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COOPERATIVE AGREEMENT

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State Geological Survey

Department of Mining Engineering, University of Illinois

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BULLETIN 5

Coal Mining Practice

IN

District I (Longwall)

BY

S. O. ANDROS

Field Work by S. O. Andros 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 cooperation with the United States Bureau of Mines. A cooperative 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 investigations 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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CONTENTS

ILLUSTRATIONS

TABLES

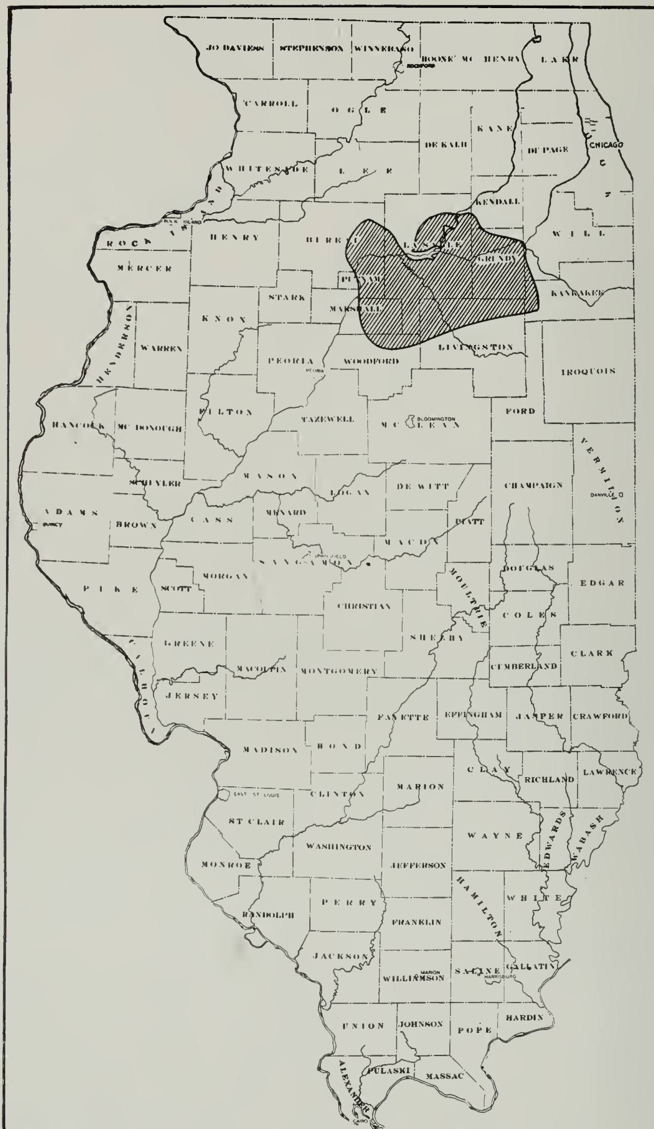

FIG. 1. Map showing area of District I. (Shaded portion). Drawn by F. H. Kay

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INTRODUCTION

This is the only field in the United States where longwall mining produces any considerable tonnage of coal, although in a few states this method is practiced to a limited extent. The Longwall District, as shown in fig. 1, includes all longwall mines, thirty-six in number, working bed No. 2 of the Illinois Geological Survey correlation in Will, Woodford, Putnam, Marshall, LaSalle, Grundy, and Bureau counties, and is District I of the Illinois Coal Mining Investigations. A detailed description of the districts into which the State has been divided and of the method of collecting data from which this bulletin was written is contained in Bulletin 1, *A Preliminary Report on Organization and Method.*

The coal produced by the longwall mines during the fiscal year ended June 30, 1912, totaled 5,032,346 tons,[1] or 8.7 per cent of the total coal production of Illinois. No undercutting machines are used in these mines. The coal mines of the district have 11,631 employees, 14.7 per cent of the total number in the coal mines of the State. Bureau County with 1,664,092 tons produced in longwall mines leads the counties of the district. On account of the initial expense of opening a mine to be operated on the longwall system only two local mines are found in the district, all others being shipping mines.

These longwall mines had an average of 209 days of active operation during the year ended June 30, 1912, as compared with an average of 160 days for all mines in the State. The average daily production of the district is 24,078 tons.

Table 1 gives general data tabulated by counties on the longwall mines of the district. Table 2 shows comparative statistics for the district and for the State, representing the year ended June 30, 1912.

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

Table 1.—*General Data by Counties*[1]

County	Number of mines		Production in short tons for the year which ended June 30, 1912	Average days of operation	Total number employees	Number of surface employees	Kegs of powder used in blasting coal	Haulage: Number of mines using—				Accidents to employees	
	Shipping	Local						Locomotive	Cable	Mule	Hand	Killed	Injured
Bureau	7	....	1,664,092	226	3,901	251	....	1	....	6	....	2	81
LaSalle	12	1	1,158,767	189	2,924	312	5,826	1	....	12	....	4	41
Grundy	6	....	742,606	211	1,661	110	5,282	....	2	4	....	3	19
Will	2	1	179,001	211	429	31	....	....	....	2	1	....	7
Putnam	2	....	716,531	244	1,354	84	....	....	....	2	....	1	31
Marshall	3	....	387,463	228	939	98	....	2	1	1	....	1	10
Woodford	2	....	183,896	212	423	26	10	....	....	2	....	1	7
Total for Dist. I	34	2	5,032,346	*209	11,631	912	11,108	3	3	29	1	12	196

[1] Compiled from the Thirty-first Annual Coal Report of Illinois.
* Averaged by mines; not by counties.

Table 2.—*Comparative Statistics for the State and for District I for the Year Ended June 30, 1912*[1]

	District I (all mines)	State (all mines)	Per cent
Total production	5,032,346	57,514,240	8.7
Average dailty tonnage	24,078	359,464	6.6
Average days of active operation	209	160	....
Number days of work performed in 1912	2,430,879	12,705,760	19.1
Total employees	11,631	79,411	14.7
Number surface employees	912	7,049	12.9
Number underground employees	10,719	72,362	14.8
Number underground employees per each surface employee	11.8	10.3	....
Number tons mined per day per employee	2.1	4.5	....
Number tons mined a day per surface	26.3	50.9	....
Number tons mined a day per underground employee	2.3	4.9	....
Number fatal accidents	12	180	6.7
Per cent from falling coal or rock	58.3	54.4	....
Per cent from pit cars	16.6	18.8	....
Per cent from explosives	16.6	7.2	....
Number deaths per one thousand employees	1.0	2.3	....
Number tons mined to each life lost	419,362	319,524	....
Number non-fatal accidents	196	800	24.5
Per cent from falling coal or rock	67.8	45.5	....
Per cent from pit cars	21.9	26.3	....
Per cent from explosives	1.0	2.6	....
Number injuries per one thousand employees	16.8	10.1	....
Number tons mined to each man injured	25,675	71,893	....

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

Acknowledgments of assistance are due to the mine operators of the district who very courteously granted access to their mines and who freely supplied whatever information was requested; to the superintendents and managers of the mines who accompanied the engineers in their inspections and who helped obtain desired information; and especially to the following individuals who rendered conspicuous service by furnishing much supplemental information and by suggesting alterations in the report for its improvement: Mr. Gordon Buchanan, President,

Wilmington Star Mining Company; Mr. E. T. Bent, President, Oglesby Coal Company; Mr. H. S. Hazen, General Manager, and Mr. C. C. Swift, General Superintendent, LaSalle County Carbon Coal Company; Mr. S. M. Dalzell, General Manager, Spring Valley Coal Company; Mr. J. A. Ede, Consulting Engineer; Mr. John Dunlop, State Inspector of Mines; Mr. C. H. Herbert, General Superintendent, Chicago, Wilmington and Vermilion Coal Company.

This district was the first to be developed in Illinois and for many years, by reason of its geographical position, nearly all the interstate shipments of Illinois coal to the northwest came from its mines. On account of the greater cost of production, the coal from this field cannot move either to the east or south toward other mining districts. It is estimated that the average cost of produuction in this district is $1.65 per ton. With the development of the great fields in southern Illinois and Indiana the production of the district has decreased and few mines have been opened in recent years.

DESCRIPTION OF COAL BED

In the longwall mines of District I the No. 2 bed of the Illinois Geological Survey correlation varies in thickness from 2 feet 8 inches to 4 feet, with an average of 3 feet 2 inches. The coal is used extensively for domestic purposes as well as in industrial plants. An average analysis obtained from 33 face samples from the 11 mines examined is given below:

Average Coal Analysis of the District

Number samples	Proximate analysis of coal—First: "As received" with total moisture. Second: "Dry" or moisture free				Sulphur	B. t. u.	Unit coal B. t. u.
	Moisture	Volatile matter	Fixed carbon	Ash			
33	16.18	38.83	37.89	7.08	2.89	10,981	....
	Dry	46.33	45.21	8.45	3.45	13,101	14,528

The chief physical characteristic of the coal in this district 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 LaSalle anticline which runs in a general northwest-southeast direction divides the district into two fields with slightly different physical conditions: the Wilmington on the east and the LaSalle, 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 LaSalle 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 embedded in the clay. In the LaSalle 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 LaSalle anticline it dips as much as 51 degrees.

Table 3 gives data on the physical characteristics of the bed, roof, and floor for each mine examined.

TABLE 3.—*Physical Characteristics of Bed.*

No. mine	Average thickness of seam in feet	Immediate roof	Location of bands	Nature of floor
1	3¼	Gray shale and black shale.	A pyritous clay band averaging two inches in thickness under the gray shale only.	Gray, micaceous, clayey sandstone which grades into fireclay.
2	3¾	Gray shale and black shale.	Irregular local bands of pyrites mixed with mother coal.	Fireclay bedded in irregular, thin, inclined layers.
3	3½	Gray shale and black laminated shale with many nigger-heads.	A persistent band of sulphur balls twenty-one inches from top of coal.	Hard, dark-gray fireclay containing very little carbonaceous matter with embedded ironstone balls; a hard sandy shale in places immediately below the coal.
4	3¼	Gray shale.	Irregular bands of pyrites at varying distances from floor.	Fireclay soft in some places, sandy and hard in others.
5	3	Gray shale and black shale; sandstone in small areas.	Bands of pyrites of irregular horizontal and vertical extent in limited areas.	Sandy fireclay.
6	3	Sandy gray shale.	A few bands of pyrites and mother coal.	Soft fireclay; heaves badly when wet and under pressure.
7	3	Gray shale.	Numerous bands of pyrites and mother coal of irregular horizontal extent between roof and coal; bands "freeze" to the coal.	Dark-gray fireclay containing a small quantity of root remains.
8	3¼	Gray shale and black shale.	A few pyrite lenses in the black shale.	Fireclay; at the depth of four feet contains boulders.
9	3½	Gray shale and black shale.	Lenses of pyrites in layers with the longer axis of the lense parallel to the bedding plane.	Soft fireclay subject to bad heaving when wet.
10	3½	Gray shale and laminated black shale. Nigger heads of pyrites in the black shale.	Irregular layers of pyritous mother coal.	Hard, dark-gray fireclay approaching shale in character; plant impressions visible.
11	2¾	Gray shale.	Occasional lenses of pyrites.	Soft fireclay.

A detailed and comprehensive report on the geology of this district is in preparation, and will be published later as a separate bulletin.

SYSTEM OF MINING

Every mine examined in this district is worked according to the longwall advancing system, and 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. 2.

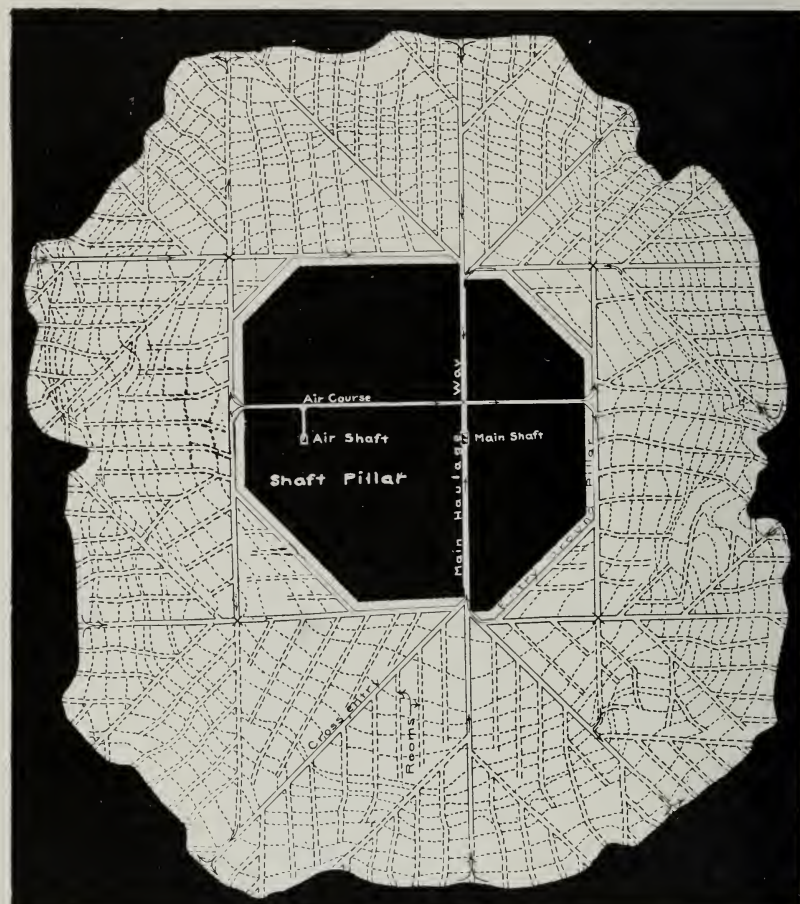

FIG. 2. Plan of longwall mine. (After Swift)

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 semi-circle or a semi-ellipse.

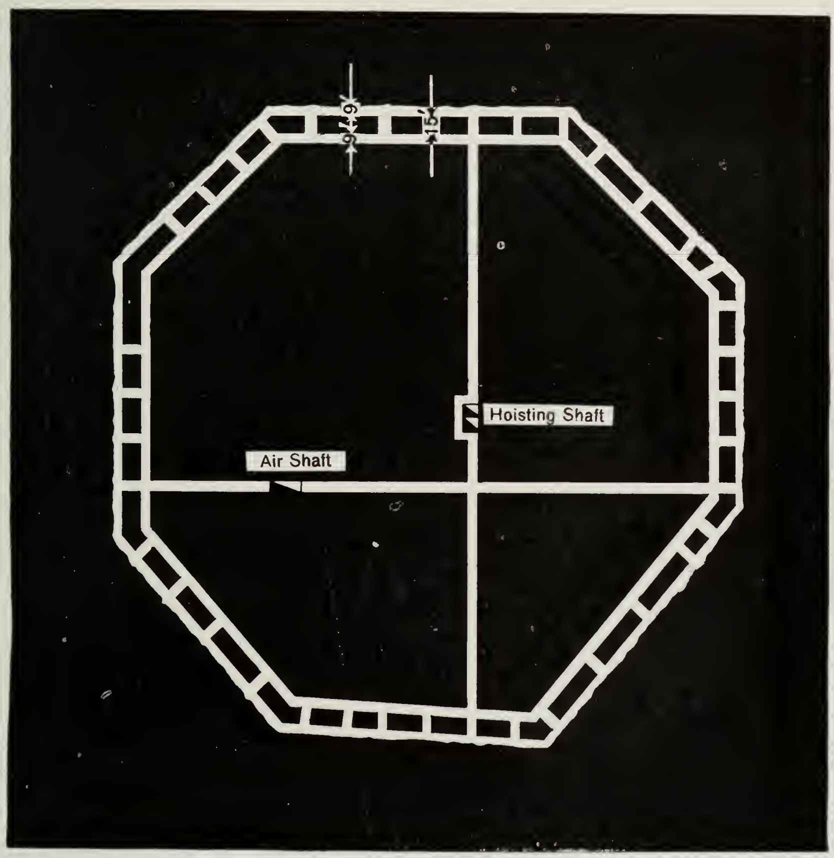

FIG. 3. Entries in shaft pillar

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. 3, from each side of the hoisting shaft for a distance of about 225 5feet. 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. The air shaft may be offset from the line of this entry as shown in fig. 2. 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 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.

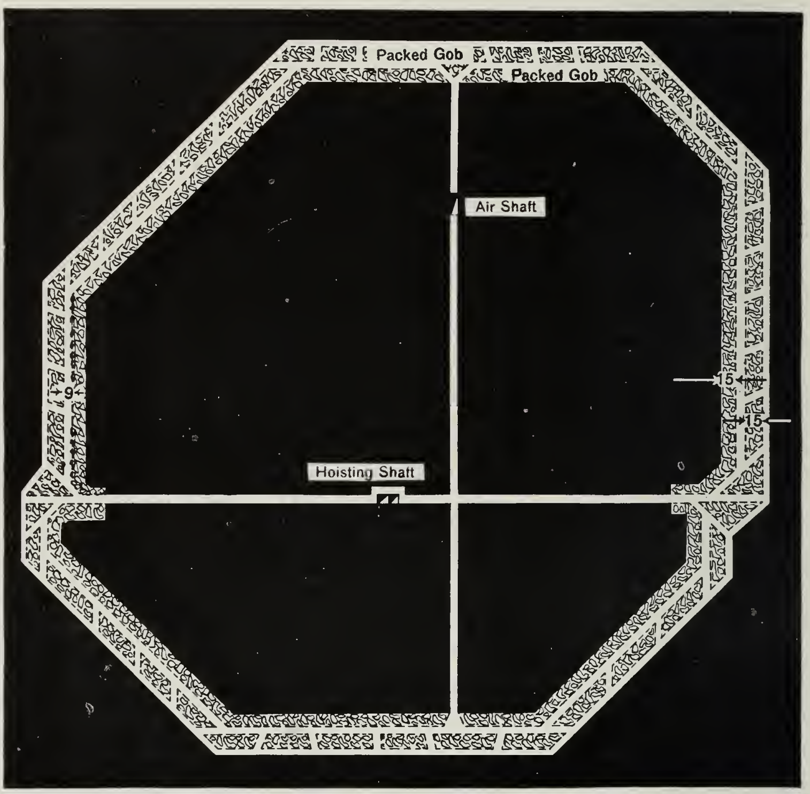

FIG. 4. Pack walls around shaft pillar

A critical time in longwall mining is when the first roofbreak 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 shaftpillar. Consequently the roof will break at the shaftpillar. The subsidence of roof following this break continues violently for three weeks and more gradually for a year. Unless the entry-around-pillar is protected by a packwall or coal pillar, it will be closed by this first violent roofsubsidence. After the entry-around-pillar has been established, openings 9 feet wide as shown in fig. 3, 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.

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. 4 and is replaced by a pack wall. The 15-foot pillar left for entry protection is also replaced by a pack wall. 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.

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.

One of the mines examined has an elliptical shaft pillar as shown in fig. 5. A main entry, "A," was driven past the hoisting shaft parallel to its longer dimension. On the opposite side of the shaft a short back entry "B," was driven parallel to the main entry and at each end was turned into the main entry at a point far enough from the shaft so that a trip of empty cars could be stored on each side. At each end of the shaft a cross-cut connects the two entries, allowing the passage of mules. The empty cars, bumped off the cage into the back entry by the loaded cars, are then hauled through the back entry and into the main entry at a point beyond the end of any trip of loaded cars which may be standing at the bottom. This method obviates the necessity of a main entry wide enough for double tracks and saves much timbering at the bottom. From the hoisting shaft at a right angle to the main entry the entries "C" were driven to the boundary of the pillar.

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

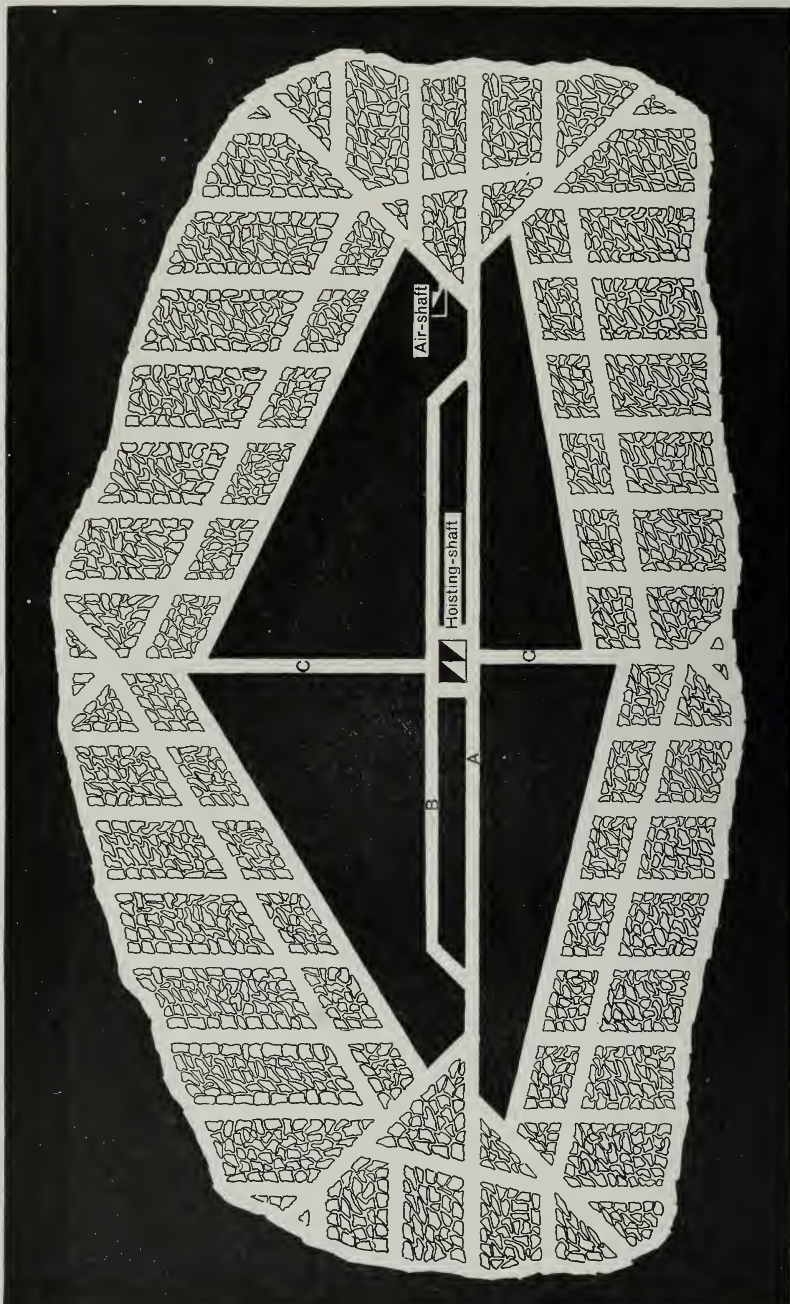

FIG. 5. Elliptical shaft pillar

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. Fig. 6 shows in a mine opened without leaving a shaft pillar of coal an entry at a point about 50 feet from the hoisting shaft. This entry has stood many years without retimbering.

The advantages claimed for removing the coal around the shaft are that the expense of timbering the bottom is reduced, and that the roof-

FIG. 6. Entry in mine with no shaft pillar

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 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. 5, 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. 2, 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 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

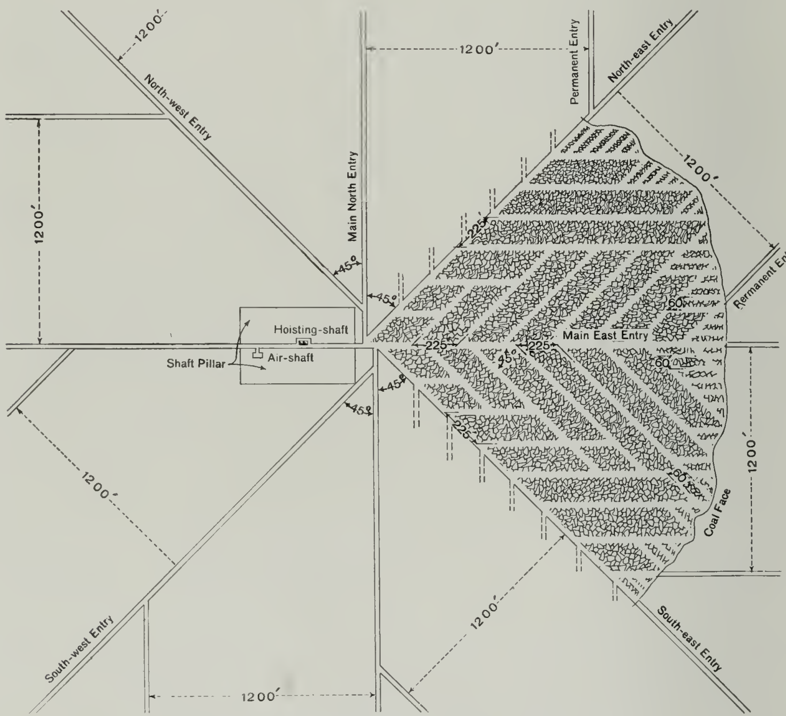

FIG. 7. Plan of mine with auxiliary permanent entries

heavy timbering is necessary, entries are maintained from the shaft pillar as shown in fig. 7 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. 8. The coal from all the face below a cross entry is thrown on a sheetiron chute down which it slides to the entry below. 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

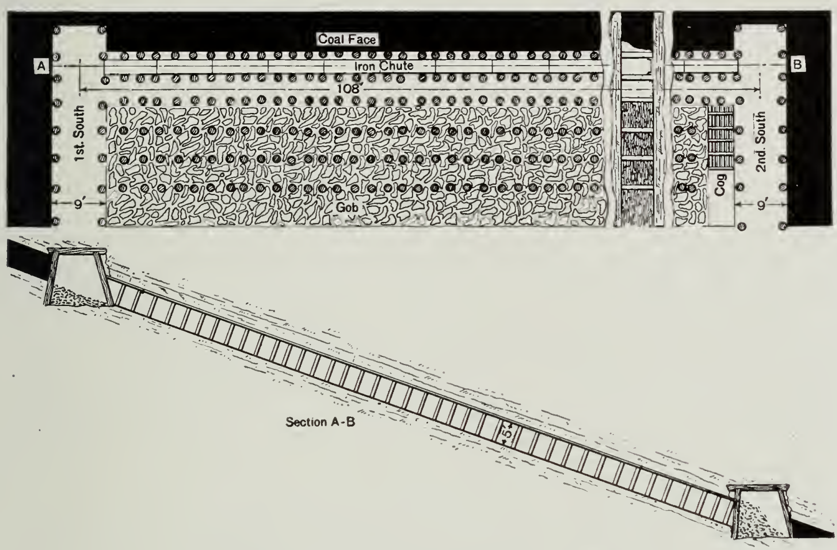

Fig. 8. Method of working panel long wall. (After Ede)

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 4 gives dimensions of workings at each mine examined.

Table 4.—*Dimensions of Workings*

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 x 600	225	45	45	42	9	9	8	12
2	465	44	250 x 250	225	45	45	42	9	9	9	9
3	398	42	550 x 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	360 x 560	275	45	45	42	7	7	7	12
6	100	36	150 x 300	225	45	45	42	7	7	7	9
7	200	37	350 x 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 x 500	225	45	45	42	9	9	7½	12
11	530	34	600 x*3,600	225	45	45	49	8	8	8	12

* This pillar was left for the protection of three hoisting shafts.

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 control 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

Fig. 9. Roof breaks

6 feet parallel to the coal face and extending upward away from the face and toward the gob as the face advances. See fig. 9. 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 LaSalle 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

FIG. 10. Diversion of face around a closed 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 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 as shown in fig. 10.

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 depths and under different kinds of cover. In only one of the mines examined was surface subsidence easily apparent.

WORK AT THE FACE

Room centers at the longwall face are usually 42 feet apart. Halfway between the center of the road head of each room and the center of the road head of the adjacent rooms a prop called the "march prop" is set as shown in fig. 11. The 42 feet of coal face included between

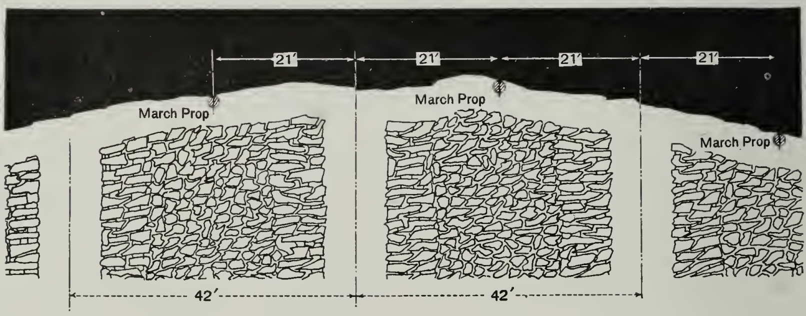

FIG. 11. Location of march props

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

FIG. 12. Mining in fireclay

walls along the roadway of the room, and of proper gobbing of the space between the marches.

FIG. 13. Props at working face

When the bed is underlain by fireclay, beginning at the center of the roadway each miner picks out the clay under the coal as shown in fig. 12 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. 13, 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 under-mining 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.

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 coal 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 5 gives data on blasting.

TABLE 5—*Blasting*

No. mine	Is coal shot down?	Size of powder	Explosive used in brushing roof	Under-mining in clay or coal	Per cent of lump coal over 1¼ inches‡	Drill holes in coal	
						Diam-eter in inches	Length in feet
1	No		None	Both	80		
2	Under nigger heads	FF	Black powder	Clay	83	1¼	2½
3	Under black shale only	FF	40 per cent dynamite	..do	79	1½	4
4	Yes	FFF	Black powder	Coal	65	1½	5
5	Yes	FF	40 per cent dynamite	Clay	70	1¾	4
6	No		..do	..do	80		
7	Yes	FF	60 per cent dynamite	..do	*73	1½	4
8	Under black shale only	FF	Black powder	..do	*73	2	4
9	Yes	FF	35 per cent dynamite	..do	Mine run	2½	7
10	No		30 per cent dynamite	Both	†83		
11	No		45 per cent dynamite	..do	83		

‡ Figures furnished by operators.
* Over 1½ inches.
† Over ⅞ inch.

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 22-4/10 cents per car where larger cars are used." In spite of this agreement considerable sulphur is thrown in the gob.

If the working places in longwall mines are properly inspected by face-bosses, there should be fewer accidents per ton of coal gained or per 1,000 employees than in room-and-pillar mines because of the comparatively small amount of blasting. Under existing conditions, however, the contrary is true. During the year ended June 30, 1912, in this district 196 men were so injured as to lose at least 30 days work and 12 men were killed. The district with its output of 5,032,346 tons for the fiscal year had 8.7 per cent of the production of the State. During this period 24.5 per cent of the non-fatal accidents in coal mines in Illinois occurred in the district. This apparently enormous disproportion is reduced when it is considered that a very small tonnage is produced by each employee per day in the longwall field, the average number of tons being less than one-half of the average for the other districts combined. In the year which ended June 30, 1912, the average number of tons of coal produced per employee per day was 2.1 for District I, as compared with 4.6 for all the other districts combined.

The number of employees consequently is out of proportion to the amount of coal gained, the number employed in the district being 14.7 per cent of all employees in coal mines of Illinois. The number of days of active operation for the district averaged 209, as compared with 160 for the State. With an average of 11,631 employees working 209 days there were 2,430,897 days of labor performed. This number is 19.1 per cent of the total for the State as a whole. It is seen, therefore, that its 24.5 per cent of non-fatal injuries shows careless mining.

TABLE 6.—*Comparison of accidents for the year which ended June 30, 1912*

	District I	All other districts combined
Number fatal accidents	12	168
Per cent from falling coal or rock	58.3	54.2
Per cent from pit cars	16.6	19.1
Per cent from explosives	16.6	6.6
Number deaths per one thousand employees	1.0	2.5
Number tons mined for each life lost	419,362	313,124
Number non-fatal accidents	196	604
Per cent from falling coal or rock	67.8	38.2
Per cent from pit cars	21.9	27.7
Per cent from explosives	1.0	3.1
Number injuries per one thousand employees	16.8	8.9
Number tons mined to each man injured	25,675	86,827

Table 2 compares fatal and non-fatal accidents for the State and the district.

A comparison of this district with all the other districts of the State combined, as given in Table 6, shows that District I has fewer fatalities per ton of coal mined or per 1,000 employees, but has almost twice as many non-fatal injuries per 1,000 employees, and produces less than one-third as many tons of coal per non-fatal injury. Including both fatal and non-fatal accidents the district has 17.8 per 1,000 employees as compared with 11.4 for all other districts combined. In both fatal and non-fatal accidents the percentage caused by falling rock or coal greatly exceeds the percentage from this cause in the remainder of the State; and in non-fatal accidents this discrepancy is marked, the ratio being as 67.8 to 38.2. This high percentage of accidents for the district is due principally to inability to enforce proper spragging of the coal and propping of the roof at the face. Unless compelled to mine properly the miner will pull the coal down with a pick, or will wedge it down after he has undermined 2 to 8 inches. He does not consider it necessary to sprag the coal for this short undermining, and is often injured when the unsupported coal falls away suddenly.

A comparison of production per employee is given in Table 7 for each of the 11 mines examined, for District I and for all the other districts of the State combined.

TABLE 7.—*Per capita production of employees*

Number	Employees				Average daily tonnage	Underground employees per each surface employee	Number face workers to each other employee	Tons a day per each surface employee	Tons a day per each underground employee	Tons a day per each face worker	Tons a day per each employee
	Surface	Underground	Workers at face	Total							
1	33	570	518	603	1,450	17.3	6.1	43.9	2.5	2.8	2.4
2	40	400	320	440	900	10.0	2.7	22.5	2.3	2.8	2.2
3	33	279	225	312	750	8.5	2.6	22.7	2.7	3.3	2.4
4	10	216	200	226	550	21.6	7.7	55.0	2.5	2.8	2.4
5	9	160	150	169	400	17.7	7.9	44.4	2.5	2.7	2.4
6	10	375	340	385	900	37.5	7.5	90.0	2.4	2.7	2.3
7	11	376	291	387	800	34.2	3.0	72.8	2.1	2.8	2.0
8	26	300	260	326	700	11.5	3.9	26.9	2.3	2.7	2.1
9	17	121	104	138	200	7.1	3.1	11.7	1.6	1.9	1.4
10	40	400	325	440	1,000	10.0	2.8	25.0	2.5	3.1	2.3
11	25	510	448	535	1,200	20.4	5.2	48.0	2.3	2.7	2.2
All mines in District I.	902	10,632	8,510	11,534	24,299	10.7	2.8	26.9	2.4	2.8	2.1
All other districts combined[1]	5,576	59,297	44,808	64,873	301,845	10.6	2.2	54.1	5.1	6.3	4.7

[1] Shipping mines only during the year ending June 30, 1912.

VENTILATION

The ventilation of mines operated on the longwall system presents few difficulties, and the problem of supplying air to the men at the

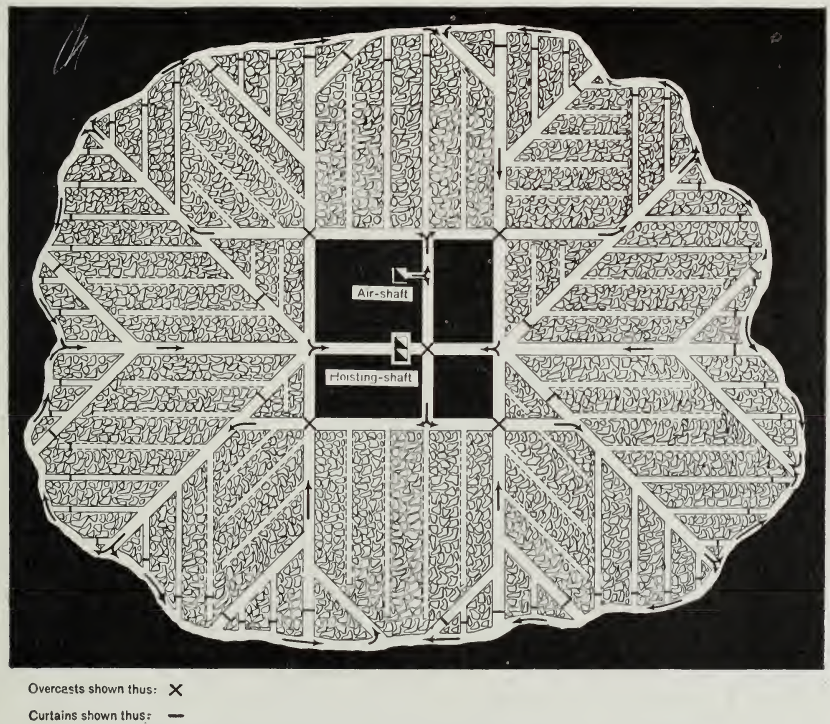

FIG. 14. Plan showing direction of ventilating current. (After Swift)

working face is easy of solution. In room-and-pillar mining, the faces of the rooms, that is, the working places of the miner, 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 longwall mines the air-current always flows along the working face, as shown by fig. 14. More physical discomfort is suffered by the longwall miners, however, because the temperature at the face of longwall mines is greater than at the face of room-and-pillar mines. This is shown in Table 8 which gives return air temperature for mines worked under both systems.

TABLE 8.—*Comparative temperatures*

Location	Mining system	Number weeks of daily readings	Average temperature at bottom of intake air shaft—degrees F	Average temperature at bottom of return air shaft—degrees F	Degrees of heating in passage through mine
Oglesby	Longwall	39	52.2	74.0	21.8
LaSalle	..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

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. Every condition necessary for spontaneous combustion is then found in the gob about 15 feet from the face:

Fine particles of coal.
Finely divided iron pryites.
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 further than twenty feet behind the face 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 temperature at the longwall face is shown by readings in Table 9 taken at the face 10 feet from a gob fire after the air current has passed the sealed-off fire, and also by readings taken at the face 100 feet distant from the fire before the current has passed over it.

TABLE 9.—*Temperature readings near gob fire*

Location	Temperature degrees F.
Face one hundred feet towards intake from fire	73
Ten feet beyond fire	84

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 occasional pockets are discovered in small sand deposits immediately above the shale roof. Whenever 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 downcast 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 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 the longwall mines is covered with shale and clay within a few days after it is made so that

FIG. 15. An entry closely timbered. (Photo by J. J. Rutledge)

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 10 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 10.—*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 mines of this district the haulage roads are sprinkled at intervals varying from one week to three months.

FIG. 16. Cog built of props

The work performed by the ventilating fan was determined by a water gage at 5 of the mines examined. The readings varied from 1.7 to 2.5 inches. By a provision of the State law effective July 1, 1913, water gages must be installed in all mines.

Table 11 gives data covering ventilating equipment at the mines examined in this district.

TABLE 11.—*Ventilating equipment*

No. mine	Depth of air shaft in feet	Clear dimensions of air shaft in feet	Number compartments	Fan		Material of fan house	Water gage readings in inches
				Diameter in feet	Length in feet		
1	413	9 x 12	2	14	8	Brick	2.0
2	Slope	8 x 12	2	10	4	Frame	No gage
3	398	5 x 9	2	8	4	Corrugated iron	No gage
4	546	8 x 10	2	20	10	Concrete	[illegible]
5	135	6 x 12	2	20	6	Frame	No gage
6	100	10 feet diameter	1	16	4	Brick and concrete	2.5
7	200	8 x 16	2	....	....	Brick, steel and concrete	No gage
8	300	6 x 6	2	10	....	....	1.9
*9	Slope	5 x 6 6 x 7	1 1	19	4	Frame	1.7
10	480	8 x 12	2	16	6	Brick and concrete	No gage
11	530	5 x 9	2	20	6	Brick	No gage

* Two air shafts.

TIMBERING

The continual subsidence of the strata overlying the coal in longwall mines makes timbering of roadways difficult and expensive. Permanent timbering can be extended only to that point where the first rapid and violent subsidence 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. These are bat-

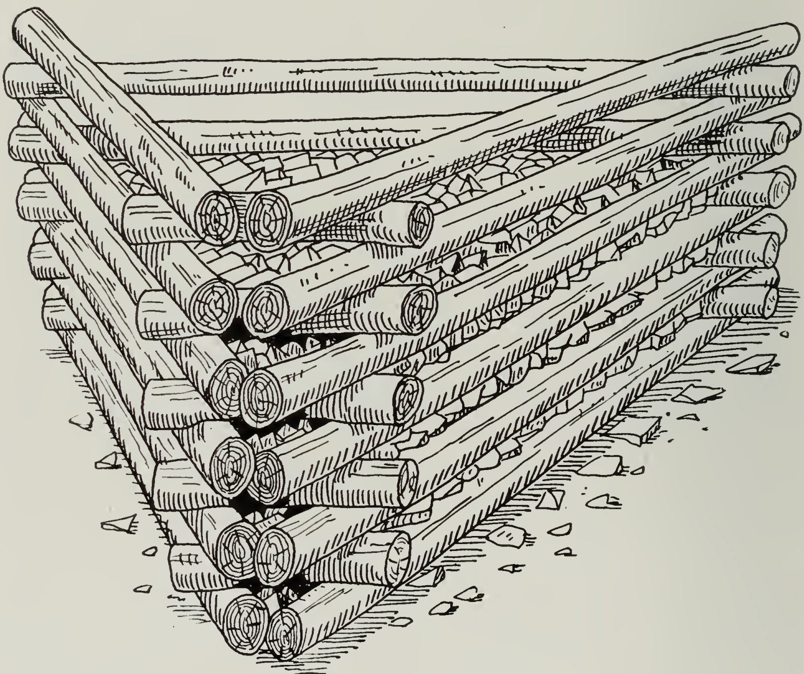

FIG. 17. Sketch of branch cog

tered 1½ inches for each vertical foot between rail and cross bar. Under bad roof the entry is usually closely timbered as shown in fig. 15. The frames in this photograph 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 are built with props as shown in fig. 16. A sketch showing details of these cogs, called "branch cogs," is given in fig. 17. These cogs are filled two-thirds full of waste rock and mining dirt. It is necessary to allow for subsidence 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

FIG. 18. A typical lye

partings in room-and-pillar mines. In this district the timbering of the bottoms does not generally differ from the timbering of 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. 18, is 14 feet; ten-inch collars and legs are used for the timber sets which are spaced 6 feet apart. This lye is 75 feet long and provides storage for 13 cars on each track.

The high temperature of the return air current in this district 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 of the district 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.

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

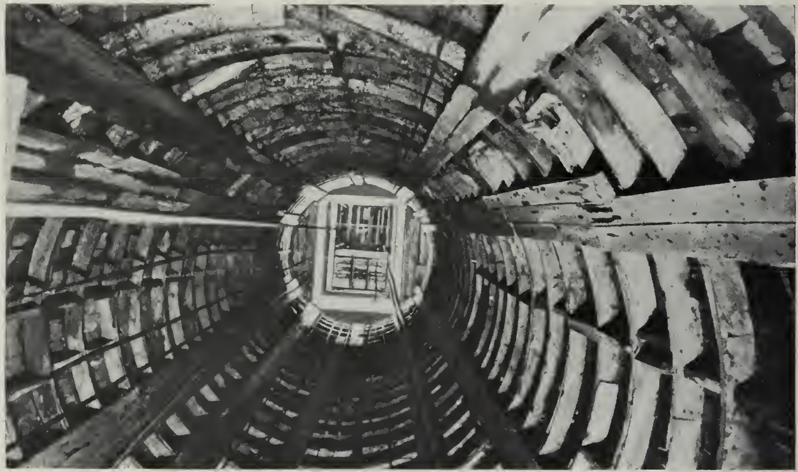

FIG. 19. Circular hoisting shaft

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 cost of timbering in a district where conditions of roof and floor are so widely different varies with each mine. Total cost of timbering at the 11 mines examined varied 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 $3\frac{1}{2}$ or 4 inches in diameter are usually bought. From .5 to 1 cent per linear foot is paid for props; the number used per ton of coal mined varies from $1\frac{1}{2}$ to 3. The expense of cross bars increases rapidly with increased diameter and length of span. Table 12 gives average cost in the 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.

TABLE 12.—*Cost of mine timbers*

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

Shaft linings are generally of timber, but concrete is also used. One of the earliest concrete-lined shafts built in the country is at the No. 6

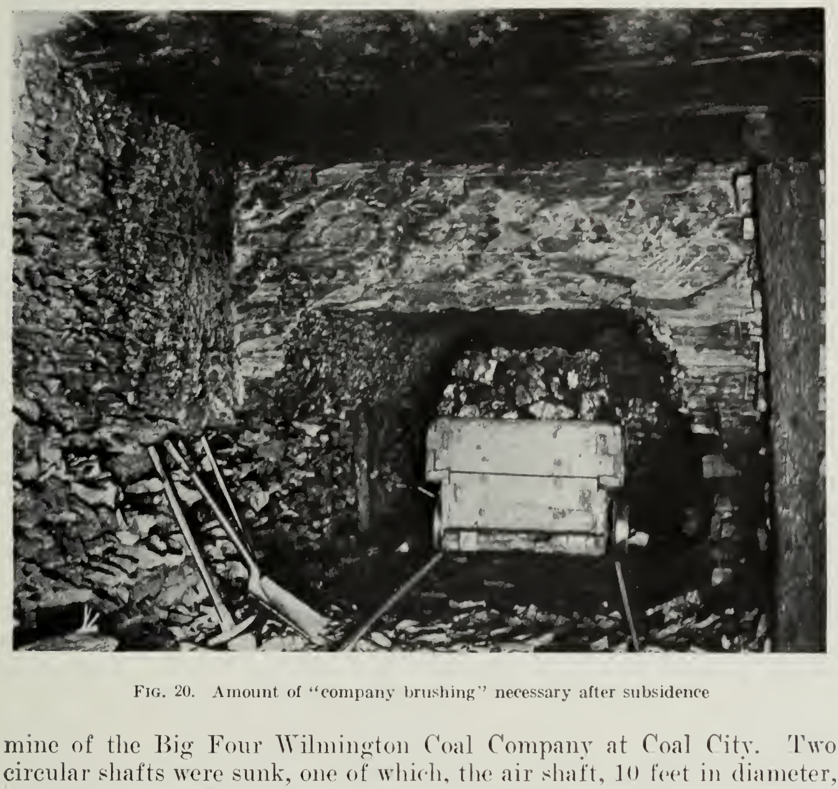

FIG. 20. Amount of "company brushing" necessary after subsidence

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. 19, 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.

HAULAGE

The older mines in the district were opened when mechanical haulage was not in general use. Mules are still used for moving the coal from the face to the bottom in many of these mines, although the face may be over a mile from the hoisting shaft. A tendency to supersede mules by mechanical haulage is apparent in this district. Several mines are arranging for the installation of electric locomotives.

At present locomotives are found in only 3 of the 36 mines in this district; rope haulage in 3 mines. Mules are used both for main and

Fig. 21. Typical shaft bottom

secondary haulage in 29 mines and in one pit cars are pushed to the bottom by men. The costs of haulage and maintenance of haulage ways are high per ton of coal because from $1/4$ to $1/3$ 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. 20 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 $12\frac{1}{2}$ cents. Maintenance of mules and car repairing costs $5\frac{1}{2}$ 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 thin bed and narrow entries limit the height of cars and the capacity of the pit car generally used in the district is small. The average weight of pit cars used in the 11 mines was 900 pounds. The light weight of pit cars and the slow speed

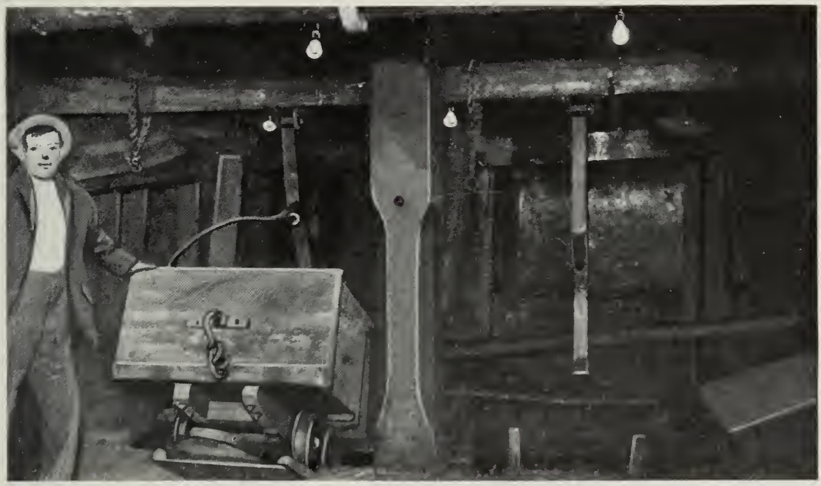

FIG. 22. Receiving hopper at shaft bottom

attained by the trips allow a comparatively light rail; a 16-pound rail is in some mines used in the entries and a 12-pound rail in rooms. Table 13 gives haulage statistics for the 11 mines examined. Pit cars are not generally kept in good repair but in many mines are leaky. Fig. 21 shows a shaft bottom in the vicinity of Coal City.

TABLE 13.—*Underground haulage*

No. mine	Kind of haulage through main entries	Track gage	Rail weight		Pit cars		Ratio of load to weight of empty car	Percentage of empty car weight in total weight of car and load
			Main	Secondary	Weight empty	Capacity		
1	Mule	33	16	16	1,800	2,600	1.44	40.9
2	Third rail electric locomotive	37	16	12	840	2,200	2.62	27.6
3	Mule	42	16	16	900	2,500	2.77	26.5
4	Main and tail rope	26½	40	16	900	1,700	1.88	34.6
5	Mule	36	16	16	425	1,000	2.35	29.8
6	Main and tail rope	24	20	12	825	2,000	2.43	29.2
7	Main and tail rope	32	16	16	500	1,000	2.00	33.3
8	Electric locomotive	36	30	16	1,100	2,700	2.45	28.9
9	Mule[1]	37	24	12	850	1,000	1.17	45.9
10	Mule	42	16	12	1,200	2,650	2.21	31.2
11	Electric locomotive	36	35	16	1,100	2,600	2.36	29.7

[1] Cable on slope.

HOISTING

The daily production of mines in the district is comparatively small; the average daily tonnage of the 11 mines examined varies from 200 to 1,450. Hoisting speed is lower than in some districts because the amount of coal daily raised to the surface does not necessitate high speed. A greater number of hoists is made daily than the figures for coal production disclose because about one-third as much rock as coal is taken to the surface. In one mine having a coal production of 1,450 tons a day 1,400 hoists a day are made. The shaft is 413 feet deep. Raising waste rock to the surface requires 350 of these hoists.

None of the mines examined had automatic caging at the bottom, and the self-dumping cage was found at only one mine in the district. Here an adaptation of ore skip is used. Pit cars from the face on

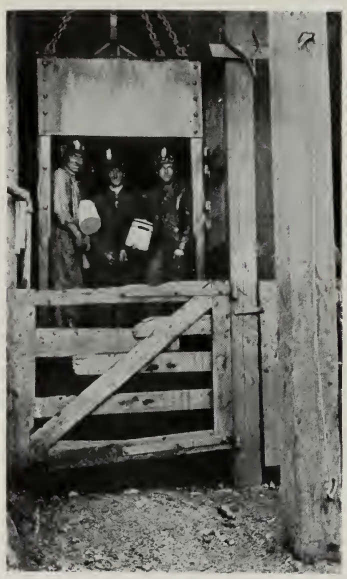

FIG. 23. Skip adjusted to hoist men

reaching the shaft bottom have their contents dumped as shown in fig. 22 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 in the tipple, discharging the contents of the skip on to the screens. The skip can be adjusted to hoist men as shown in fig. 23. Weighing is done at the bottom. Hand caging and hand unloading are common at the smaller mines,but the steam ram and transfer table are used in the tipple in the larger mines. This method of automatic unloading is not general in Illinois.

At several mines in the district cages built to hold two pit cars tandem were used as shown in fig. 24.

FIG. 24. Tandem cage

At the mines examined all but one of the hoisting engines were direct connected with cylindrical drums. Table 14 gives hoisting data for the 11 mines examined.

TABLE 14.—*Hoisting equipment*

No. mine	Average daily tonnage	Type of cage	Hoisting shaft				Hoisting engine		Drum[2]	
			Depth	Size in feet	Kind of lining	Number of compartments	First or second motion	Size	Diameter in feet	Length in feet
1	1,450	Tandem platform.......	413	12 x 12	Timber......	2	First...	24 x 42	8	7
2	900	Platform.....	465	8½ x 12	..do.........	2	..do....	24 x 36	6½	8
3	750	Platform.....	398	9 x 12	..do.........	2	..do....	20 x 32	8	8
4	550	Skip.........	546	7 x 12	..do.........	2	..do....	13½ x 42	5	7
5	400	Platform.....	135	6 x 12	..do.........	2	..do....	18 x 36	8	4
6	900	Platform.....	100	*13	Concrete and timber.....	3	..do....	14 x 20	3½	4
7	800	Platform.....	200	7 x 16	Timber......	2	..do....	16 x 30	5	6
8	700	Self dumping.	300	7 x 16	..do.........	2	..do....	32 x 42	8	....
9	200	....	Slope	6 x 8	..do.........	1	Second.	14 x 20	6	5
10	1,000	Tandem platform.......	480	12 x 16	..do.........	2	First...	24 x 42	8	8
11	1,200	Platform.....	530	9 x 12	..do.........	2	..do....	24 x 42	8	8

* Diameter; circular shaft.
[2] Largest diameter if conical.

PREPARATION OF COAL

The amount of lump coal over 1¼ inches made in proper longwall mining is 15 to 20 per cent higher on the average than is made in room-and-pillar mines, but when shooting is allowed in longwall work the percentage of lump coal is not so large. In this district the amount of 1¼ inch lump as reported by the mine operators varies from 65 to 83 per cent. In those mines where no shooting is allowed the coal breaks in large blocks.

At several of the mines in the district the following sizes of coal are made at the tipple:

Name	Size
Lump	Over 6 inches
Chunk	Over 3½ inches, through 6 inches
Egg	Over 1½ inches through 3½ inches
Screenings	Through 1½ inches

Four of the 11 mines examined send their screenings to washeries where a further separation is made into 3 sizes.

Name	Size
No. 1 nut	Over 1 inch, under 1½ inches
No. 2 nut	Over ⅝ inch, under 1 inch
Slack	Under ⅝ inch

Two mines shipped *run-of-mine* coal only.

TABLE 15.—*Tipple equipment*

No. mine	Material of tipple	Primary sizing screen: Type	Screening surface: Length in feet	Screening surface: Width in feet	Inclination	Shakes per minute	Rescreened or washed coal	Per cent of lump coal over 1¼ inches
1	Timber	Shaking	24	6	1 in 4	120	Neither	80
2	Timber	..do	43	6	1 in 4	85	..do	83
3	Timber	..do	34	6	1 in 4	110	..do	79
4	Timber	..do	27	6	1 in 4	80	Rescreened	65
5	Timber	..do	57	6	1 in 4	80	Washed	70
6	Timber	..do	22	6	1 in 4	90	..do	80
7	Timber and steel	..do	24	6	1 in 4	120	..do	*73
8	Steel	..do	48	6	1 in 4	75	Neither	*73
‡9	Timber							
10	Steel	Shaking	50	8	1 in 5	60	Both	†83
11	Timber	..do		5	1 in 5	60	Washed	83

* Over 1½ inches.
† Over ⅝ inch.
‡ Run-of-mine.

Table 15 gives data on coal preparation at each mine. The surface plants of the district are not generally so compact as the average surface plant of a room-and-pillar mine. Fig. 25 shows a representative tipple of the district. The comparatively small outputs do not require rapid continuous hoisting and consequently the power plants of the 11 mines are comparatively small.

Table 16 contains data on power plant equipment at each mine visited.

FIG. 25. Typical surface plant

TABLE 16.—*Power plant equipment*

Number mine	Car storage above tipple	Number loading tracks	Boilers			Electric generators	
			Number	Total H. P.	Average steam pressure	K. W.	Volts
1	50	4	6	900	90		
2	25	4	6	720	115	125	275
3	10	2	4	600	90		
4	15	3	2	300	106	100	250
5	10	3	4	300	85		
6	50	3	2	300	140		
7	20	3	6	200	75		
8	25	3	3	800	100	150	250
9	9	1	2	200	90		
10	80	3	6	900	90	120	250
11	20	3	9		112		

PUBLICATIONS OF THE ILLINOIS COAL MINING INVESTIGATIONS

Bulletin 1. Preliminary Report on Organization and Method of Investigations, 1913.

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, 1914

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.