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State Geological Survey
Department of Mining Engineering, University of Illinois
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BULLETIN 12

Coal Mining Practice

IN

District IV

BY

S. O. ANDROS
(Field Work by S. O. Andros, C. M. Young, and J. J. Rutledge)

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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.

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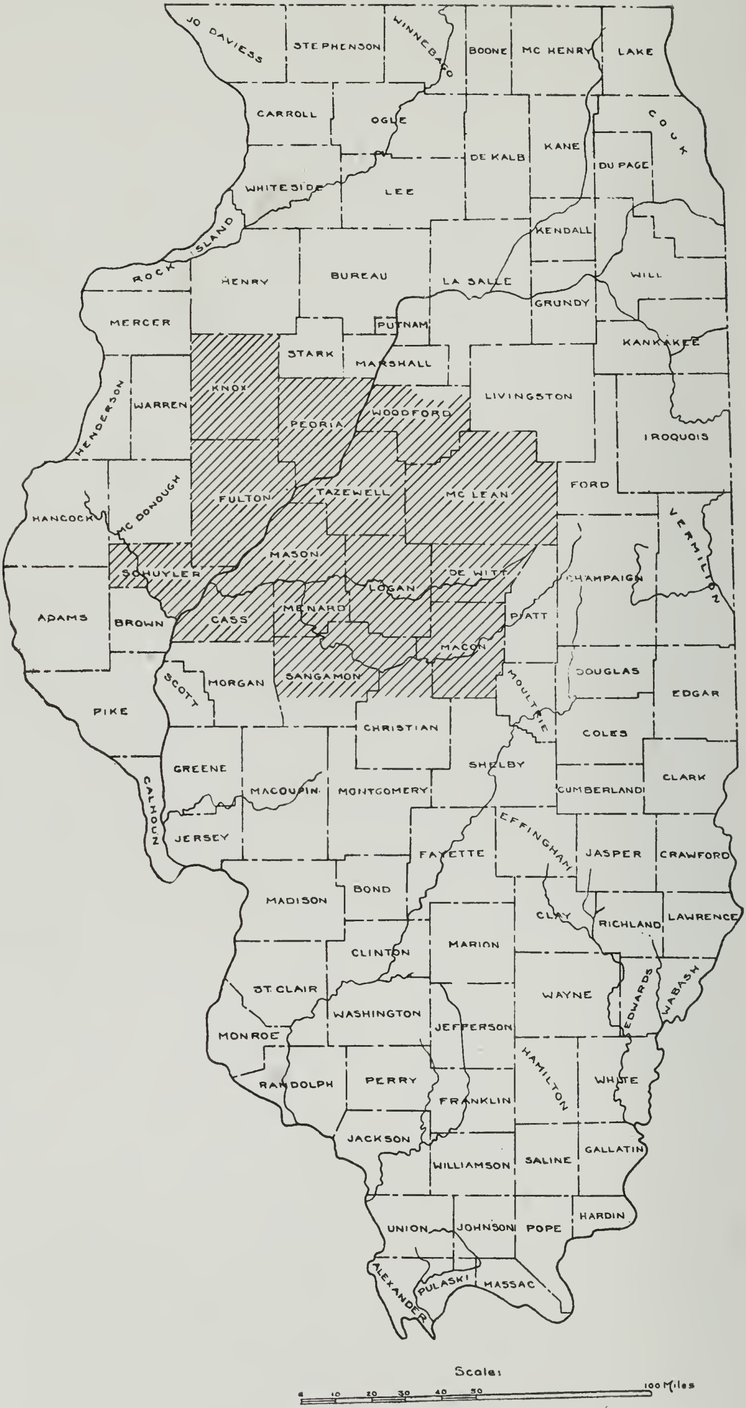

FIG. 1. Map showing area (shaded) of District IV.

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INTRODUCTION

District IV of the Illinois Coal Mining Investigations as shown in fig. 1, includes all mines in seam 5 of the Illinois Geological Survey correlation operating in Cass, DeWitt, Fulton, Knox, Logan, Macon, Mason, McLean, Menard, Peoria, Sangamon, Schuyler, Tazewell, and Woodford Counties.

A detailed description of the districts into which the State has been divided and the method of collecting the data upon which this report is based are contained in Bulletin 1, "A Preliminary Report on Organization and Method of Investigations."

Comparative statistics have been compiled for the year ended June 30, 1912, although later information is available, because statistics for the seven districts previously reported on have been compiled for that year.

The discovery of coal in District IV was made early. 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. 2) 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. 3) 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, says with reference to the country along the Illinois River from its source to the site of the present city of Peoria:[5] "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[5] locates

[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.

[5]Thwaites, Hennepin's New Discovery, Vol. I, p. 152.

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

Fig. 2. Copy of Joliet's map made in 1674 (From "A History of the Mississippi Valley," by Spears and Clark)

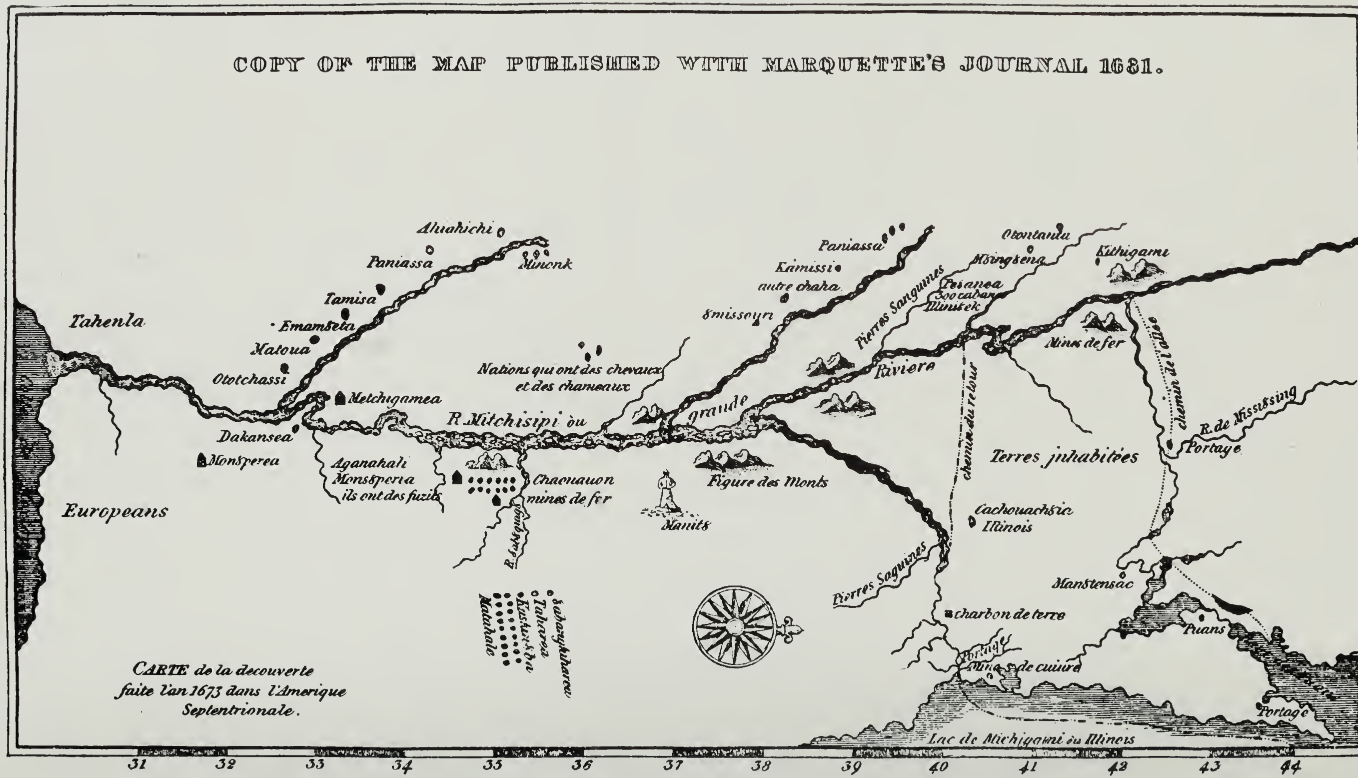


FIG. 3. Copy of Marquette's map published by Thévenot, 1681 (From "A History of the Mississippi Valley," by Spears and Clark).

a "cole mine" on the Illinois River above Fort Crevecœur (Peoria) copied from Joliet's map or Marquette's.

Other early mention of coal in District IV is made by 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, he writes[1], "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."

In 1823[2] Peoria was called "a small settlement in Pike county on the west bank of the Illinois river, about 200 miles above its junction with the Mississippi." Beck says, "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; is overlaid by slate, limestone and sandstone; and contains vegetable remains."

By 1837 the existence of workable coal was known in three newly created counties in the district. In McLean County it was stated[3] "Of the minerals, limestone and coal abound in several settlements." A description of Peoria County published in the Peoria Register and North-western Gazette[4] contains the following statement: "The stone-coal 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." In Schuyler County[3],

[1] Hicks, Thomas Hutchins. A Topographical Description, p. 127.

[2] Beck. Gazetteer of Illinois and Missouri.

[3] Illinois in 1837 & 8: With A Map.

[4] April 8, 1837.

TABLE 1.—*General data by counties for District IV for the year ended June 30, 1912.*[a]

County	No. mines		Production in short tons	Tons mined by machine	Average days of active operation	Total no. employees	No. surface employees	No. kegs of powder used in blasting coal	Haulage: No. mines using				Accidents to employees	
	Shipping	Local							Motor	Cable	Mule	Hand	Killed	Injured
Cass	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DeWitt	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fulton	19	76	2,381,605	395.533	148	3,719	302	117.473	6	3	23	63	6	4
Knox	0	19	21,456	0	155	71	13	443	0	0	1	18	0	0
Logan	4	0	429,555	0	185	677	83	20,899	1	1	2	0	1	0
Macon	4	0	211,219	0	138	521	39	2,219	0	0	4	0	2	6
Mason	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McLean	2	0	96,898	0	226	200	20	1,000	0	1	1	0	0	0
Menard	4	8	220,418	0	180	376	43	9,721	0	0	11	1	2	0
Peoria	14	50	1,207,723	117,101	164	1,652	176	68,535	9	4	39	12	1	5
Sangamon	23	5	3,712,869	0	159	5,217	385	181,047	12	0	12	4	3	16
Schuyler	0	4	2,736	0	129	10	1	156	0	0	0	4	0	0
Tazewell	5	3	239,424	126,206	175	392	47	7,689	0	1	7	0	0	4
Woodford	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	75	165	8,523,903	638,840	157[b]	12,835	1,109	409,182	28	10	100	102	15	35

[a]Compiled from Thirty-first Annual Coal Report of Illinois.
[b]Averaged by mines; not by counties.

"Mount Sterling was a thriving village of about 50 houses. Coal of a good quality was found within one mile of the town."

By 1870 the output of the district amounted to about 250,000 tons and in 1880 it had increased to over one million. In the year ended June 30, 1912, the production of the district was 8,523,903 tons, 14.8 per cent of the production of the State. This output came from 240 mines, 75 shipping and 165 local, employing 12,835 men and operating on an average 157 days during the twelve months.

Only 7.5 per cent of the production is mined by machines and the district is characterized by wasteful and dangerous shooting off the solid with excessive charges of black powder. The average number of tons gained per 25-pound keg of powder is 20.8. Although the production of coal is only 14.8 per cent of the production of the State, there is used in District IV 31.2 per cent of all the black powder used in Illinois.

The proportion of accidents caused by pit cars is remarkably high, 33.3 per cent of the fatal and 45.7 per cent of the non-fatal accidents occurring from this cause. The accident record of the district is the best of any important district in the State. Table 1 gives general data for the district and Table 2 comparative statistics for District IV and for the State.

Thanks are due to the operators of the district who willingly allowed examination of their mines and to the superintendents and mine managers who accompanied the engineers through the mines.

Especially generous assistance was rendered by Mr. F. S. Peabody, President, Peabody Coal Company; Mr. F. J. Devlin, Superintendent, The Jones and Adams Coal Company; Mr. Horace Clark, President, Clark Coal and Coke Company; Mr. M. S. Coleman, Superintendent, Big Creek Coal Company; and the officials of the Woodside Coal Company. Professor C. W. Alvord of the University of Illinois gave valuable aid in determining the site of the first discovery of coal.

TABLE 2.—*Comparative statistics for District IV and the State for the year ended June 30, 1912*[a]

	District (All mines)	State (All mines)	Per cent of district
Total production	8,523,903	57,514,240	14.8
No. tons mined by machine	638,840	25,550,019	2.5
Average daily tonnage	54,292	359,464	
Kegs of powder used in blasting coal	409,182	1,313,448	31.2
Average no. days of active operation	157	160	
Total no. employees	12,835	79,411	16.1
No. days work performed	2,015,095	12,705,760	15.8
No. surface employees	1,109	7,049	15.7
No. underground employees	11,726	72,362	16.2
Average no. face workers (miners, loaders, and machine men)[b]	9,265	53,318	17.4
No. underground employees per each surface employee	10.6	10.3	
No. tons mined per day per employee	4.2	4.5	
No. tons mined per day per surface employee	48.9	50.9	
No. tons mined per day per underground employee	4.7	4.9	
No. tons mined per day per face worker[b]	5.9	6.7	
No. fatal accidents	15	180	8.3
Per cent from falling rock or coal	33.3	54.4	
Per cent from pit cars	33.3	18.8	
Per cent from use of explosives	6.7	7.2	
Per cent from gas explosions	.....	.....	
Per cent from undercutting machines	.....	.....	
No. fatal accidents per 1000 employees	1.2	2.3	
No. tons mined to each life lost	568,260	319,524	
No. non-fatal accidents	35	800	4.4
Per cent from falling rock or coal	34.3	45.5	
Per cent from pit cars	45.7	26.3	
Per cent from use of explosives	5.7	2.6	
Per cent from gas explosions	5.7	2.9	
Per cent from undercutting machines	2.9	2.8	
No. non-fatal accidents per 1000 employees	2.8	10.1	
No. tons mined to each man injured	243,540	71,893	

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

DESCRIPTION OF COAL SEAM

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 on the surface 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]. Table 3 gives the analysis of the coal in No. 5 seam.

TABLE 3.—*Analyses of No. 5 coal in District IV*

Average thickness of coal	No. samples	Proximate analysis of coal: 1st, "as rec'd," with total moisture. 2nd, "Dry," or moisture free				Sulphur	B. t. u.	Unit coal B. t. u.
		Moisture	Volatile matter	Fixed carbon	Ash			
4 ft., 8 in.	54	15.10	36.79	37.59	10.52	3.52	10514	———
		Dry	43.33	44.28	12.40	4.15	12384	14447

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

[1]Illinois Geological Survey, Bull. 14, Coal Resources of Illinois, DeWolf.

the land and operators are careful to avoid unprofitable explorations of places where 'wash' has been encountered."[1]

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

Fig. 4. Typical clay vein

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.

[1]U. S. G. S. Bull. 506, Geology and Mineral Resources of the Peoria Quadrangle, Illinois, Udden.

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.[1] It is then called clod and the niggerheads are iron carbonate.

FIG. 5. Displacement due to horizontal movement (Photo by J. A. Udden)

From the viewpoint of the miner the chief characteristic of the district is the great number of clay veins extending through the coal and roof shale crossing their bedding planes. Fig. 4 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

[1]Udden, op. cit.

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. Fig. 5 shows the result of horizontal movement near Peoria. "A wedge of sandstone has divided the roof shale part of which continues under the sandstone and part above.[1] In the figure "a" is dark shale with some streaks of coal somewhat shattered; "b" is the roof shale; "c" is the coal seam; and "d" is sandstone.

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.

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.

[1]Udden, op. cit.

MINING PRACTICE

Seam 5 in this district dips at the rate of about five feet to the mile towards the southeast. It outcrops in Peoria, Fulton, and Knox Counties and in the face of the bluffs of the Illinois River. The cover is thickest in Macon County where the coal lies at a depth of 600 feet. There is one stripping on a surface outcrop and there are 96 mines at which the coal is reached by drifts. At the remaining 143 mines shafts or slopes are sunk to the seam. The mines examined vary in depth from 60 to 570 feet but all except two were less than 300 feet deep.

In the closed workings 235 mines are worked on the room-and-pillar system. Four mines are operated on the longwall system.

Mining methods in most of the room-and-pillar mines are crude and dimensions of workings are not suited to physical conditions. The mines are comparable to those in the Danville District[1] where the many rolls in the roof cause deviations from projected systems. The workings are irregular and in some small mines are but little better than "gophering." The district is characterized by many horsebacks where the roof, either sandstone or limestone, cuts out the coal. The original method of mining in the district is to run the parallel main entries from the shaft toward the boundaries, and from the main-entries to turn cross-entries at intervals of 350 to 400 feet. Rooms are turned off these cross-entries on 30 to 42-foot centers and are run 20 to 30 feet wide. Room-pillars are gouged as the miner pleases and average 9 feet in width. This haphazard method is productive of so many squeezes that in some mines a modification of the system has been made in which stub or room entries are turned off the cross-entries. This method approaches the panel system and is called locally "block

[1]Andros, S. O., Coal Mining Practice in District VIII (Danville), Illinois Coal Mining Investigations, Bulletin 2, 1914.

TABLE 4.—*Dimensions of workings in feet.*

Mine no.	Depth of shaft	System of mining	Past life in years	Entry width			Entry pillar width			Barrier pillar width		Room		Width of room pillar	Room neck		Distance from entry to full room width	Distance between room centers	Width of room stump	Width of crosscuts	No. rooms on room entry	Has mine had squeezes?	Per cent of seam gained[a]
				Main	Cross	Room	Main	Cross	Room	Main	Cross	Width	Length		Width	Length							
25	185	Semi-panel	22	8	8	8	36	30	24	50	24	24	180	6	8	7	18	30	22	8	23	Yes	54
26	Slope	Room-and-pillar	25	8	8	....	30	21	....	50	....	26	190	6	8	8	30	32	24	8	....	No	56
27	170	Semi-panel	12	12	12	12	20	15	12	50	50	30	200	8	8	9	20	38	30	8	30	No	53
28	150	Semi-panel	12	8	8	8	25	20	8	40	20	24	180	10	8	10	15	34	26	8	18	Yes	54
29	185	Room-and-pillar	5	8	8	....	36	24	....	40	....	24	180	8	8	7	18	32	24	8	....	No	57
31	Slope	Room-and-pillar	10	8	10	....	15	12	....	25	....	22	210	10	8	7	18	32	24	13	....	No	63
32	Slope	Semi-panel	6	8	8	8	30	30	24	20	20	20	150	12	8	10	15	32	24	8	30	No	57
33	285	Semi-panel	12	8	8	8	20	20	20	50	40	30	150	6	8	10	35	36	28	6	15	No	64
34	200	Room-and-pillar	21	8	10	....	30	34	....	38	....	28	180	10	10	9	30	38	28	4	....	Yes	42
35	187	Semi-panel	12	8	8	8	35	35	30	60	50	26	200	9	8	9	27	35	27	8	14	Yes	56
36	238	Semi-panel	19	12	12	12	30	24	10	30	20	25	240	10	8	9	27	35	27	12	24	Yes	48
37	235	Semi-panel	7	12	12	12	35	30	30	60	40	30	240	12	12	15	15	42	30	12	28	Yes	50
38	245	Semi-panel	25	10	10	10	27	24	20	35	35	30	200	6	10	9	20	36	26	10	25	No	62
39	204	Semi-panel	8	12	12	12	30	30	20	50	40	24	250	12	12	11	18	36	24	10	25	Yes	65
40	270	Semi-panel	20	10	10	10	30	24	20	35	35	24	200	6	8	9	18	30	22	7	27	Yes	50
41	365	Room-and-pillar	31	16	16	....	20	30	....	80	....	25	200	10	12	9	15	35	23	8	....	No	56
42	570	Longwall	10	10	10	....	....	....	....	....	....	9	....	....	....	....	....	42	....	....	....	......	96

[a]Figures supplied by operators.

room-and-pillar." (See fig. 6.) In a few mines a sufficient cross-barrier pillar is left to confine a squeeze to the block in which it originates but in most mines the barrier pillar is gouged and squeezes ride over it extending unchecked until they reach a horseback or some ungouged pillar which is large enough to stop them. In several mines squeezes originating in rooms have traveled to the main barrier pillar and to the solid coal at the entry face. In one mine an entry was saved from a threatened squeeze by very heavy timbering ahead of the squeeze.

Eleven of the 16 mines examined are at present operated on this semi-panel system but the relative dimensions of room and room-pillar have not been changed from previous operation. The average room is 26 feet wide and the average room-pillar 9 feet. These dimensions are unsafe under the roof found in the district. Room width is not uniform but rooms are narrowed to avoid horsebacks and widened again where the coal resumes its normal thickness. There is a temptation to get all the coal possible on the advance working because the numerous rolls make uncertain the total tonnage which can be extracted from any area, and the rolls interfere seriously with any projected plan because they are expensive to cut through. When 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. (See fig. 7). 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.

Cleat is not sufficiently developed to be a factor in the direction of driving rooms.

Cross-cuts are sometimes driven at irregular distances to avoid cutting through the rolls.

Room-necks vary in width from 8 to 12 feet and are generally widened on both sides to reach full room width but the angle of widening varies. The distance from the entry to the point where full room-width is reached varies from 15 to 35 feet. Room track is almost always in the center of the rooms

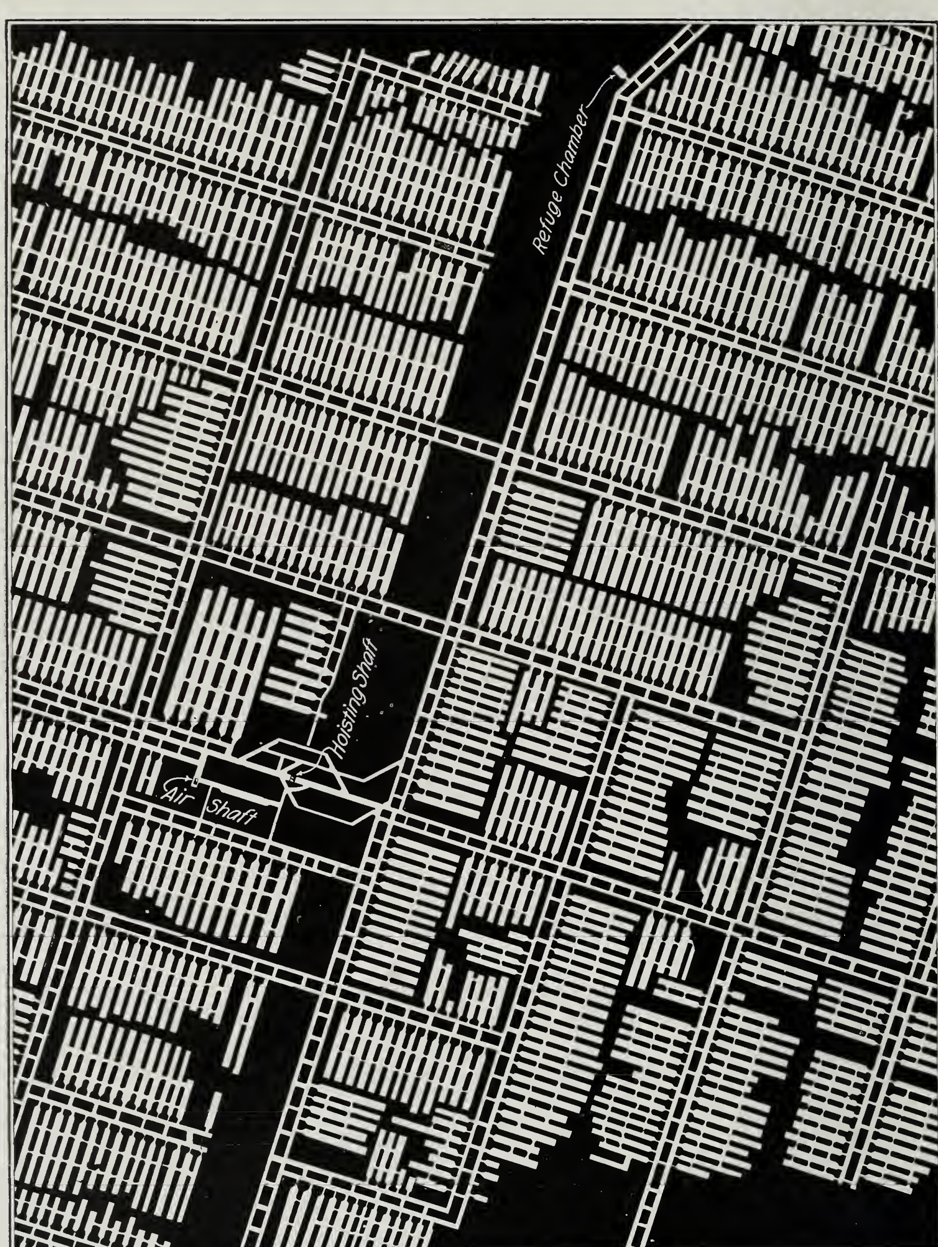


FIG. 6. Typical block room-and-pillar mine

and the gob is thrown on each side of the track. Table 4 gives dimensions of workings at the mines examined.

Pillars are drawn in only a few mines and in those drawing is not done systematically but is confined to shooting slabs off the pillars where they are thickest. In nearly all mines room-

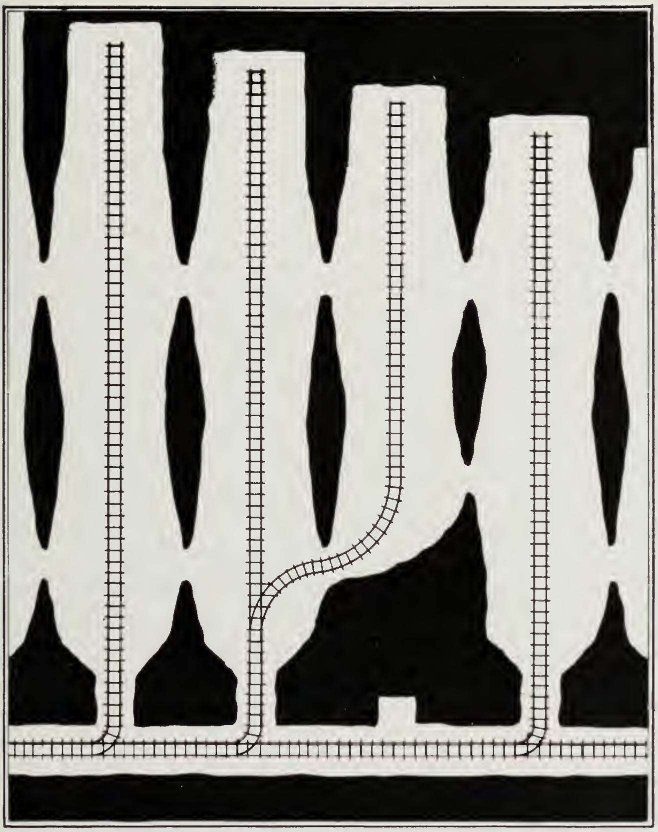


Fig. 7. Wing-room turned to avoid roll

pillars are tapered to cross-cuts as shown in fig. 7. 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.

The floor is a fireclay which heaves badly even when dry.

The principal cause of the heaving floor is insufficient pillar-width.

One of the mines examined is now worked on the longwall system although it was opened on the room-and-pillar system. This mine is worked by the 45-degree advancing system and the method of working does not differ from that employed in District I.[1] Room centers at the longwall face are 42 feet apart and the face between centers is called a "place." Two men work in each place. The clay under the coal is undercut with a pick to a depth of two feet and is wedged down as needed to fill cars. The miners at each place are required to brush two feet of roof along the roadway and to build packwalls to protect the roadway. Where the amount of rock obtained from the miners' brushing is not sufficient for completing the packwall, "company men" make a further brushing on the permanent haulage ways and bring to the face the rock thus obtained. Two men can average 10½ tons of coal daily. The coal at this mine averages 4½ feet in thickness and the amount of rock hoisted is less than in mines in District I. When producing 750 tons of coal per day there are only 18 to 20 tons of rock which can not be used underground in the gob. In District I about one-third as much rock as coal is hoisted. There is considerable difficulty in cleaning up after a suspension of working. After a shut-down of three months it takes two weeks to clean the mine during which period about 125 tons of rock per day are hoisted. Fig. 8 shows the rock dump at this mine.

Although the mines are shallow operators have very little trouble with seepage water and at no mine is more than 30,000 gallons of water pumped in 24 hours. Several mines are muddy but the water drains off easily into the sumps at the shafts or is pumped to them by electric gathering pumps from small sumps inby. The shallowest mines are the muddiest and the water seeps through the roof or comes in where breaks to the surface occur. One or two gasoline pumps are used at the main sumps but in general the main pump is operated by steam and the gathering pumps by electricity. The source of the

[1]Andros, S. O., Coal Mining Practice in District I (Longwall). Bulletin 5, Illinois Coal Mining Investigations, 1914.

water can 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 be given to the mules which are stabled underground.

Fig. 8. Rock dump at longwall mine

The labor in the district is of various nationalities. Americans perhaps predominate but there are many Italians, Germans, Hungarians, Poles, Lithuanians, and Croatians. Table 5 gives the per capita production of coal for the mines examined, the district, and the State. The small percentage of its production which is undercut accounts for its low per capita tonnage as compared with the remainder of Illinois. Face workers average only 5.8 tons per day in District IV as compared with 7.4 tons for all other districts combined. The per

TABLE 5.—*Per capita production of coal*

Mine no.	Employees: Surface	Employees: Underground	Employees: Face-workers (miners, loaders, and machine men)[a]	Employees: Total	Average daily tonnage	Underground employees per each surface employee	Tons per day per surface employee	Tons per day per underground employee	Tons per day per face-worker (miners, loaders, machine men)[a]	Tons per day per employee
25	15	275	199	285	1200	18.3	80.0	4.4	6.0	4.2
26	22	220	190	242	900	10.0	40.8	4.1	4.7	3.7
27	10	155	110	165	550	15.5	55.0	3.5	5.0	3.3
28	16	290	200	306	950	18.1	59.3	3.3	4.8	3.1
29	17	250	160	267	1100	14.7	64.7	4.3	6.9	4.1
31	30	380	266	410	1200	12.7	40.0	3.2	4.5	3.0
32	14	170	160	184	550	12.3	39.3	3.2	3.4	3.0
33	25	320	247	345	1600	12.8	64.0	5.0	6.5	4.6
34	12	125	85	137	650	10.4	54.2	5.2	7.6	4.7
35	7	65	47	72	275	9.3	39.3	4.2	5.8	3.8
36	25	400	311	425	2450	16.0	98.0	6.1	7.9	5.8
37	35	472	370	507	2700	13.5	77.1	5.7	7.3	5.3
38	17	320	260	337	1400	18.8	82.3	4.4	5.4	4.2
39	21	370	295	391	2400	17.6	114.1	6.5	8.2	6.1
40	13	160	115	173	700	12.3	53.8	4.4	6.1	4.0
41	10	52	44	62	325	5.2	32.5	6.3	7.4	5.3
42	15	200	179	215	750	13.3	50.0	3.8	4.2	3.5
Total District IV	1,109	11,726	9,265	12,835	54,292	10.6	49.0	4.7	5.8	4.2
All other districts combined	5,940	60,636	44,053	66,576	305,192	10.2	51.4	5.0	7.4	4.6

[a]Shipping mines only.

capita production of coal for employees of longwall mines is greater than in District I, the ratio for face workers being 4.2 to 2.8. This higher average daily production is due to the greater thickness of the seam in longwall mines in District IV, inasmuch as the same amount of labor at the face is required to gain a slice of coal three feet thick as to gain one four and one-half feet thick.

TABLE 6.—*Tonnage per fatal and non-fatal accident*

District	I	II	III	IV	V	VI	VII	VIII
No. tons per non-fatal accident	25,675	62,513	85,363	243,540	63,872	95,472	78,788	57,194
No. tons per fatal accident	419,362	No fatalities	128,045	568,260	148,275	316,564	362,172	187,469

The accident record of this district is by far the best of any district in Illinois. Its mines produce more than twice as much coal per non-fatal accident as the mines of any other district and over one-third more tons per fatal accident, except

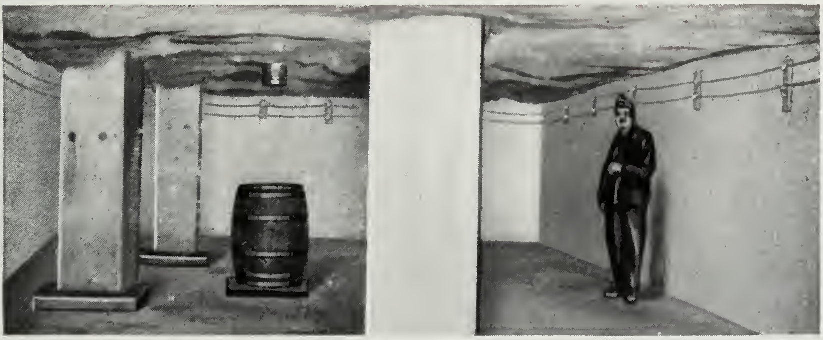


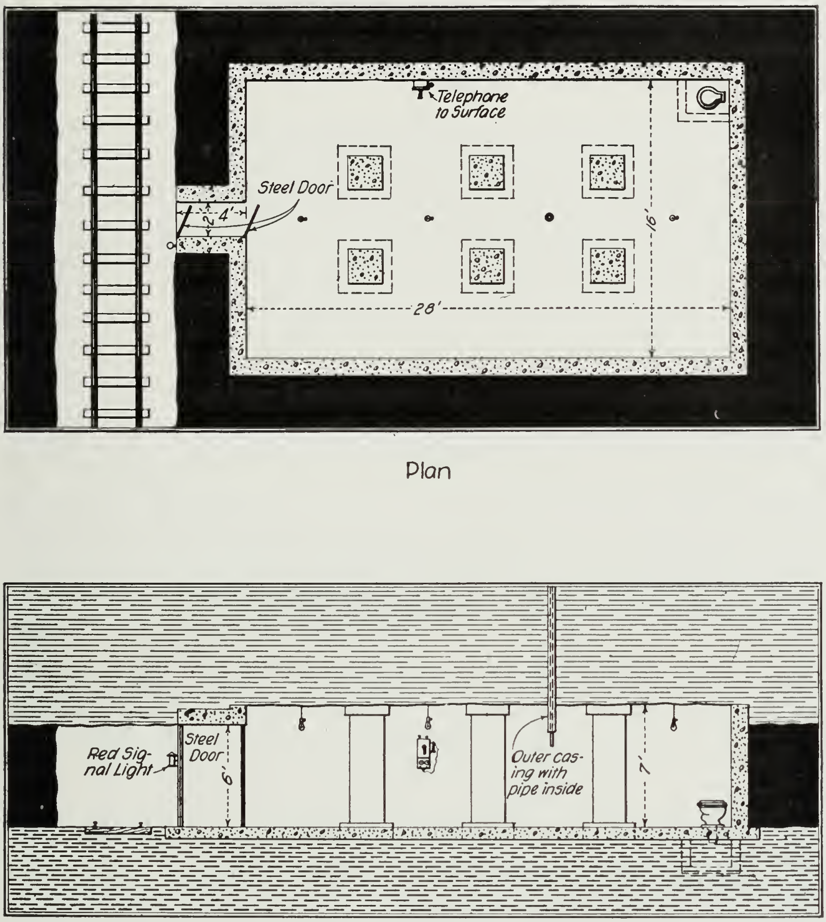
FIG. 9. Photograph of underground refuge chamber

those mines in District II. The total annual production of District II is only 500,102 tons; its mines are small and employ comparatively few men. A comparison of the tonnage per fatal and non-fatal accident for each district in Illinois is given in Table 6. The percentage of accidents from pit cars in this district is very high. Nearly one-fourth of the total fatal and non-fatal accidents can be prevented by better discipline along the haulage roads and by cleaning up the gob lying close to the tracks. In no district in the State can a material decrease in accidents be accomplished so easily. The roof is comparatively good and the percentage of accidents from falls of roof and coal is low. Table 7 gives causes of accidents in the district.

TABLE 7.—*Causes of accidents to employees*

	Percentage	
	District IV	All other districts combined
Causes of fatal accidents		
Fall of rock or coal	33.3	56.3
Pit cars	33.3	17.6
Use of explosives	6.7	7.3
Gas explosions	0.0	0.0
Undercutting machines	0.0	0.0
Causes of non-fatal accidents		
Fall of rock or coal	34.3	46.0
Pit cars	45.7	25.4
Use of explosives	5.7	2.5
Gas explosions	5.7	2.7
Undercutting machines	2.9	2.7

The Peabody Coal Company in its Peabody mine at Sherman has prepared an underground refuge chamber, 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. 9 in perspective and in fig. 10 in plan and vertical elevation, 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 where the shale roof 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. 9. 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, one on each side, particularly in mines in southern Illinois in which explosive gas and dust are found.



Longitudinal Section through Center
Fig. 10. Sketch of underground refuge chamber

Where there have been so many squeezes under comparatively shallow cover surface subsidence is to be expected. Surface cracks and subsidence seem to be related to the absence of limestone cap rock. Where sandstone is the cap rock subsidence is more marked. Several cases of damage to buildings and of broken foundations have been reported and in some instances after a squeeze sink-holes, 9 to 10 feet deep, have appeared in fields.

The percentage of extraction of coal from the seam in room-and-pillar mines in the district is low varying from 50 to 65 and averaging 54.

VENTILATION

The coal of this district generates very little explosive gas and therefore it is not necessary to supply extraordinary quantities of air to the working face for the purpose of gas dilution. In only a few of the mines examined is gas found in sufficient quantity to make a cap in a testing lamp. Gas is found in some mines in roof caves and it occurs casually in small quantities in abandoned areas. An occasional accident occurs from ignition of small bodies of gas in these areas. The quantity of air supplied to the working face is generally adequate for proper ventilation.

TABLE 8.—*Pressures developed by dust of face samples in explosibility apparatus*

District	No. samples	Pressure in pounds per square inch at 2192 degrees 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

The coal dust on the ribs and roof of rooms near the face is explosible as shown in Table 8. Coal dust on the ribs of entries is intimately mixed with finely ground shale and fireclay and is kept moist in many mines by seepage of surface water. At some mines the rib dust along all entries is wet. The admixture of shale dust and water with the coal dust accounts for the comparative freedom from explosions which the district has enjoyed. The moisture extracted from the dust by the air current is continuously replaced by seepage. The humidity of the mine air is normal. Hygrometers were installed by the Illinois Coal Mining Investigations in the intake and return of the three following mines: Empire No. 2 mine,

Fig. 11. Stopping built of Pyrobar block

Clark Coal and Coke Company, Peoria; Peerless mine, Jones and Adams Coal Company, Springfield; Woodside mine, Woodside Coal Company, Springfield. Readings three times daily were made at each mine during the working year. The average temperature of the outside air during the months these mines operated was 40 degrees F. The average temperature of the return air was 63 degrees F. The relative humidity of the outside air was 70 per cent and of the return air in the mines 94 per cent. Details of this study of humidity of air in Illinois mines can be found in Bulletin 83, U. S. Bureau of Mines, The Humidity of Mine Air, by R. Y. Williams.

The average size of air shafts at the mines examined is 7 by 10 feet. The average width of fan is 4 feet and the average diameter 13 feet. At one mine in which insufficient air was being given by the fan a booster fan was installed underground near the end of the main entry. The present intake of this mine is 26,200 cubic feet per minute. It is reported by the operators that before the installation of the booster fan the intake was 10,800 cubic feet.

At most mines the fans are always run as blowers but in a few they exhaust in summer and blow in winter. At two

FIG. 12. Pyrobar block showing core holes

mines 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 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 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.

TABLE 9.—*Data relative to ventilation*

Mine no.	Air shaft			Fan[a]		
	Depth in feet	Size in clear in feet	No. of compartments	Type	Diameter in feet	Width in feet
25	185	8 by 8	2	Paddle-wheel	15	3½
26	196	8 by 15	2	Sturtevant	6¾	4
27	170	6 by 14	1	Paddle-wheel	12	4
28	150	5 by 10	2	Paddle-wheel	20	7
29	185	8 by 16	2	Paddle-wheel	16	4
31	60	9 by 15	1	Duncan	22	6
32	68	6 by 9	2	Paddle-wheel	10	4
33	285	6 by 12	2	Robinson	12	6
34	200	5 by 10	2	Paddle-wheel	12	4
35	162	6 by 8	2	Paddle-wheel	12	6
36	200	7½ by 15	....	Stevens	12	4
37	235	10 by 14	3	Buffalo-Forge	16	5
38	245	6 by 12	2	Jeffrey	10	4
39	204	10 by 12	2	Cappell	13½	7½
40	270	....	2	Jeffrey	6	3½
41	365	4½ by 7	1	Stevens	10	2
42	570	6 by 8	2	Duncan	15	3½

[a]Paddle-wheel refers to straight blade type of fan—often home made.

Gob stoppings are built in most mines and in many they are leaky allowing a large percentage of the air blown by the fan through the intake to short-circuit into the return before reaching the faces of the rooms. At one mine a tight gob stopping is provided and a considerable amount of gob removed from the road by filling the entire cross-cut through the 20-foot pillar. At two of the mines examined tight stoppings are built of Pyrobar blocks as shown in fig. 9. Pyrobar is a gypsum block made in two sizes: 12 by 30 by 4 inches and 12 by 30 by 5 inches. For decreasing weight three longitudinal core holes are made in the blocks as shown in fig. 12. 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 is due to greater thickness of its walls. The four-

Fig. 13. Fire-seal repaired by Pyrobar

inch block weighs 12 pounds per square foot of surface and the five-inch block, 13½ pounds. The price of the four-inch block 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. 13 shows a broken fire seal repaired with Pyrobar.

Many mines in the district are troubled with small fires which originate from two causes: the use of excessive charges of black powder at the face in blasting coal and the mixture of fine coal and iron pyrites in gob in damp rooms and entries. Almost all of the fires are quenched with water before they attain serious proportions but some of them require sealing off.

Fig. 14. Concrete overcast

The usual seal is built of concrete and costs from 50 to 100 dollars in place. In some mines an unnecessarily expensive mixture of concrete is used. In a few mines seals are built of brick and gob.

Table 9 gives ventilating equipment. The shafts of the mines examined were all sunk before the passage of the law requiring fire-proofed linings and each one of the air-shafts is timber-lined.

For carrying the intake air over the return airway overcasts are built at all but one mine at which an undercast has been excavated and the intake air carried under the return airway. Overcasts are constructed of timber only, timber and concrete, old rails or steel I-beams and concrete, concrete only, brick and timber, brick and steel, and Pyrobar. Fig. 14 shows a concrete overcast at a point where the haulage way underlies a railroad track on the surface. To prevent possible subsidence of the surface and consequent damage to the railroad track the approaches to the overcast are made 5 feet thick and the floor of the overcast is reinforced with 4-inch steel I-beams.

At those mines at which there were water gages, previous to the passage of the State law requiring water gages at all mines, the readings varied from 1 to 3¼ inches. At one mine the fan is driven by an electric motor; at all of the others examined the fan is steam driven.

BLASTING

In District IV only 7.5 per cent of the annual production is mined by machines. The remaining 92.5 per cent, 7,885,063 tons, is gained by shooting off the solid. In no other important district in Illinois mining on the room-and-pillar system is so small a percentage of the production undercut. Dangerous and wasteful excess of black powder is used in blasting coal. 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 19 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 consequently are not exposed to the danger resulting from blown-out shots. The excess of powder above that necessary to bring down the coal shatters the coal producing an unnecessary amount of slack, cracks the roof increasing the danger of accident from roof-fall, and causes fires at the face.

Black powder is used in every room-and-pillar mine in the district. At one mine size CC only is used; at six, C only; at two, C and CC; at four, F only; at two, FF only; and at one F, C, and CC. In the longwall mines 40 per cent dynamite is used in roof brushing. In a few places where the coal in longwall mines is tight size CC black powder is used for blast-

TABLE 10.—*Blasting data.*

Mine no.	Kind of under-cutting machine	Size of powder	Pounds of powder per ton of coal	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	Holes per shot firer	Per cent of coal over 1¼ inches[b]
25	Solid shooting	F, C and C C	1.47	17	10.29	6	2¼	112	68
26	Solid shooting	C	1.39	18	9.73	6	2½	150	70
27	Chain	F	0.45	56	3.15	6	2½	No shot firers	70
28	Solid shooting	F	1.39	18	9.73	6	2¼	300	75
29	Solid shooting	F	1.56	16	10.92	7	2	250	71
31	Chain	F F	0.63	40	4.41	6	2½	125	67
32	Solid shooting	F F	1.19	21	8.33	6	2½	90	68
33	Solid shooting	C	1.39	18	9.73	5	2½	100	75
34	Solid shooting	C and C C	1.32	19	9.24	6	1½	70	67
35	Solid shooting	C and C C	1.19	21	8.33	7	2½	50	....
36	Solid shooting	C	1.04	24	7.28	6	2¼	125	67
37	Solid shooting	C	1.32	19	9.24	6	1½	100	65
38	Solid shooting	C	0.81	31	5.67	6	2½	80	....
39	Solid shooting	F	1.25	20	8.75	6	1¾	100	70
40	Solid shooting	C	1.19	21	8.33	6	2¼	100	71
41	Solid shooting	C C	1.39	18	9.73	7	2½	65-70	70
42	Longwall	....	....	....	......	....	......	......	[a]

[a]68 per cent over 2 by 2½-inch holes.
[b]Figures supplied by operators.

ing coal. The amount used for this purpose is very small. Black powder is purchased in metal kegs throughout the district.

Shots were formerly 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.

At many mines powder is carelessly handled during trans-

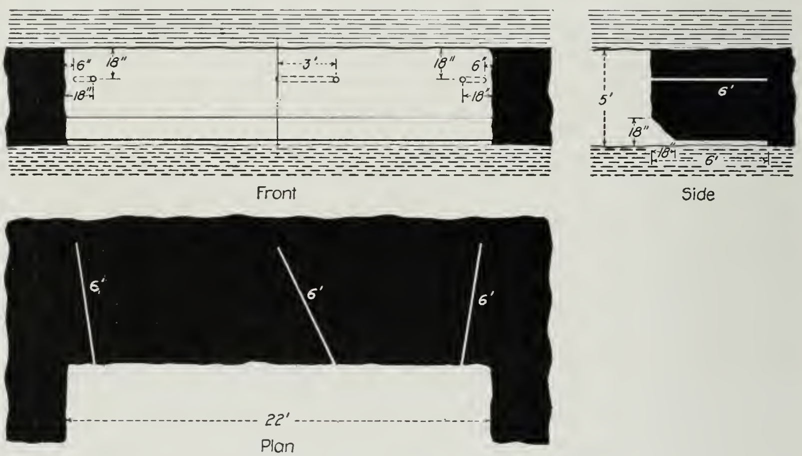


Fig. 15. Typical method of placing shots after undercutting

portation to the face and is carried from the surface to the underground partings exposed in open cars.

As in every district in Illinois, metal powder kegs are often opened with pick points, dummies are frequently filled with "bug dust," and miners many times fill their cartridges while wearing lamps on their caps.

Stricter discipline in regard to common-sense observance of safety regulations is greatly needed in the district and will reduce both the number of accidents and the proportion of slack coal.

In the mines where shooting off the solid is practiced shooting in rooms is done off the weak rib. A round usually consists of four holes, two rib and two center shots. At one mine an irregularly shaped piece of coal was seen 17 feet in circumference and 6 feet high which had been blasted off a rib with an 8-foot shot.

In those mines in which the coal is undercut the usual method of placing drill holes is shown in fig. 15. Seam 5 has always been considered hard by the miners and in undercutting machines only chisel bits are used. At every mine examined in which the coal is undercut electric undercutting machines are used. Chain breast machines are most popular but "pneumelectric" are used in a few mines in the district.

Fig. 16. Entry sixteen feet wide without timber

In many mines the coal sticks to the roof and to the floor. In one mine where shooting is done off the solid about an inch of coal is left on the roof. At another an inch or so of fireclay sticks to the bottom of the seam and causes some difficulty in maintaining proper cleanliness of the coal arriving at the tipple. Table 10 gives blasting data. The figures for percentage of lump coal were supplied by the operators. The average tonnage per keg of powder for the district is 20.8.

TIMBERING

The black sheety shale roof of the district falls and caves badly when exposed to the air. In many mines in places the thin layer of iron pyrites called "sulphur" between the coal and the shale protects the shale which stays up in entries without propping. Fig. 16 shows an entry 16 feet wide where the roof stays up without any timbering. In some mines this layer of pyrites may be present in one section and absent in others and it may be present in one of two adjacent mines and absent in the other. For this reason the timbering costs of mines in this district are variable. The amount of timbering necessary also depends upon the number of clay veins in the coal. In the vicinity of these veins the roof is difficult to support and usually requires heavy timbering. The total cost of timber in the room-and-pillar mines including room props ranges from

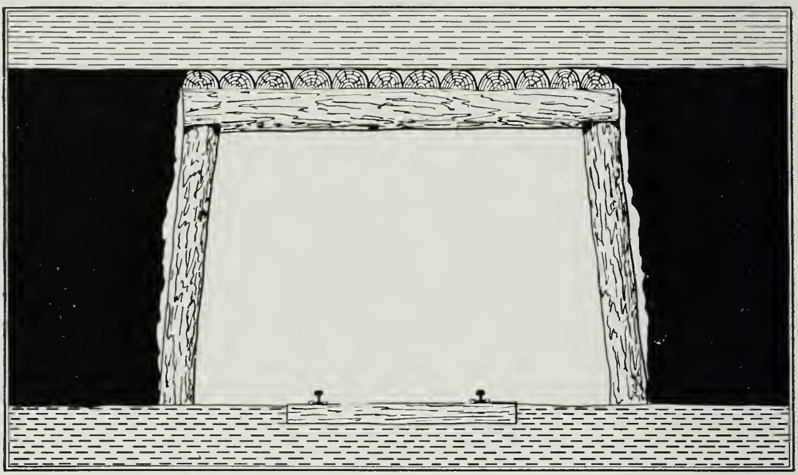


Fig. 17. Three-piece entry set

1½ to 4 cents per ton of coal hoisted and the total timbering expense including cost of timber and labor of setting in place varies from 12 to 20 cents per ton. The average cost of timber supply is estimated at 3 cents per ton of coal and the average cost of timber in place at 14 cents.

Where entry timbering is necessary the three-piece entry set of round timber is much used as shown in fig. 17. Legs are usually battered to resist side pressure. In some mines one end of the crossbar is placed in a hitch in the rib and in others where narrow entries must be driven both ends are hitched in the rib as shown in fig. 18. Centers vary from 2 to 8 feet.

The percentage of white-oak in purchased timber varies from 10 to 70 and averages 60. The life of timber is generally two to three years although in some mines timber stands for ten years without decay. In a few mines where timber loss by decay has been heavy the timbers are given a preservative treatment before installation. At one mine where creosote is used as a preservative timber is treated with one gallon 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.

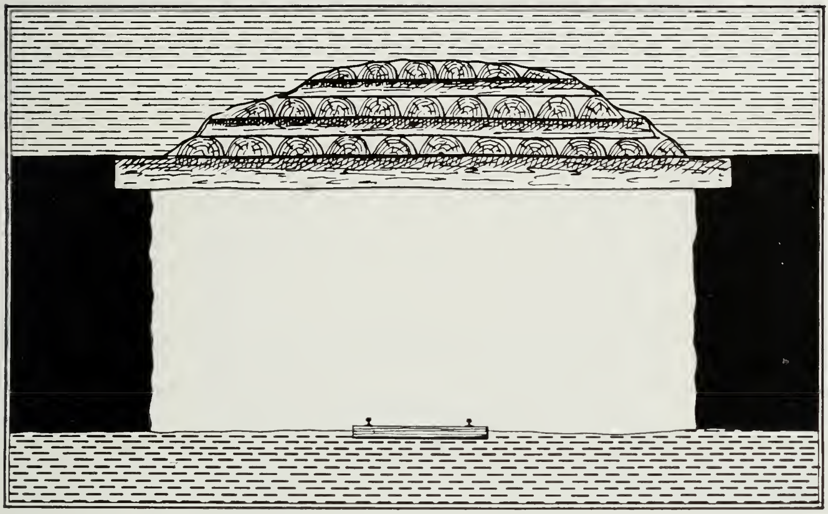


Fig. 18. Cross-bar set in hitches in ribs

At one mine if a crossbar breaks it is replaced by one which has been treated with carbolineum. In another all new shaft sets are being treated with it.

Steel I-beams are used in many mines for collars of entry sets. Comparative average sizes of white-oak round timbers and steel I-beams in District IV for various spans are as follows:

Span in feet	Diameter of round white-oak timbers in inches	Size and weight of steel I-beams
8	6	18 pound; 8-inch
10	7	18 pound; 8-inch
12	9	18 pound; 8-inch
14	10	40 pound; 12-inch
16	12	40 pound; 12-inch
18	14	52 pound; 12-inch

At one mine where white-oak crossbars after failure are being replaced by second-hand steel I-beams, a 30-pound 12-inch I-beam 16 feet long costs $4.80 at the pit-mouth and a 12-inch white-oak timber of the same length costs $3.00. The cost of setting in place is reported to be about the same for steel and timber. An average estimate for the district is 3 cents per pound for I-beams in place including cost of steel and labor in setting. If there is much rock work to do in set-

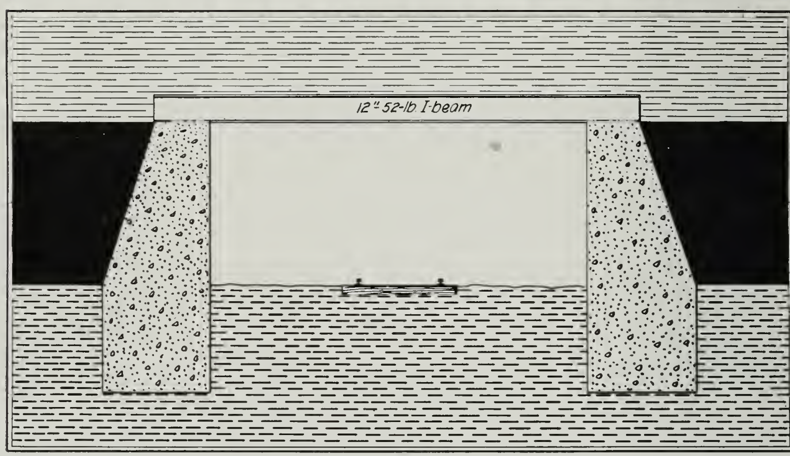


Fig. 19. Steel I-beams and concrete at bottom

ting the crossbar the cost is increased. In one mine where placing the sets requires considerable rock work an entry-set composed of a 10-inch 35-pound steel I-beam 16 feet long on 8-inch white-oak legs 8 feet long costs approximately $20.00 in place.

At one mine on one side of the shaft the bottom for 200 feet is concreted as shown in fig. 19 and 52-pound 12-inch I-beams on 2-foot centers support the roof. The concrete walls are imbedded four deep in the floor.

At several mines old railroad and streetcar rails are used as crossbars. In one mine at the partings the sets are composed of old railroad ties as legs and 17-foot rails as crossbars. The rails were purchased for $12.00 per ton. Old rails purchased for this purpose vary in weight from 55 to 65 pounds per yard. They are not as good as structural-steel I-beams for support of heavy roofs because their carbon content is high and their section is not the best for this purpose. Therefore, they break more easily than do I-beams. It is not unusual to find that they have deteriorated in use, and have little value as roof supports.

The roof in rooms in this district is supported by unpeeled split and round props with a diameter of 4½ inches at the small end. Crossbars are seldom used in rooms. For ordinary use the length of props varies from 4½ to 6 feet. Longer props are used in some mines where clay veins are cut through or where caving roof is encountered. For lengths up to five feet the average cost of room-props is one cent a running foot. With increasing length the cost advances rapidly. The prices paid at several mines 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

The cost of room props per ton of coal ranges from ½-cent to 3½ cents. The number of tons of coal produced for each room prop purchased ranges from 2 to 12, varying in different mines and in different sections of the same mine.

Table 11 gives data on props in rooms. The figures for the number of props per 100 square feet of roof were obtained by counting the props in a measured length in each of several typical rooms of measured width. The average number of props per 100 square feet of roof is 3.3 for the mines examined. Table 12 compares the number of props used in rooms for each district.

Table 11.—*Data concerning props in rooms*

Mine no.	No. per 100 square feet of roof	Cost in cents per 100 square feet of roof	Average length in feet	Round or split	Cost in cents per ton of coal[a]
25	3.7	16.7	4½	Both	......
26	5.4	25.2	4⅔	Both	3.00
27	3.7	17.2	4⅔	Both	1.75
28	....	......	5	Both	3.00
29	....	......	4¾	Both	2.90
31	6.5	30.0	5¼	Both	2.00
32	4.0	20.0	5	Both	2.70
33	2.8	16.8	5	Both	2.50
34	....	......	6	Split	......
35	....	......	6	Both	......
36	2.6	26.0	6	Both	......
37	2.8	18.2	6	Both	2.40
38	1.6	8.8	5½	Split	......
39	1.1	10.0	6	Split	0.50
40	2.4	14.4	5⅔	Round	1.00
41	....	......	5½	Split	2.00
42	....	......	4½	Both	......

[a]Figures supplied by operators.

Table 12.—*Comparison for each district of number of props used in rooms*

District	Average no. props in rooms per 100 sq. ft. of roof
I	Longwall
II	6.0
III	Few props except at clay veins
IV	3.3
V	3.2
VI	2.9
VII	3.7
VIII	5.5

Generally throughout the district props are not kept close enough to the face. More face bosses are needed to keep the props near enough to the face to prevent accidents from roof fall.

All shafts at the mines examined have timber linings.

HAULAGE

Seam 5 is flat lying in this district and few heavy grades are encountered in mine entries. An occasional two per cent grade is found persisting for a few hundred feet. Entries are not very narrow and physical conditions generally are favorable to comparatively rapid and economical haulage. Yet efficient haulage is found in few mines. In only 28 of the 240 mines of the district are locomotives used. Rope haulage is

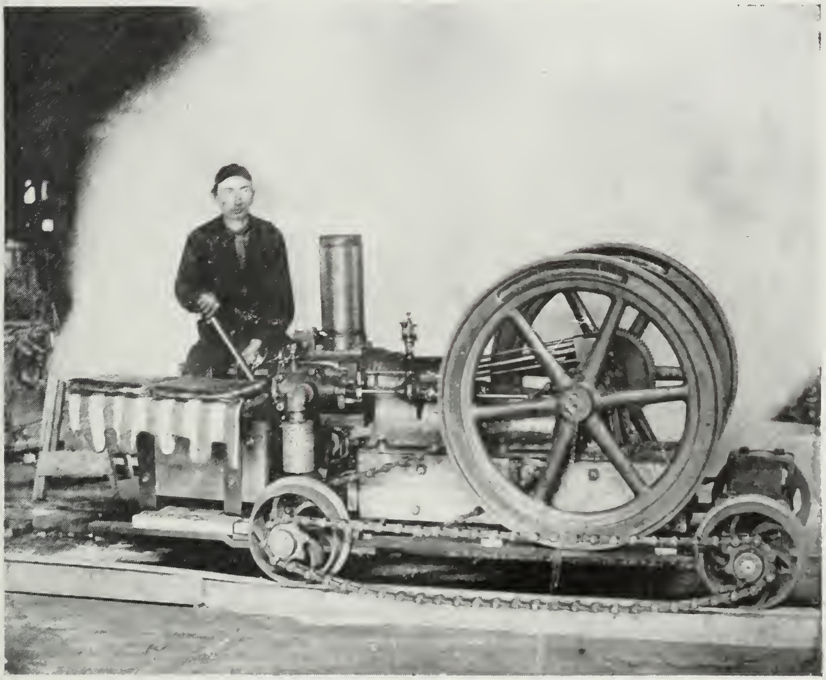


Fig. 20. First gasoline mine-locomotive in Illinois (Photo loaned by Mr. Frank R. Fisher)

used in 10 mines. In 100 mines underground haulage is done by mules and in 102 the cars are pushed to the bottom by hand. At 7 of the mines examined cars are hauled by mules from the face to the bottom. At 8 mines electric locomotives are in use and at two, gasoline locomotives.

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. 20, pulled in a trip seven to nine mine cars each weighing loaded 4,000 pounds. The rails in the mine at that time weighed 16 pounds per yard.

At all but one of those mines in which mechanical haulage is installed track conditions are fairly good. The speed of locomotives averages about 10 miles per hour. At one mine alternating current is used for driving a 7-ton locomotive.

TABLE 13.—*Ton mileage of locomotives*

Mine no.	Kind of locomotive	Weight of locomotive in tons	Miles traveled per shift by locomotive	Ton mileage per shift		
				In coal	In cars	Total
25	Electric	10	....	......	......	....
26	Electric	11½	39.77	736	620	1356
27	None	....	....	......	......	....
28	Electric	10	37.87	710	426	1136
29	Gasoline	8	13.25	167	103	270
31	Electric	12	34.09	690	665	1355
32	None	....	....	......	......	....
33	Electric	7½	20.00	590	190	780
34	None	....	....	......	......	......
35	None	....	....	......	......	......
36	Electric	12	31.06	852	582	1434
37	Electric	15	30.00	990	726	1716
38	Electric	10	38.63	946	676	1622
39	Gasoline	12	33.14	829	563	1392
40	None	....	....	......	......	......
41	None	....	....	......	......	......
42	None	....	....	......	......	......

An illustration of the false economy of neglecting road bed is shown by the comparison of ton-mileage obtained by gasoline locomotives in two mines (See Table 13). At one of these proper attention is paid to the road-bed and a daily ton-mileage of 1392 is achieved by a 12-ton locomotive. The locomotive travels 33.14 miles per shift and burns 27 gallons of gasoline using 2 gallons of engine oil. Engine oil costs 34 cents per gallon at the mine. At the other mine road-bed and track are neglected and in poor condition and only 270 ton-miles are made during eight hours; the eight-ton locomotive travelling 13.25 miles per shift.

TABLE 14.—*Amount of air required for ventilation with various sizes of gasoline locomotives.*

Engine cylinder size, in.	No. cylinders	Speed, rev. per min.	Piston displacement[a] (Cu. ft. per min.)	Maximum probable amount of noxious gases (Cu. ft. per min. at 60° F. and 30 in. barometer) produced with				Amount of air (Cu. ft. per min.) required to dilute exhaust gases to 1 part CO per 1000 parts of air[b]	
				Good carburation		Bad carburation		Good carburation	Bad carburation
				CO	CO_2	CO	CO_2		
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

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

The limitations of the gasoline locomotive 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 mixed with the exhaust gases in the most unfavorable portion of the run of the locomotive. For each cubic foot of carbon

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

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 14 gives the data compiled by Prof. Hood.

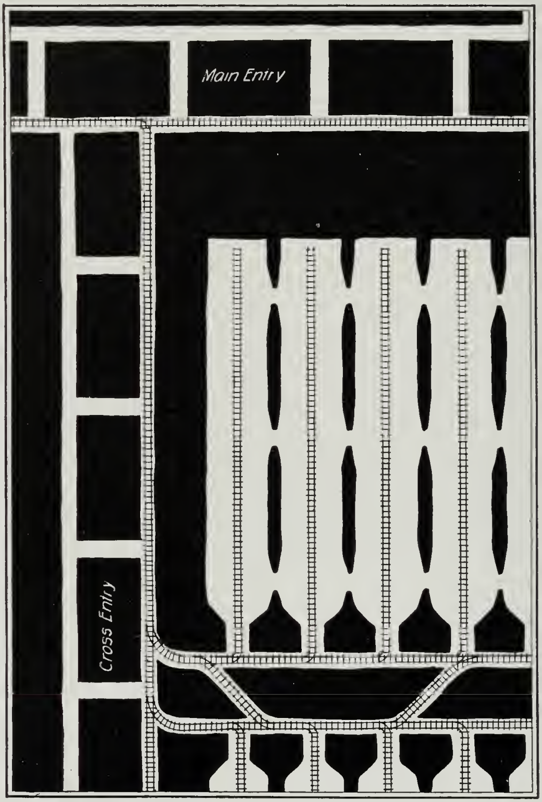


FIG. 21. Parting at mouth of room-entry

In no other district in Illinois is such a large percentage of fatal and non-fatal accidents caused by pit cars. Undoubtedly one reason for this high percentage is the gob alongside the tracks. Trip riders and drivers stumble on the pieces of shale or coal lying close to the rails and fall between the cars.

A comparison of the percentages of accidents caused by pit cars in Illinois districts is as follows:

District	Fatal	Non-fatal
I	16.6	21.9
II	No fatalities	25.0
III	25.0	0.0
IV	33.3	45.7
V	10.7	18.5
VI	23.7	27.8
VII	24.2	29.5
VIII	5.5	27.1

Table 15 gives haulage data.

The average weight of an empty pit car is 1329 pounds; of its load 3458 pounds; of car and load 4787 pounds. The percentage of total weight of car and load which is car weight 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.

Track gage varies from 24 to 42 inches, averaging 36, and rail weight on the main entries ranges from 16 pounds per yard to 45, averaging 28. In rooms in some mines wooden rails are used.

Gathering from rooms is entirely done by animals in the mines examined. Mules are used in all but one mine in which gathering is done by ponies. Mules are generally stabled underground and are kept in good condition. Their ton-mileage is not determined and very little is known about the work performed by them.

In mines working on the semi-panel system partings are made on the room-entries near the cross-entry as shown in fig. 21. No trolley is carried into the room-entry and the locomotive does not leave the cross-entry in picking up its load. At one mine empties coming from the cage are lifted to grade by an automatic steam car lift.

TABLE 15.—*Data relative to underground haulage*

Mine no.	Kind of haulage		Locomotive weight in tons and number of each weight[b]	Track gage in inches	Rail weight in pounds per yard		Weight of pit cars in pounds	Capacity of pit cars in pounds	Percentage of total weight which is car weight
	Main	Secondary			Main haulage	Secondary haulage			
25	Electric	Mules and ponies	One 10; three 6; one 3	36	30	12	1200	2600	31.6
26	Electric	Mules	One 12; one 7; one 6	42	40	16	1500	3700	29.6
27	Mules	Mules	....	36	16	16	1400	2800	33.3
28	Electric	Mules	Two 10	36	30	16	900	3000	23.1
29	Gasoline	Mules	One 8	36	30	16	1300	4200	23.6
31	Electric	Mules	Two 12; one 6	36	45	20	1300	3700	26.0
32	[a]	Mules	....	36	45	Wood in rooms	1000	2400	29.4
33	Electric	Mules	Two 7½; two 5	42	35	16	1900	4000	32.2
34	Mules	Mules	....	36	16	12	1400	3000	31.8
35	Mules	Mules	....	36	16	Wood in rooms	900	2300	28.1
36	Electric	Mules	Two 12	36	30	16	1500	4400	25.4
37	Electric	Mules	One 15; two 13	42	35	16	2200	6000	26.8
38	Electric	Mules	One 10; two 8	36	35	Wood in rooms	1000	2800	26.3
39	Gasoline	Mules	Three 12	42	30	20	1700	5000	25.4
40	Mules	Mules	....	35	16	Wood in rooms	1500	3500	30.0
41	Mules	Mules	....	24	20	12	740	2300	24.3
42	Mules	Mules	....	38	16	16	1165	3000	29.0

[a]Gasoline locomotive to be purchased. Rope haulage for 1500 ft. from slope
[b]Weight in tons expressed in figures

Ties are usually of white-oak and on the main haulage where locomotives are used have the dimensions 6 by 8 inches by 5 feet and on the secondary haulage 4 by 6 inches by 5 feet. At a few mines old props are used as ties.

The construction of underground stables complies with the State law. The stable at one mine is lined with brick and old boiler plates are used for ceiling. The provision of the State Mining Law to the effect that no light with an unprotected flame shall be taken into an underground stable is frequently violated but no oftener than in other districts. This provision should be strictly enforced throughout the State.

HOISTING

In District IV at 106 mines cars are hoisted from the bottom by steam; by horses at 43; and by hand at 90. The moderate daily production of the mines of this district and the comparatively short hoists require neither elaborate appliances nor great speed of hoisting. The hoisting equipment is adequate for their needs. The average daily production of the mines examined is about 1200 tons and the longest hoist 570 feet. As the mines with hoists longer than 300 feet have a production of less than 800 tons daily all of the coal mined can be raised to the surface by slow hoisting. Because speed of hoisting is not essential there is no automatic caging at the mines examined. The size of the average hoisting shaft is 7½ by 15½ 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 loads.

At slope mines second-motion engines are used but at all except one of the shafts a first-motion engine hoists the cage. The cylinder size varies from 12 by 15 inches to 24 by 36, averaging 18 by 32.

The self-dumping cage is used at 11 of the mines examined but at most of the mines in the district the operators have purchased the platform cage.

Weighing is done at the tipple throughout the district.

Table 16 gives hoisting data.

TABLE 16.—*Hoisting data.*

Mine no.	Average daily production	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
25	1200	Yes	185	8 by 16	Yes	18 by 36	5	6
26	900	Drift	......	....	......	....	....	....
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
29	1100	Yes	185	8½ by 15½	Yes	18 by 36	6	6
31	1200	Slope	90	7 by 8	No	....	....	....
32	550	Slope	68	6 by 12	No	12 by 15	....	....
33	1600	Yes	285	8½ by 16	Yes	24 by 40	8	3⅙
34	650	Yes	200	7 by 14	Yes	16 by 32	6	7¾
35	275	No	187	8 by 16	No	12 by 15	5½	4½
36	2450	Yes	238	9⅓ by 19	Yes	24 by 36	8	6
37	2700	Yes	235	10 by 16	Yes	24 by 36	7	5
38	1400	Yes	245	7 by 14	Yes	20 by 36	6	2
39	2400	Yes	204	10 by 20	Yes	22 by 36	7	3
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
42	750	No	570	8 by 16	Yes	20 by 36	8	7

PREPARATION OF COAL

This district 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. 22 shows a tipple designed for handling the 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

At those mines which do not have a local trade the sizes commonly made are:

Name	Size in inches
Lump	Over 6
Egg	Over 3; through 6
Nut	Over 1¼; through 3
Screenings (Steam)	Through 1¼

Many mines ship run-of-mine coal and the percentage of the total production thus shipped varies from 1½ to 30.

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 the total output of this district about 80 per cent of the coal is larger than ¾-inch, 75 per cent larger than 1 inch, 70 per cent larger than 1¼ inches, 48 per cent larger than 3 inches, and 25 per cent larger than 6 inches.

Fig. 22. Tipple designed for local trade and shipping

The impurities, 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.

Screens are of various types. They are built with one, two, and three decks and have a throw of 8 to 12 inches, making 75 to 80 shakes per minute. At one mine the screen is split into two compartments longitudinally, each division being five feet wide.

Table 17 gives data on coal preparation.

Power is usually obtained by burning slack under steam boilers. The largest installation at any mine examined is 750 H. P., the moderate outputs requiring only moderate horse-power. The efficiency of these power plants is low. From 3.2 to 4.3 per cent of the output is burned under boilers at the surface plant. Good combustion under boilers is obtained at one mine by the use of steam blowers and the slack burns with no clinkers. Wasted coal ranges from 0.5 to 0.7 per cent.

There is no power plant at one mine. Electric 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. Alternating current is reported to be less satisfactory for haulage than direct, but by using an A. C. locomotive a converter is dispensed with.

TABLE 17.—*Preparation of coal for market*

Mine no.	Material of tipple	Shaker screen				Is coal rescreened or washed?	Per cent of total output	
		Length in feet	Width in feet	Inclination; inches per foot	Shakes per minute		Over 1¼ inches	Over 6 inches
25	Steel	25	6	4	76	Rescreened	68	....
26	Steel	37½	8	4	80	Neither	70	35
27	Steel	32	8	4	78	Neither	70	32
28	Wood	....	12	4	82	Rescreened	75	32
29	Wood	75	....	4	76	....	71	72
31	Wood	31	7	3	80	Neither	67	20
32	Wood	30	6	4	80	Neither	68	20
33	Wood	68	8	3	78	Rescreened	75	50
34	Wood	30	5½	4	79	....	67	25
35	Wood	36	6	3	80	Neither	....	....
36	Wood	....	12	....	80	Neither	67	33
37	Wood	55	12	3	80	Neither	65	30
38	Wood	38	6	4	76	Neither	....	....
39	Steel	45	15	3	80	Neither	70	32
40	Wood	46	4	3	80	Neither	71	33
41	Wood	....	6	....	75	Rescreened	70	....
42	Wood	....	7	....	....	Rescreened	[a]	....

[a]68 per cent over 2 by 2½-inch holes.

Steel tipples have been built at four of the mines examined. Fig. 23 shows a typical surface plant in the district. Automatic recording track scales have been placed at several plants and at one pit cars are weighed on automatic scales which weigh each car and print the weight automatically.

Fig. 23. Typical surface plant at shipping mine (Photo loaned by Mr. F. S. Peabody)

In a few instances where platform cages are used cars are pushed by hand on to a revolving cradle and dumped. Box car loaders are found at several mines.

The surface overlying the workings is owned by the operators at some mines and at one it is farmed, and corn is raised for 36 mules.

Table 18 gives surface plant equipment.

TABLE 18.—*Surface plant equipment*

Mine no.	No. loading tracks beneath tipple	No. cars stored above tipple	Boilers			Electric generators	
			No.	Total H. P.	Av. steam pressure	K. W.	Volts
25	2	40	5	700	90	200	250
26	3	30	0	......	......	150	250
27	4	40	3	700	70	100	250
28	4	40	3	225	100	150	250
29	4	23	2	250	100	100	250
31	4	45	6	875	90	300	250
32	4	25	3	250	90	100	250
33	2	50	6	750	105	150	250
34	3	35	2	250	95	50	125
35	3	20	3	175	80	100	225
36	3	55	5	700	90	......	......
37	4	120	5	750	90	200	250
38	3	50	4	600	100	150	250
39	4	100	4	600	115	45	125
40	4	25	3	185	80	100	250
41	2	20	4	280	80	50	150
42	2	18	4	350	110	8	110

PUBLICATIONS OF THE ILLINOIS COAL MINING INVESTIGATIONS

Bulletin 1. Preliminary Report on Organization and Method of Investigations, 1913. (Out of print.)

Bulletin 2. Coal Mining Practice in District VIII (Danville), by S. O. Andros, 1914.

Bulletin 3. A Chemical Study of Illinois Coals, by Prof. S. W. Parr. (In press.)

Bulletin 4. Coal Mining Practice in District VII (Mines in bed 6 in Bond, Clinton, Christian, Macoupin, Madison, Marion, Montgomery, Moultrie, Perry, Randolph, St. Clair, Sangamon, Shelby, and Washington counties), by S. O. Andros, 1914.

Bulletin 5. Coal Mining Practice in District I (Longwall), by S. O. Andros, 1914. (Out of print.)

Bulletin 6. Coal Mining Practice in District V (Mines in bed 5 in Saline and Gallatin counties), by S. O. Andros, 1914.

Bulletin 7. Coal Mining Practice in District II (Mines in bed 2 in Jackson County), by S. O. Andros, 1914.

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*Bulletin 72. U. S. Bureau of Mines, Occurrence of Explosive Gases in Coal Mines, by N. H. Darton, 1915.

*Bulletin 83. U. S. Bureau of Mines, The Humidity of Mine Air, with Especial Reference to Coal Mines in Illinois, by R. Y. Williams, 1914.

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