLE 38.—*Continued*

District	No. seam	No. mine	Material of tipple	Sizing screen: Type	Length in feet	Width in feet	Inclination, inches per foot	Shakes per minute	Is coal rescreened or washed?	Per cent of total output over 1¼ inches
VI	6	50	Steel	Shaking	30	8	4	90	Neither	65
		51	Frame	Shaking	24	8	5	70	Neither	62
		52	Steel	Shaking	40	8	4	90	Rescreened	60
		53	Steel	Shaking	11½	8½	5	85	Rescreened	63
		54	Frame	Shaking	12	7	2½	40	Rescreened	60
		55	Frame	Shaking	24	7	4	90	Both	60
		56	Steel	Shaking	38	8	3	90	Rescreened	46
		57	Frame	Shaking	46	6	3	90	Neither	65
		58	Steel	Shaking	40	9	2	80	Rescreened	58
		59	Frame	Shaking	40	8	3	60	Neither	60
		60	Steel	Shaking	..	..	4	65	Neither	60
		62	Frame	Shaking	40	8	3	80	Both	60
		63	Steel	Shaking	..	..	4	..	Both	..
		64	Frame	Shaking	16	10½	4	75	Both	45
		65	Frame	Shaking	45	7	3	90	Neither	47
VII	6	66	Steel	Gravity bar	12	6	4	90	Washed	..
		67	Corrugated iron	Shaking	40	8	3	80	Neither	65
		68	Corrugated iron	Shaking	28	8	4	66	Washed	73
		69	Frame	Shaking	18	6	3	80	Neither	60
		70	Corrugated iron	Shaking	30	7	4	60	Washed	70
		71	Frame	Shaking	..	7	3	80	Neither	70
		72	Frame	Shaking	55	8	4	85	Neither	75
		73	Steel	Shaking	50	7	4	80	Neither	72
		74	Steel	Shaking	48	7	3	80	Rescreened	75

TABLE 38.—*Continued*

District	No. seam	No. mine	Material of tipple	Sizing screen: Type	Length in feet	Width in feet	Inclination, inches per foot	Shakes per minute	Is coal rescreened or washed?	Per cent of total output over 1¼ inches
VII	6	75	Frame	Shaking	36	8	3	80	Neither	67
		76	Steel	Shaking	50	7	4	100	Washed	74
		77	Corrugated iron	Shaking	25	10	3	48	Neither	71
		78	Corrugated iron	Shaking	40	8	3½	90	Neither	75
		79	Frame	Shaking	30	8	3	95	Neither	71
		80	Frame	Shaking	30	6	4	90	Rescreened	..
		81	Frame	Shaking	30	6	4	90	Neither	60
		82	Steel	Shaking	40	9	4	82	Neither	72
		83	Corrugated iron	Shaking	32	10	4	90	Neither	70
		84	Steel	Shaking	30	9	4	90	Washed	72
		85	Steel	Shaking	25	8	3	..	Neither	..
		86	Steel	Shaking	..	8	4	92	Neither	67
		87	Frame	Gravity bar	8	6	4	..	Rescreened	70
		88	Frame	Shaking	18	6	4	60	Neither	65
		89	Frame	Shaking	40	6	4	60	Neither	65
		90	Frame	Gravity bar	30	8	4	..	Neither	70
		91	Frame	Gravity bar	12	8	4	..	Neither	40
		92	Frame	Gravity bar	24	8	4½	..	Neither	70
		93	Frame	Gravity bar	33	9	4	..	Neither	65
VIII	6 and 7	94	Frame	Shaking	22	6	4	100	Neither	60
		95	Frame	Gravity bar	6	4	4	..	Neither	55
		97	Frame	Shaking	36	8	4	100	Neither	50

TABLE 38.—*Continued*

District	No. seam	No. mine	Material of tipple	Sizing screen: Type	Length in feet	Width in feet	Inclination, inches per foot	Shakes per minute	Is coal rescreened or washed?	Per cent of total output over 1¼ inches
Averages by districts										
I	2				37	6	3	88		77
II	2				35	6½	3½	84		60
III	1 and 2				22	7	4	86		76
IV	5				42	8	3½	79		69
V	5				48	6½	3½	81		68
VI	6				31	8	3½	71		58
VII	6				33	7½	3¾	80		69
VIII	6 and 7				23	7	4	100		57
Average of 90 mines					33	7¼	4	82		67

Shaking screens are of various types. They are built with one, two, or three decks, and are from 12 to 75 feet long and 4 to 12 feet wide. They make from 48 to 120 strokes per minute. Their inclination averages 4 inches per foot.

Revolving screens in rescreeners vary in length from 16 to 24 feet, in diameter from 2½ to 6 feet, and in inclination from 1¾ to 2¼ inches per foot. They average 15 revolutions per minute.

District IV was among the first in Illinois to attempt to remove the separable impurities from coal and to separate sizes. Several large cities are located in the district and the local trade for domestic purposes has always been and still is a prominent factor. Fig. 64 shows a tipple designed for handling local trade and shipping. Those mines located in or near cities naturally separate the coal into more sizes than the others and for this purpose several of them have installed rescreening plants. A typical separation at a mine catering to local domestic or "wagon" trade is:

Name	Size in inches
6-inch lump	Over 6
3-inch lump	Over 3
1¼-inch railroad lump	Over 1¼
6-inch egg	Over 3; through 6
Nut	Over 2; through 3
Pea	Over ¾; through 1¼
Screenings	Through ¾

The location of some mines near cities having diversified manufactures and various kinds of domestic furnaces leads to particular demands. At one mine 30 per cent of the output is crushed to 2-inch size for use in distilleries. At another, 8-inch lump and egg are in demand. Several mines make a nut through 1¼ inches and over 1 inch and one makes a "domestic lump" over 3 inches.

In District VIII in seam 7 where iron pyrites or "sulphur" is not disseminated through the coal but is present in nodular form, it can easily be separated from the coal by hand at the working face. This separation serves the double purpose of making cleaner coal and of segregating a valuable by-product. The amount of pyrites thus obtained was sufficient at two mines working in No. 7 bed to warrant the erec-

TABLE 39.—*Surface plant equipment of mines producing less than 1000 tons daily*

District	No. seam	No. mine	Average daily tonnage	Boilers		Average steam pressure	Electric generators		Air compressors	
				No.	Total H. P.		K. W.	Volts	No.	Pressure in pounds per sq. in.
I	2	2	900	6	720	115	125	275	..	...
		3	750	4	600	90	...	...	..	...
		4	550	2	300	106	100	250	..	...
		5	400	4	300	85	...	...	..	...
		6	900	2	300	140	...	...	..	...
		7	800	6	200	75	...	...	..	...
		8	700	3	800	100	150	250	..	...
		9	200	2	200	90	...	...	..	...
II	2	12	150	2	300	100	...	...	..	...
		14	300	9	450	80	...	...	..	...
		15	800	8	200	120	125	250	..	...
III	1 and 2	17	500	7	500	100	...	...	..	...
		18	850	3	750	110	...	...	..	...
		19	850	3	450	100	...	...	..	...
		22	30	1	16	70	...	...	..	...
		24	350	2	300	90	...	...	..	...
IV	5	25	900	..	...	...	150	250	..	...
		27	550	3	700	70	100	250	..	...
		28	950	3	225	100	150	250	..	...
		32	550	3	250	90	100	250	..	...
		34	650	2	250	95	50	125	..	...
		35	275	3	175	80	100	225	..	...
		40	700	3	185	80	100	250	..	...
		41	325	4	280	80	50	150	..	...
		42	750	4	350	110	8	110	..	...

District	No. seam	No. mine	Average daily tonnage	Boilers: No.	Boilers: Total H. P.	Boilers: Average steam pressure	Electric generators: K. W.	Electric generators: Volts	Air compressors: No.	Air compressors: Pressure in pounds per sq. in.
V	5	47	400	3	240	95	...	...	..	...
		48	800	2	250	120	150	250	..	...
VII	6	69	500	3	240	90	...	...	..	...
		78	800	4	300	100	...	...	1	85
		81	800	1	150	115	...	...	..	...
		83	800	4	600	110	...	...	1	90
		87	800	4	550	100	100	250	..	...
		89	400	3	450	100	75	250	..	...
		90	500	4	600	80	...	...	1	80
VIII	6 and 7	92	150	1	90	125	...	...	..	...
		94	800	3	450	100	22½	250	..	...
		95	50	1	18	80	...	...	..	...
		97	300	3	310	...	...	...	..	...
Averages by districts										
I	2		650	4	428	100	125	258	..	...
II	2		417	6	317	100	125	250	..	...
III	1 and 2		433	3	403	94	...	...	..	...
IV	5		628	3	302	88	89	207	..	...
V	5		600	3	245	108	150	250	..	...
VII	6		657	3	413	100	88	250	1	85
VIII	6 and 7		360	2	217	102	22½	250	..	...
Average of 38 mines			573	3	353	97	97	228	1	85

tion of small plants for removing before the pyrites is shipped to a sulphuric-acid plant the coal that adheres to the nodules of pyrites. The pyrites with adhering coal is crushed to 1½-inch mesh and elevated to a bin whence it is discharged into a revolving trommel 4 feet long and 3 feet in diameter with 2-inch round holes. The oversize from this trommel goes to a one-cell jig for washing. The undersize goes to a second trommel with ¼-inch perforations and the undersize from the second trommel is discharged into a three-cell jig which separates coal and pyrites. The oversize from the second trommel and the undersize from the first trommel are elevated to a third trommel with ⅝-inch perforations from which the oversize goes to market and the undersize to the three-cell jig which cleans the fine pyrites. Table 38 gives data on tipple equipment for coal preparation.

FIG. 65. Inflammable material piled against frame tipple

Power at surface plants is usually obtained by burning slack under steam boilers. The efficiency of nearly all of these plants is low. At only a few mines has the steam plant the refinements of the modern manufacturing plant. From 1.7 to 4.3 per cent of the output of each mine is burned under boilers at the surface plant. Wasted coal ranges from 0.5 to 0.7 per cent.

In District IV good combustion under boilers is obtained at one mine by the use of steam blowers and the slack burns with no clinkers.

Electric power is purchased at a few mines and at one where power is purchased at 2½ cents per kilowatt-hour, three-phase 60-cycle alternating current is brought to the plant at 4000 volts and there transformed to 275 volts. The installation consists of three 15 H. P. motors. An A. C. electric locomotive is used on the main haulage. Alternating current is reported to be less satisfactory for haulage than direct, but by using an A. C. locomotive a converter is dispensed with.

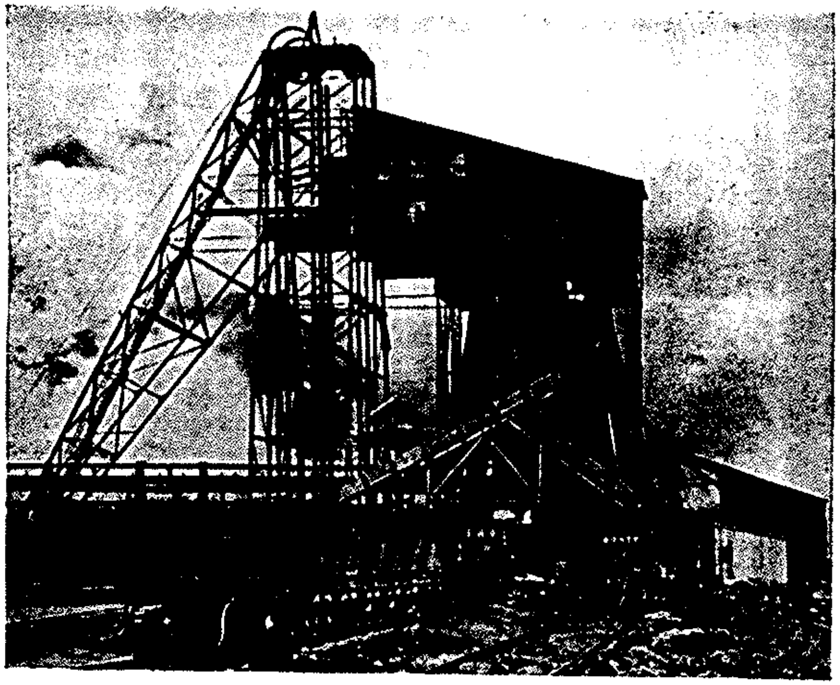


FIG. 66. Fireproof steel tipple

At the older mines tipples are usually of frame construction and at many of them proper precautions against fire are neglected. Often inflammable material, such as empty oil barrels shown in fig. 65, is stored near the tipple. The frequent loss of tipples by fire emphasizes the need of greater care in the storing of combustible material on the surface.

At almost every new mine a steel tipple is built. Fig. 66 shows a typical modern surface plant in District VI. Tables 39, 40, and 41 give power plant equipment for mines of different daily outputs.

The average cost of preparation where the coal is neither rescreened nor washed is said by Mr. B. L. Shepard to be 3 cents per ton of coal.

TABLE 40.—*Surface plant of mines producing 1000 and less than 2000 tons daily*

District	No. seam	No. mine	Average daily tonnage	Boilers			Electric generators		Air compressors	
				No.	Total H. P.	Average steam pressure	K. W.	Volts	No.	Pressure in pounds per sq. in.
I	2	1	1,450	6	900	90	...	...	...	...
		10	1,000	6	900	90	120	250	...	...
		11	1,200	9	...	112	...	...	...	...
II	2	13	1,300	6	900	125	225	250	...	...
IV	5	25	1,200	5	700	90	200	250	...	...
		29	1,100	2	250	100	100	250	...	...
		31	1,200	6	875	90	300	250	...	...
		33	1,600	6	750	105	150	250	...	...
		38	1,400	4	600	100	150	250	...	...
V	5	44	1,400	4	600	100	300	275	...	...
		45	1,600	4	600	110	150	250	...	...
		46	1,100	3	450	110	100	250	...	...
		49	1,100	3	450	120	150	250	...	...
VI	6	51	1,200	6	900	100	100	250	3	100
		54	1,600	4	600	120	258	275	1	70
		55	1,200	8	800	110			...	...
		56	1,400	6	900	100	300	250	...	...
		57	1,600	2	565	120	200	250	...	...
		64	1,350	4	450	90	...	...	...	...
		65	1,600	4	500	80	150	250	...	...

TABLE 40.—*Continued*

District	No. seam	No. mine	Average daily tonnage	Boilers			Electric generators		Air compressors	
				No.	Total H. P.	Average steam pressure	K. W.	Volts	No.	Pressure in pounds per sq. in.
VII	6	67	1,250	8	900	80	100	250	..	...
		70	1,250	5	500	90	150	250	2	90
		79	1,700	4	400	110	125	250	..	...
		80	1,000	4	500	90	100	250	..	...
		85	1,200	4	450	100	100	250	..	...
		86	1,800	5	575	100	200	275	..	...
		88	1,050	5	400	110	200	250	1	80
VIII	6 and 7	91	1,250	2	300	120	10	250	..	...
Averages by districts										
I	2		1,216	7	900	97	120	250	..	...
II	2		1,300	6	900	125	225	250	..	...
IV	5		1,300	5	635	97	180	250	..	...
V	5		1,300	4	525	110	175	256	..	...
VI	6		1,422	5	674	103	202	255	2	85
VII	6		1,322	5	532	97	140	254	2	85
VIII	6 and 7		1,250	2	300	120	10	250	..	...
Average of 28 mines			1,325	5	619	102	164	253	2	85

TABLE 41.—*Surface plant equipment of mines producing 2000 tons daily and over*

District	No. seam	No. mine	Average daily tonnage	Boilers			Electric generators		Air compressors	
				No.	Total H. P.	Average steam pressure	K. W.	Volts	No.	Pressure in pounds per sq. in.
IV	5	36	2,450	5	700	90	...	...	..	...
		37	2,700	5	750	90	200	250	..	...
		39	2,400	4	600	115	45	125	..	...
V	5	43	2,500	5	750	110	150	250	..	...
VI	6	50	2,000	8	1,500	100	150	265	2	80
		52	2,400	7	1,050	125	300	300	..	...
		53	2,500	6	400	130	500	250	3	100
		58	2 500	7	1,050	120	...	250	..	...
		59	3,000	8	900	125	150	250	..	...
		60	2,250	4	750	85	300	250	..	...
		62	2,325	9	1,350	90	175	250	2	85
		63	2,600	12	2,000	90	150	250	2	65
VII	6	66	4,000	8	1,200	110	200	260	2	70
		68	2,500	10	1,250	100	175	250	2	80
		71	2,500	6	1,400	110	275	250	1	80
		72	4,000	8	1,000	120	200	275	..	...
		73	3,750	5	750	100	150	250		
		74	2,800	6	900	120	175	250	..	...
		75	2,000	6	840	100	250	250	..	...
		76	2,120	10	1,200	120	200	250	1	100
		77	2,500	3	750	125	300	250	..	...
		82	3,000	9	1,350	125	250	260	2	90
		84	2,000	8	1,200	110	550	260	2	100

TABLE 41.—Continued

District	No. seam	No. mine	Average daily tonnage	Boilers: No.	Boilers: Total H.P.	Boilers: Average steam pressure	Electric generators: K.W.	Electric generators: Volts	Air compressors: No.	Air compressors: Pressure in pounds per sq. in.
VIII	6 and 7	93	2,600	6	900	100	150	275	...	...
Averages by districts										
IV	5		2,517	5	683	98	123	188	...	...
V	5		2,500	5	750	110	150	250	...	...
VI	6		2,447	8	1,125	108	247	258	2	82
VII	6		2,834	7	1,076	113	248	255	2	87
VIII	6 and 7		2,600	6	900	100	150	275	...	...
Average of 24 mines			2,641	7	1,023	109	227	251	2	85

MARKETS AND SELLING PRICE

The opening in the early nineties of the rich fields in southern Illinois east of the *Duquoin anticline* was a *most* important economic factor, and a disturbing one to the other fields. The causes of the low market prices which have prevailed for several years are well cataloged by Mr. Geo. S. Rice, Chief Mining Engineer of the U. S. Bureau of Mines in the Year Book for 1908 of the Illinois Geological Survey. Mr. Rice says, "The tremendous development of the coal-carrying railroads and the policy of making low ton-mile rates for long hauls has resulted in excessive competition, both from within and from without the State. The cheaply produced coals of the eastern states, *and particularly West Virginia, resulting* from favorable natural conditions and lower labor-cost, with through low freight-rates, have enabled them to enter the natural coal markets of Illinois and sell at prices very little above what the Illinois coals bring. The high quality of these coals, particularly those that make little smoke, has allowed them to set the pace in making prices.

The competition between the Illinois coals has been even more severe. This results from the multiplicity of ownerships, due mainly to the ease of opening new mines. Each period of unusual prosperity *in the western coal business, like* that at the time of the anthracite strike, is followed by an immense increase in capacity. For example: in 1906 and 1907 railroad shipping mines operated an average of 190 and 195 days, during the respective years, out of 300 working days; in other words, only 63 and 65 per cent of the time. To a certain extent this is unavoidable, as the markets are in a climate of extreme cold in winter, and as the Illinois coal stocks very indifferently, the winter demand tends to fix the capacity. This, in turn, makes the labor-rates high, to cover the period *of idleness. On the other hand, it makes severe competition* during the spring and summer months, in the effort of each operator to keep his mine running as much as possible."

The markets for Illinois coal in 1907 were defined by Mr. H. Foster Bain in the same volume as follows:

"Practically no Illinois coal moves eastward. This is due not only to competition based on the quality of the eastern coals, but to the present organization of freight traffic, which makes it difficult to get cars. Such coal as goes east from this coal field is supplied by Indiana. To the west, Illinois coal dominates the markets of Missouri and Iowa almost to the eastern margin of their own coal fields, and has a scattering trade beyond. To the southwest, coal is furnished to the railways to a point about half way between St. Louis and Kansas City, and to a few supply stations beyond. Directly south, there is very little coal movement except to supply certain connecting railways. The larger markets are dominated by eastern coal shipped by river, a traffic practically closed to Illinois operators for the present, owing to lack of terminals within the State, and the poor stocking-qualities of the coal. To all intents and purposes the only Illinois coal delivered to the rivers is that used by the local steamboats.

To the north and west, the coal goes in large quantities into southwestern Wisconsin, northern Iowa, southern Minnesota, and eastern South Dakota. On the one hand it must meet the competition of the nearer Iowa fields, and on the other, of the lake-shipped eastern coal. The coal of this lake trade may be illustrated by the figures for 1907.

LAKE SHIPMENTS OF COAL IN 1907

	Tons
Western Pennsylvania coal	8,306,143
Ohio coal	3,703,322
West Virginia coal	3,343,752
Total	13,353,217

The lake coal dominates the market as far south as Milwaukee, and it is only of recent years that Illinois coal has begun to go in any quantity as far northwest as St. Paul and Minneapolis. In the territory between these points there is much debatable ground, and if methods of storage can be devised so that coal may be shipped in the summer, large increases in trade may be looked for. The same is true of western Iowa and eastern Nebraska, where at present there

is only a moderate trade. If, in addition to finding a solution of the storage problem, water transportation be made available, Illinois coal may become a dominant factor in the Northwest. It must be admitted, however, that this is far from being accomplished, and for the present, in extending the markets, reliance must be placed mainly on a campaign of education in the proper burning of high volatile coals."

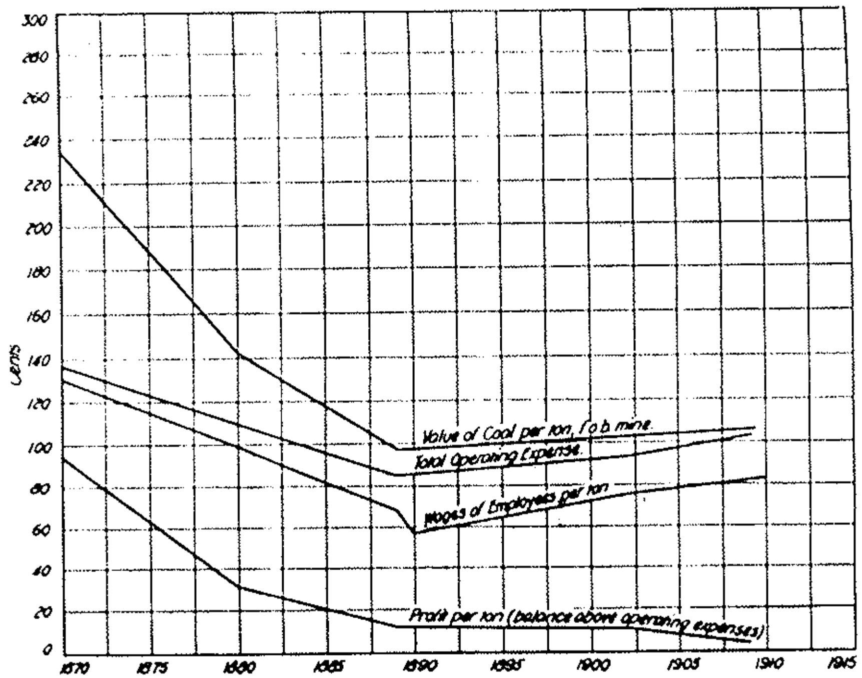


FIG. 67. Graph showing decline of margin of profit

At the present time about 4 per cent of the production is consumed or wasted at the plant, 4 per cent is sold at the mines to local trade, 18 per cent is sold to the railroads of which 1.1 is loaded into locomotives at the mines and 74 per cent is shipped to other consumers. Chicago consumes about 14 per cent of the production of the State; East St. Louis and St. Louis 10 per cent; and other shipping points within the State 20 per cent.

Including East St. Louis and St. Louis which cannot be segregated, Illinois absorbs about 50 per cent of her own production.

Mr. E. B. Boyd, Secretary of the Illinois-Indiana Traffic Association has courteously supplied the following figures for tonnage hauled by the railroads of the association to various destinations for the year ended March 31, 1915:

Destinations	Tons
Little Rock, Ark.	2,099
Arkansas (except Little Rock)	148,471
Chicago, Ill., Group	8,358,836
Peoria, Ill.	465,445
St. Louis and E. St. Louis	5,645,557
Illinois (except Chicago Group, Peoria and E. St. Louis)	7,993,786
Ft. Wayne, Ind.	9,626
Gas Belt Points	54,551
So. Bend, Ind.	62,166
Indianapolis, Ind.	15,027
Indiana (except So. Bend, Ft. Wayne, Gas Belt Points and Indianapolis)	851,282
Council Bluffs, Omaha and So. Omaha	124,972
Des Moines, Ia.	29,533
Sioux City, Ia.	89,443
Dubuque, Ia.	86,050
Iowa (except Council Bluffs, Des Moines, Sioux City and Dubuque)	2,430,551
Atchison and Leavenworth, Kan., and St. Joseph, Mo.	73,067
Kansas (except Atchison and Leavenworth)	381,499
Louisiana	200,163
Michigan	224,029
Minneapolis, Minnesota Transfer, St. Paul and So. St. Paul, Minn.	198,736
Minnesota (except So. St. Paul, Minn. Transfer, St. Paul and Minneapolis)	381,404
Mississippi	106,705
Kansas City, Mo.	49,202
Missouri (except St. Joseph, Kansas City and St. Louis)	2,297,561
Lincoln, Neb.	27,249
Nebraska (except So. Omaha and Lincoln)	266,227
North Dakota	4,370
Sioux Falls, So. Dak.	16,308
South Dakota (except Sioux Falls)	75,833
Memphis, Tenn.	44,631
Tennessee (except Memphis)	32,843
Milwaukee, Wis.	33,262
Wisconsin (except Milwaukee)	586,817
States other than foregoing	35,225
Total	31,402,526

Of the tonnage hauled by the association as given by these figures about 3 per cent is destined for Indiana, 8 per cent for Missouri and 8 per cent for Iowa.

The decline of the margin of profit per ton of coal mined in Illinois since 1870 is shown graphically in fig. 67. This graph was compiled from statistics taken from the Reports of the U. S. Census, the Reports of the Illinois Bureau of Labor Statistics and the Coal Reports of Illinois.

TABLE 42.—*Capitalization of coal mines*[1]

Year	Production in tons	Capitalization (dollars)	Capital per ton of coal produced annually (dollars)
1870	2,624,163	4,286,575	1.63
1880	6,115,377	10,654,261	1.74
1885	11,834,459	9,898,950	0.84
1889	12,104,272	17,630,351	1.45
1909	50,904,990	60,426,629	1.19

[1] Compiled from Reports of the U. S. Census.

The capital required to finance coal mining operations in Illinois cannot be estimated with accuracy because no precise returns have been made to State or Federal bureaus. Table 42 is compiled from such statistics as are available in the sources mentioned in the preceeding paragraph. From this table the conclusion is reached that recent operations have been financed on the basis of approximately one dollar and twenty cents per ton of annual production. The promotion of mining companies has often been more profitable than the operation of the mines.

The coal mines of the State in 1914 were afforded transportation facilities by counties by the following railroads:[1]

Bond County: Vandalia; Chicago, Burlington & Quincy. *Bureau County:* Chicago & Northwestern; Chicago, Rock Island & Pacific; Chicago, Milwaukee & St. Paul; Chicago, Burlington & Quincy. *Christian County:* Wabash; Illinois Central; Chicago & Illinois Midland; Chicago & Eastern Illinois; Cleveland, Cincinnati, Chicago & St. Louis; Baltimore & Ohio Southwestern. *Clinton County:* Baltimore & Ohio Southwestern; Southern. *Franklin County:* Chicago,

[1]Compiled from Thirty-third Annual Coal Report of Illinois.

Burlington & Quincy; Chicago & Eastern Illinois; Illinois Central; St. Louis, Iron Mountain & Southern. *Fulton County:* Chicago, Burlington & Quincy; Minneapolis & St. Louis; Toledo, Peoria & Western. *Gallatin County:* Louisville & Nashville. *Grundy County:* Elgin, Joliet & Eastern; Atchison, Topeka & Santa Fe; Chicago & Alton. *Jackson County:* Illinois Central; St. Louis, Iron Mountain & Southern; Mobile & Ohio. *Jefferson County:* Chicago & Eastern Illinois; Louisville & Nashville. *La Salle County:* Chicago, Burlington & Quincy; Illinois Central; Chicago & Alton; Chicago, Milwaukee & St. Paul; Chicago, Indiana & Southern; Chicago, Rock Island & Pacific; Atchison, Topeka & Santa Fe; Wabash; Cleveland, Cincinnati, Chicago & St. Louis. *Livingston County:* Topeka, Peoria & Western; Chicago & Alton; Illinois Central. *Logan County:* Illinois Central; Chicago & Alton. *Macon County:* Wabash; Illinois Central; Vandalia; Cincinnati, Hamilton & Dayton. *Macoupin County:* St. Louis, Peoria & Northwestern; Chicago, Burlington & Quincy; Chicago & Alton; Chicago & Northwestern. *Madison County:* St. Louis, Troy & Eastern; Litchfield & Madison; Cleveland, Cincinnati, Chicago & St. Louis; Vandalia; Chicago & Eastern Illinois; Wabash; Illinois Traction System; Toledo, St. Louis & Western; Illinois Terminal. *Marion County:* Illinois Central; Chicago, Burlington & Quincy; Baltimore & Ohio Southwestern. *Marshall County:* Illinois Central; Chicago & Alton; Atchison, Topeka & Santa Fe; Chicago, Rock Island, & Pacific. *McLean County:* Illinois Central. *Menard County:* Chicago & Alton; Chicago, Peoria & St. Louis. *Mercer County:* Rock Island Southern; Chicago, Rock Island & Pacific. *Montgomery County:* Chicago & Eastern Illinois; Cleveland, Cincinnati, Chicago & St. Louis; Toledo, St. Louis & Western; Illinois Central. *Moultrie County:* Wabash; Vandalia. *Perry County:* Illinois Central; Mobile & Ohio; Wabash, Chester & Western. *Peoria County:* Minneapolis & St. Louis; Peoria & Pekin Union; Chicago, Burlington & Quincy; Peoria Railway Terminal; Toledo, Peoria & Western. *Putnam County:* Chicago, Milwaukee & St. Paul. *Randolph County:* Illinois Central; Mobile & Ohio; Illinois Southern. *Saline County:* Cleveland,

Cincinnati, Chicago & St. Louis; Illinois Central; Louisville & Nashville. *Sangamon County:* Chicago & Alton; Chicago & Illinois Midland; Wabash; Chicago, Peoria & St. Louis; Illinois Central; Cincinnati, Hamilton & Dayton; Chicago, Burlington & Quincy; Baltimore & Ohio Southwestern; Illinois Traction System; Chicago & Northwestern. *Shelby County:* Cleveland, Cincinnati, Chicago & St. Louis; Illinois Central; Baltimore & Ohio Southwestern. *Stark County:* Chicago, Burlington & Quincy. *St. Clair County:* St. Louis & O'Fallon; Illinois Central; Vandalia; East St. Louis and Suburban; Louisville & Nashville; St. Louis & Belleville; Baltimore & Ohio Southwestern; Southern; Mobile and Ohio. *Tazewell County:* Peoria & Pekin Union; Cleveland, Cincinnati, Chicago & St. Louis; Atchison, Topeka & Santa Fe; Lake Erie & Western. *Vermilion County:* Chicago & Eastern Illinois; Cleveland, Cincinnati, Chicago & St. Louis; Illinois Traction System; Wabash. *Washington County:* Illinois Central; Chicago, Burlington & Quincy; Louisville & Nashville; Illinois Southern. *White County:* Baltimore & Ohio Southwestern; Cleveland, Cincinnati, Chicago & St. Louis. *Will County:* Elgin, Joliet & Eastern; Chicago & Alton. *Williamson County:* St. Louis, Iron Mountain & Southern; Illinois Central; Chicago, Burlington & Quincy; Chicago & Eastern Illinois; Coal Belt. *Woodford County.* Atchison, Topeka & Santa Fe; Illinois Central.

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Amer. Inst. C. E. Trans.—Transactions of American Institute of Civil Engineers.
Amer. Inst. Min. Engr. Trans.—Transactions of American Institute of Mining Engineers.
Amer. Jour. Sci.—American Journal of Science.
Assn. Engrs. Soc. Jour.—Journal of the Association of Engineering Societies.
Blk. Diam.—Black Diamond.
Coal and Coke Opr.—Coal and Coke Operator.
Coal and Gas Opr.—Coal and Gas Operator.
Coll. Eng.—Colliery Engineer.
Coll. Guard.—Colliery Guardian.
Econ. Geol. of Ill.—Economic Geology of Illinois.
Eng. and Con.—Engineer and Contractor.
Eng. Exp. Station—Engineering Experiment Station.
Eng. and Min. Jour.—Engineering and Mining Journal.
Eng. News—Engineering News.
Ill. Agric. Dept. Trans.—Transactions of Illinois Department of Agriculture.
Ill. Geol. Surv.—Illinois Geological Survey.
Ill. Soc. Engrs. and Surv. Annual Report—Annual Report of the Illinois Society of Engineers and Surveyors.
I. and C. Tr. Rev.—Iron and Coal Trade Review.
Min. and Engr. Wld.—Mining and Engineering World.
Min. Mag.—The Mining Magazine.
Mines and Min.—Mines and Minerals.
State Agricultural Soc. Trans.—Transactions of the State Society of Agriculture.
U. S. Geol. Sur.—U. S. Geological Survey.
Wash. Acad. Sci. Jour.—Journal of the Washington Academy of Science.
West. Soc. Eng. Jour.—Journal of the Western Society of Engineers.

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