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A STUDY OF SKIP HOISTING
AT
ILLINOIS COAL MINES

BY

ARTHUR J. HOSKIN

ILLINOIS COAL MINING INVESTIGATIONS COOPERATIVE AGREEMENT

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AT
ILLINOIS COAL MINES

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CONTENTS

I. INTRODUCTION ........................................... 7
   1. Advantages and Disadvantages of Skip Hoisting .... 7
   2. Method of Investigation ............................. 9
   3. Acknowledgment ...................................... 9

II. THE SKIP-HOISTING MINES OF THE STATE ............. 9
   4. Location and Physical Features ..................... 9
   5. Mining Methods ..................................... 10
   6. Production from Wide Work and Narrow Work ...... 12

III. SKIP-HOISTING MINE BOTTOMS ......................... 12
    7. Bottoms for Cage Hoisting and Skip Hoisting Com-
       pared .................................................. 12
    8. The Kathleen Mine Bottom ......................... 14
    9. The Thermal Mine Bottom ......................... 15
   10. The Valier Mine Bottom ............................ 16
   11. The Schoper Mine Bottom ........................... 18
   12. The Zeigler No. 1 Mine Bottom .................... 19
   13. The Orient No. 2 Mine Bottom ..................... 20
   14. Summary of Shaft-Bottom Practices ............... 22

IV. SKIP-HOISTING PLANTS ................................ 27
    15. Skips .............................................. 27
    16. Headframes and Shafts ............................. 28
    17. Hoists ............................................. 31
    18. Hoisting Cycles ................................... 33

V. GENERAL CONSIDERATIONS ............................... 41
    19. Handling Men, Supplies, Waste and Air ........... 41
    20. Coal Dust on Mine Bottom .......................... 43
    21. Sump Cleaning ..................................... 44

VI. COAL PREPARATION .................................... 45
    22. Standard Coal Sizes and Markets Served .......... 45
    23. Screening, Picking and Loading .................... 48
    24. Coal Inspection ................................... 48
VII. DEGRADATION OF COAL ........................................ 50
25. Significance of Degradation to Illinois Coal Industry ........ 50
26. Influencing Factors ........................................... 51
VIII. COST FEATURES .................................................. 53
27. Initial Costs of Plants ........................................ 53
28. Labor Costs for Hoisting Only .................................. 54
29. Power Costs in Hoisting ....................................... 56
30. Total Hoisting Costs .......................................... 60
IX. SUMMARY ............................................................. 62
31. Résumé of Advantages and Disadvantages of Skip Hoisting .... 62
LIST OF FIGURES

NO. |
--- |
1. | The Kathleen Shaft Bottom | 14 |
2. | The Thermal Shaft Bottom | 16 |
3. | The Valier Shaft Bottom | 17 |
4. | The Schoper Shaft Bottom | 18 |
5. | The Zeigler No. 1 Shaft Bottom | 19 |
6. | The Orient No. 2 Shaft Bottom | 21 |
7. | Skip-loading Station at Orient No. 2. | 23 |
8. | Speed—Time Curves for Skip Hoisting | 40 |

LIST OF TABLES

NO. |
--- |
1. | General Features of Six Large Skip Mines | 11 |
2. | Handling of Coal at Shaft Bottoms | 24-25 |
3. | Skip Details | 29 |
4. | Headframes and Shafts | 32 |
5. | Hoists | 34-35 |
6. | Hoisting Cycles | 36-37 |
7. | Sizes of Coal Shipped | 46 |
8. | Comparison of Prepared Sizes at Skip-and Cage-Hoisting Mines | 51 |
9. | Labor Costs in Skip Hoisting | 55 |
10. | Labor Costs in Cage Hoisting | 55 |
11. | Comparative Costs of Labor in Hoisting with Cages and Skips | 56 |
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A STUDY OF SKIP HOISTING AT ILLINOIS COAL MINES

I. INTRODUCTION

1. Advantages and Disadvantages of Skip Hoisting.—Skip hoisting was introduced into Illinois coal mining practice primarily to increase the production of coal and to decrease the hoisting cost per ton. Many operators in the State desire to learn to what extent these objects have been attained. A dependable conclusion has not been published by the men who are best informed—perhaps because of lack of time, or due to the fact that having knowledge of only their own plants, they have not felt warranted in drawing general conclusions.

In considering the merits of this method of hoisting, comparisons must be made with cage-hoisting practice. Among the advantages usually claimed for skip hoisting are:

(1) Greater capacity per mine shaft
(2) Easy enlargement of hoisting capacity to provide for expanding production
(3) Lower power consumption and lower power cost per ton
(4) Lower labor cost per ton
(5) For similar outputs, smoother hoisting cycles and lower rope speeds
(6) The use of solid-end mine cars
(7) A larger ratio of coal to gross load hoisted
(8) Reliability of dumping of coal in tipple

Some of the relative disadvantages urged are:

(1) More expensive hoisting installations, both in initial costs and in maintenance
(2) Greater breakage of coal, hence less lump
(3) Complication in the handling of men, materials, and waste
(4) Difficulty of any systematic inspection of coal for docking
(5) Production of obnoxious dust by double dumping (in some cases, triple dumping) of run-of-mine coal at the shaft bottom

This bulletin is the result of an investigation into the validity of these claims. One or two items were easily verified; the verification of others called for data that were either impossible or difficult to
obtain. It is believed, however, that tentative opinions can be ex-
pressed which will enable a mine operator the better to decide for
himself the merits of skip hoisting under his own conditions.

Some persons may feel that skip hoisting has not been practised in Illinois mines for a sufficient length of time or at a suf-
ficient number of mines to permit sound conclusions to be drawn. Such is not the case, however, for skip hoisting has been practised for a considerable period. Probably the first mining skips in the State were those installed in 1894 in the No. 4 shaft of the Chicago, Milwaukee and St. Paul Railroad Company at Braidwood. These were described by George S. Rice, at present chief mining en-
gineer for the U. S. Bureau of Mines, as follows:*

"Coal is hoisted in a V-shaped steel-plate bucket, resting on its bottom angle, where it is hinged so as to swing either way and dump its contents on either side as desired. It is held upright by rods pressed by springs from the top of the cage into slots at the ends or sides of the bucket. On reaching the top, the rod or dog is lifted automatically, and certain guides, under the control of the topman, cause the bucket to dump on one side if it contains coal and on the other if it has rock. The rock chute runs the waste material into a large side-dumping dirt-car, which is drawn up the side of the inclined dirt-dump, at the top of which the car automatically dumps and then returns to the shaft. When the bucket is loaded with coal it is deflected towards the coal chute, as it rises to position, and discharges its contents without shock over the screen.

"At the bottom of the shaft the pit-cars are dumped into the bucket by ordinary tipples. The bucket is large enough to receive the contents of two pit-cars dumped simultaneously from either side. This, however, involves the payment of miners by the gross-weight of their coal. At this place, at present, miners are paid for the lump-weight, and consequently only one car is being dumped or hoisted at a time. The miner's check is taken off the car and placed on a pin at the top of the cage, to be in turn removed by the topman and run to the weighing office."

Attention is drawn to the fact that at another small mine, the Sherard Mine at Sherard, Illinois, skips were installed also in 1894 and used continuously until the mine was closed down a few years ago.

Skips have been used for hoisting at two other Illinois coal mines since 1904. Six of the seven mines at present using skip hoisting are among the largest in the State, having a total output for the year ending June 30, 1924, of 3,829,594 tons. The newest of these mines, Orient No. 2, located at West Frankfort, is designed for a daily production of 12,000 tons. Experience in skip hoisting in Illinois is measured by millions of tons of coal handled rather than by the number of mines using this method or by the length of time in use. Even from the standpoint of time the accumulated experience of these skip-hoisting mines totals nearly a hundred years.

* Jour. Ill. Min. Inst., April, 1895, p. 78.
An interesting feature brought out by the investigation is the lack of similarity in the details of both equipment and practice at the few skip-hoisting mines. While this restricts numerous desired generalizations, it offers compensation in the suggested variety of applications of the practice in general.

2. Method of Investigation.—This study was undertaken during the active coal-mining season of 1924-5. The author visited each skip-hoisting mine in the State and took detailed notes of every phase of mining practice that bore directly or indirectly upon any of the supposed advantages and disadvantages of skip hoisting.

The data presented herein are correct as for January and February, 1925. Observations were made when each mine was operating under current normal conditions. With one exception the mines have been operated for a sufficient number of years to have become stabilized in their practices, and hence the hoisting data are believed to be typical. Orient No. 2, however, is a new mine and the data secured there, while expressing present practice, do not represent the practice that is contemplated under the projected scope of operations, which will perhaps not be attained for more than another year.

3. Acknowledgment.—Acknowledgment is made of the hearty cooperation of the officials of all the companies in the State that are using skip hoisting. Valuable data were furnished by them and they facilitated the investigation in every way.

II. The Skip-Hoisting Mines of the State

4. Location and Physical Features.—Inquiry revealed only eight Illinois coal mines that are equipped for skip hoisting. One of these is closed down indefinitely and no study was given to it. The seven mines that were visited and studied, with their average daily tonnages, are:

(1) Zeigler No. 1, of the Bell & Zoller Coal and Mining Co., at Zeigler, Franklin county; 7170 tons
(2) Valier, of the Valier Coal Co., at Valier, Franklin county; 7000 tons
(3) Orient No. 2 (sometimes called New Orient), of the Chicago, Wilmington and Franklin Coal Co., West Frankfort, Franklin county; 6000 tons*
(4) Kathleen, of the Union Colliery Co., at Dowell, Jackson county; 4600 tons
(5) Schoper (sometimes called Standard No. 2), of the Standard Oil Co. (of Indiana), near Carlinville, Macoupin county; 4200 tons
(6) Thermal (sometimes called Thermo), of the Donk Bros. Coal & Coke Co., Edwardsville, Madison county; 3400 tons
(7) Wenona, of the Wenona Coal Co., Wenona, Marshall county; 100 tons

* Data for Orient No. 2 are correct for January and February, 1925, but do not represent conditions that will prevail when full production is reached.
Each mine was studied analytically while in operation and the data thus obtained were supplemented by many items from the records maintained by the mine officials.

These mines all have vertical shafts, the depths from the surface to the floor of the coal seam varying from 207 to 592 ft.

The Zeigler No. 1, the Valier, and the Orient No. 2 mines are in Franklin county. The Kathleen mine is in the adjacent county of Jackson but is included in the same mining field. All of these mines are in the No. 6 coal, which has its greatest thickness in this field. In these four mines the thickness of the seam varies between 8 ft. and 10 ft. 3 in., the average being about 9 ft. From one-half foot to nearly two feet of coal is left to form the roof, so that the average working thickness of coal is about 7 1/2 ft. This particular field is famous for its big mines, three of them rating as the largest producers in the world. This point is pertinent because the Zeigler No. 1 and Valier mines, included in the present investigation, are two of these record producers.

The Schoper mine in Macoupin county and the Thermal mine in Madison county are in the Central and Belleville mining fields respectively. They, also, are in the No. 6 coal, which is much thinner here than in the Southern field, its thickness averaging 5 ft. 10 in. in the Thermal mine and 6 ft. in the Schoper mine.

The Wenona mine is in Seam No. 3 in the Northern field, and is worked by the advancing longwall method. The coal averages 2 1/2 ft. in thickness and is all extracted. The Wenona shaft is 540 ft. deep from the collar of the shaft to the bottom of the coal. This mine formerly produced about 1000 tons per working day but its present production is so small and erratic that none of the Wenona data are used in this study.

5. Mining Methods.—With the exception of the Wenona mine, all the mines are worked by modified room-and-pillar methods, commonly called "panel systems." The distance between room centers is usually, but not invariably, constant in any one mine. The standard centers vary from 40 ft. as a minimum to 60 ft. as a maximum, the average for the six mines being about 50 ft. In one section of one mine, owing to local conditions, the room centers are 85 ft.

Rooms are driven with widths variously standardized, from a minimum of 22 ft. to a maximum of 30 ft., the average width being about 26 ft. Since little attempt is made to recover any of the room pillars (except from cross-cuts) the extraction from a given panel cannot reach 60 per cent. Considering the coal remaining in panel and entry pillars and that left as roof the average extraction can be scarcely 50 per cent.
### Table 1

**General Features of Six Large Skip Mines**

<table>
<thead>
<tr>
<th>Mine</th>
<th>Daily Tonnage</th>
<th>Owner</th>
<th>Year Plant Installed</th>
<th>Depth to Floor of Coal</th>
<th>Thickness of Seam</th>
<th>Percentage Narrow Work</th>
<th>Distance Between Room Centers ft.</th>
<th>Width Rooms ft.</th>
<th>Total Number Men</th>
<th>Number Underground Men</th>
<th>Bottom Men</th>
<th>Top Men</th>
<th>Tipple and Loading Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeigler No. 1</td>
<td>7170</td>
<td>Bell &amp; Zoller Coal &amp; Mining Co.</td>
<td>1904</td>
<td>416</td>
<td>10-3</td>
<td>8-4</td>
<td>15</td>
<td>27</td>
<td>1160</td>
<td>1050</td>
<td>14</td>
<td>110</td>
<td>36</td>
</tr>
<tr>
<td>Valier</td>
<td>7000</td>
<td>Valier Coal Co.</td>
<td>1918</td>
<td>592</td>
<td>8-0</td>
<td>7-0</td>
<td>15</td>
<td>25</td>
<td>1148</td>
<td>1048</td>
<td>12</td>
<td>100</td>
<td>13</td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>6000</td>
<td>Chicago, Wilmington &amp; Franklin Coal Co.</td>
<td>1924</td>
<td>498</td>
<td>9-6</td>
<td>7-10</td>
<td>35</td>
<td>40</td>
<td>22</td>
<td>840</td>
<td>700</td>
<td>6</td>
<td>140</td>
</tr>
<tr>
<td>Kathleen</td>
<td>4650</td>
<td>Union Colliery Co.</td>
<td>1918</td>
<td>230</td>
<td>8-6</td>
<td>7-0</td>
<td>33</td>
<td>45</td>
<td>26</td>
<td>725</td>
<td>675</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Schoper</td>
<td>4200</td>
<td>Standard Oil Co. (Ind.)</td>
<td>1922</td>
<td>322</td>
<td>6-0</td>
<td>6-0</td>
<td>15</td>
<td>60</td>
<td>30</td>
<td>598</td>
<td>559</td>
<td>6</td>
<td>39</td>
</tr>
<tr>
<td>Thermal</td>
<td>3100</td>
<td>Donk Bros. Coal &amp; Coke Co.</td>
<td>1923</td>
<td>207</td>
<td>5-10</td>
<td>5-10</td>
<td>20</td>
<td>48</td>
<td>28</td>
<td>573</td>
<td>534</td>
<td>6</td>
<td>39</td>
</tr>
</tbody>
</table>

*See note, p. 9.
†Includes re-screeners.
The Wenona mine is worked by a longwall method of its own. The workings have always been chiefly to one side of the hoisting shaft and carried forward along a face that is an arc of a circle about one-quarter of a mile long. In this manner 100 per cent of the coal is extracted from a strip of land consisting of contiguous 40-acre tracts lying in an east-west tier. As such a panel nears its limit a similar panel is started to one side and is worked right up to the old gob. The method may be called advancing panel-longwall.

6. Production from Wide Work and Narrow Work.—For each of the room-and-pillar mines an estimate was made of the relative amounts of coal mined in rooms and in all forms of narrow work. This was done in order to observe, if possible, the effect on the sizes of coal produced. In no mine was the coal from narrow work less than 15 per cent of the total. The percentage varied in other mines to a maximum of about 35, this high figure being for Orient No. 2 mine, a new mine in which a large area is being developed in preparation for a heavy future production.

Probably one-fifth of all the coal produced in the southern and western Illinois fields comes from narrow work. Occasionally such coal is shot from the solid. When undercut it is usually broken down by unduly heavy charges of explosive. For these reasons the coal from narrow work invariably gives a lower percentage of lump than does the coal from rooms. While this holds true irrespective of the kind of hoisting, its significance in the present study lies in the fact that two of the skip mines are in such a stage of development that much of their coal comes from narrow work.

III. Skip-Hoisting Mine Bottoms

7. Bottoms for Cage Hoisting and Skip Hoisting Compared.—In connection with a previous study of Illinois coal mining practices* the following definition was framed:

"The term shaft bottom applies to the portion of the mine that is contiguous to the bottom of the main hoisting shaft. It includes the terminal tracks for storing the loaded cars while waiting to be hoisted, the storage tracks for empty cars while waiting to be taken back to the working faces, . . . ."

In the present study this definition will prove satisfactory if the word "hoisted" be replaced by "dumped." The shaft bottom, then, is conceived as including the outbye terminals of the main-haulage lines of the mine—both for loads and empties. This point is mentioned because comparisons between the two types of hoisting involve shaft-bottom activities in detail.

Complete details were obtained of the practices followed, in the skip-hoisting mines, in receiving the loaded trips from the main-haulage locomotives, and in the succeeding stages in handling each carload of coal until it is discharged into a skip and is hoisted; also data concerning the travel of each locomotive after delivering its loads, while securing its empty trips, and while leaving the bottom en route to the mine partings. Corresponding data were obtained for a number of large cage-hoisting mines.

The employes whose duties are exclusively in the main bottom have the following positions on payrolls: motormen, winding engineers, dummy-riders, blockers, spraggers, couplers, uncouplers, empty bosses, switchers, coupling-pin carriers, retarder or drag operators, check pullers, weighmen, recorders, dumper operators, hoist signallers, skip loaders, sump cleaners.

Frequently one man will perform two or more of these duties. At no two mines are the men's functions similar, because of different shaft-bottom layouts and different equipments. At four mines the dump operator has no other duties; at two mines he also gives hoisting signals; while at one mine he operates the car retarder and dogs.

Trip despatchers and check weighmen are not included in the data. The removal of spillage from the sumps is done on night shift by sump cleaners. Enumeration of these men is omitted from Table 1, and they are not included in calculating labor costs.

A bottom layout for skip hoisting must be considerably different from one for cage hoisting, all natural conditions being identical. Because of such necessary differences in shaft bottoms it is considered impracticable to convert a developed coal mine from one system of hoisting to the other.

The chief difference between the shaft-bottom plans for the two systems of hoisting is that the long side of the shaft is at right-angles to the main bottom in a cage mine, whereas it is parallel to the bottom in a skip mine. Another difference is that the cage shaft is directly in line with the main bottom while the skip shaft is always at one side of the bottom. Mine cars never enter nor pass through a skip-hoisting shaft.

A third distinction affecting the shaft-bottom layout is that, with skip hoisting, provision must be made underground for weighing every carload of coal—either in its car or in weigh pans—thus transferring to the inside what is ordinarily a surface activity. Still another difference is the dumping of the mine cars on the shaft bottoms with skip hoisting, instead of in the tipple, as with cage hoisting.

These are the main differences that enter into the design of skip-hoisting mine bottoms. In other respects there is much in common.
between the two systems. Practically the same general arrangements must be made for bringing in and handling the loaded trips, for making up empty trips, and for getting the empties away from the bottom. In common with cage mines, skip mines should have reasonably long main bottoms on both sides of the shaft, straight if possible, for the amount of car storage available is a very important factor in the successful operation of a shaft mine.

Sketch-plans of the shaft bottoms in the six large mines herein studied are shown in Figs. 1, 2, 3, 4, 5, and 6. They exhibit as little similarity among themselves as do the plans of cage-mine bottoms, but their diversity of layout proves interesting. The sketches indicate the routings of the mine cars, loaded and empty, with the movements of the locomotives when traveling light. Local natural conditions, sometimes unsuspected, have had much to do with the devising of some of these layouts.

8. The Kathleen Mine Bottom.—This shaft bottom (Fig. 1) is described first because it is decidedly different in general plan from any of the others. The main bottom appears unusually short. This is a specific instance of contending with adverse natural conditions. Here the coal measures dip to the east about 3 degrees. The main-haulage roads, therefore, to be reasonably level, were laid out north-and-south. By driving the main bottom east-and-west, advantage was taken of gravity to move the loads and empties. It was deemed inadvisable to have this main bottom maintain such a heavy grade (about 5¼ per cent) for more than a short distance because of the excessive loads that would be placed upon the locomotives in handling the empty trips.
With such a grade in favor of the loads, the pull of a few loads eastwardly along the short main bottom is utilized in moving a string of connected loads in either the main north or the main south entry. As a matter of fact a mechanical drag-chain retarder is a necessary unit in feeding the loads to the scales and the dumper. In this mine, then, the main bottom extends into the north entry to A and into the south entry to B.

The locomotives of loaded trips may cut off at any point c, the loads either passing on around the curve into the main bottom or being coupled to loads ahead. An average trip is 15 cars. No coal is hauled through the back entries.

The retarder engages two cars at a time and spots them on the two track scales set in tandem. One man acts as check puller and weighman, the weights being determined on ordinary beam balances. (A checkweighman is present in each of these mines but he is not included herein among employes, as he is paid by the miners.) From the scales the two loads enter the dumper to be unloaded simultaneously, uniting in the hopper beneath the dumper and being deflected to either skip by the manipulation of a swinging partition, or so-called butterfly. The skiploads average 7.5 tons each. The dumping cycle occupies 9 seconds for spotting and 6 seconds for the forward and reverse rotations.

The empty cars may be stored as far as C to the northeast and as far as D to the southeast. Empty trips to go north are picked up by a locomotive at p₁, and hauled through the same run-around by which the locomotive entered. Empty trips for the south are picked up at p₂ and hauled westward to the main south. The locomotive in this case is not reversed, nor does it return through the same run-around.

The following men are employed normally: 2 blockers, 1 weighman-checkpuller, 1 operator for the retarder, dogs, and dumper, who is also hoist signaler, and 2 couplers who inspect empties and couplings and make up empty trips; total 6 men.

The storage capacity of the mine-bottom tracks is approximately 85 loads and 85 empties.

9. The Thermal Mine Bottom.—This is another mine bottom in which no loaded cars traverse any crosscuts or back entries. All loads enter the main bottom by curved approaches from the south, the locomotives being uncoupled immediately at c, Fig. 2, and sent through their respective run-arounds to p where they receive their empty trips and, reversing, return through the same back entries to the main east-and-west entry. Double trackage is provided north of the dumper for making up, alternately, empty trips to go east and west.
The storage capacity for loads is 36 cars. The empty storage capacity is about 40 cars.

Two cars are emptied simultaneously by the rotary dumper, the carloads dropping into separate weighpans which are suspended from scales having both manual beams and weightographs. Cars are not uncoupled for dumping. One man operates the carfeeder (drag chain) and the dumper. The time required is 11 seconds for spotting the cars and 9 seconds for the rotations. There is never less than one carload of coal in one of the weighpans. Immediately after a dump there are two carloads in one pan and one carload in the other. A skip load is the two carloads from a single weighpan.

To keep the net coal weights separate each scale has two sets of beams, the first carload being counterbalanced on the lower beam, the second load on the upper beam. The weighman dumps each weighpan into its receiving chute. When, in its descent, the skip automatically opens the chute-gate, the coal slides into the skip. The checkpuller gives an electrical signal to hoist and as the skip rises the gates close automatically.

The shaft-bottom force comprises: 1 motorman for switching and feeding, 1 operator for the carfeeder and dumper, 1 weighman, 1 checkpuller-signalman, 1 empty boss, and 1 switcher; total 6 men.

10. The Valier Mine Bottom.—In some respects the layouts and practices are similar in the Valier and the Thermal mine bottoms. The routings of the cars are identical. However, in the Valier the locomotives with loads from opposite sides of the mine cut off at different points c, the one from the west proceeding forward, the other from the east reversing through its respective crosscut (see Fig. 3).
The main entry is triple-tracked, the middle track being reserved for a pusher locomotive that feeds the loads on both the outside tracks.

![Diagram of Valier Shaft Bottom](image)

The exact placing of the cars on the scale is done by an air-operated spotter. The cars are uncoupled before they are weighed, one at a time, on a track scale with an automatic indicator. Next, one car is fed to the dumper and dumped; then two cars are dumped together. These two dumping operations require 40 seconds, or \(13\frac{1}{3}\) seconds per carload. The three carloads, of an average combined weight of 13.5 tons, are held in a single pocket or hopper. A pivoted partition is operated to deflect the coal as it is dumped into the chute for either skip. The gates are lowered and raised automatically by the travel of the skips, exactly as at the Thermal mine.

Owing to an adverse grade to the north of the shaft, not more than 10 or 12 empties can be stored on either track in the main entry. The single track northward from \(a\) has a 10 per cent upgrade to \(b\), where an electrically-driven winding drum is installed. The outer end of the half-inch rope is attached to a "dummy" or small truck upon which rides a man who couples to a string of empties, say on the west main bottom track. After being quickly hauled up past the electric switch, he is dropped, with his trip, back into the west runaround, where he uncouples from his trip, leaving the empties to be picked up at \(p\) by the main-haulage locomotive. The dummy is then hoisted back to the switch and lowered to the main entry, where it is coupled to another string of empties, this time on the east track. These are similarly handled into the east back entry.

The air switch and the electric switch noted in Fig. 3 are homemade devices that are manipulated by the motormen or the dummy-rider while traveling.
The main-bottom crew includes 12 men, as follows: 1 push motor-man, 2 blockers, 3 couplers, 1 weighman, 1 dumper-signaler, 1 check-puller, 1 winding engineman, 1 dummy-rider, and 1 switcher.

At the time of this inspection plans were prepared for alterations on the empty side of this mine bottom as shown by broken lines in Fig. 3. The diagonal passageways will be maintained level by excavation in the floor and they will be equipped with chain hauls. The back entries also will be made level to connect with the new cross-cuts. These improvements will make it possible to dispense with the winding engine and dummy.

Here, again, no coal is hauled through any back entries or run-arounds.

11. The Schoper Mine Bottom.—This is an instance of a coal-mine shaft that was sunk in the center of the property holdings so that the mine workings were planned to extend symmetrically from the main bottom. Figure 4 indicates that the natural attitude of the coal seam favored an unusually large but simple layout for this mine bottom.

Coal approaches the bottom from the four diagonal main entries. All loaded trips from the northwest and southwest run directly into the main bottom which extends east-and-west. All trips from the eastern sections of the mine are routed through the back entries and enter the main bottom at the west end.

Locomotives cut off at c, immediately passing to their respective back entries and going around to the empty bottom where they couple to their respective empty trips. Empty trips for eastern sections of the mine pass directly into the main northeast or main southeast
entries while those for western sections traverse the same back entries as do the loads from the east. These entries are about 1600 ft. long.

This bottom has exceptionally large storage capacity on straight tracks for both loads and empties, these capacities being respectively 82 and 120 cars.

Trips average 18 cars each. All cars are uncoupled and weighed separately, being handled by a trip-feeder or, as it is called locally, a car-pull. Coal weights are automatically indicated and recorded. From the two scales the cars pass to two parallel rotary dumpers, each of which tips one car at a time. These dumpers are operated by induction motors instead of the usual long compressed-air cylinders. Each dumper has a continuously-running 15-h.p. motor to which it is geared through a clutch. After a car has been overturned, the dumping apparatus rights itself automatically by gravity.

The coal is dumped into a 100-ton storage pocket, whence it passes to two measuring pockets—one for each skip. The skip loading is controlled by an operator at a convenient station beneath the dumpers, centrally located with reference to the shaft compartments. The average skipload is 11 tons—not an exact multiple of a carload, which averages 4.76 tons at this mine.

The following bottom employes are required: 1 man who controls the car-pull, uncouples cars, and pulls checks, 1 weighman, 1 dump operator, 1 spragger, 1 coupler, and 1 skiploader-signalman; total 6 men.

12. The Zeigler No. 1 Mine Bottom.—In Fig. 5 it is seen that a loaded trip from either the south or the north section of this mine enters the main bottom from the south at a. Here the motorman takes

FIG. 5. THE ZEIGLER NO. 1 SHAFT BOTTOM
whichever of the load tracks is clear and does not cut off until he is close to the shaft at \( c_1 \) or \( c_2 \), whence he takes one of the run-arounds to pick up his empties at \( p \). Reversing his locomotive, he starts with his empty trip through whichever run-around and back entry leads to the main haulage road by which he entered the bottom. One locomotive is in constant use on the bottom in making up empty trips.

The main entry has storage capacity for 75 loads and 70 empties. A pusher locomotive travels on the middle of the three tracks on the load side of the shaft and feeds the loads to the two track scales set in tandem. The cars are weighed without uncoupling from the trip, but they are uncoupled in pairs for dumping. The loads, upon leaving the scales, run by gravity, under spragged control, to and into the dumper. The unloaded cars are also run from the dumper by gravity. Ten seconds are consumed in discharging empties and spotting loads in the dumper and 83 seconds in the forward and reverse turnings. About 1770 cars are emptied daily.

The coal drops directly into an immense storage pocket from which it is loaded into the skips by the opening of vertical-lift gates that are manually controlled by an operator whose station is on the opposite side of the shaft. The hoist signals are given electrically by the same operator.

As is the case at the Schoper mine, a skipload is not an integral multiple of a carload. The average Zeigler No. 1 carload is 4.05 tons, while the average skipload is 9.5 tons. The storage in the pocket is provided to maintain steady hoisting, regardless of irregularities in the supply of coal to the bottom. This feature has had prime significance in connection with the famous record-establishing performances at this mine. The capacity for handling and dumping coal at the bottom considerably exceeds the capacity for hoisting, so that the steadiness in the latter operation is really the governing factor in the production of this mine. A visitor to the hoist house cannot fail to note this continuity of hoisting.

The men employed on this mine bottom are: 2 motormen, 1 uncoupler, 1 weighman, 1 checkpuller, 3 spraggers, 1 dumper, 2 couplers, 1 man who carries coupling pins from the load-side to the empty-side, 1 skiploader-signalman, 1 bottom boss; total 14 men.

13. The Orient No. 2 Mine Bottom.—This, the newest skip-hoisting mine in the State, is designed for an ultimate daily production of 12,000 tons of coal. In its present stage of development it averages a daily output of 6000 tons. The practices that were observed during the inspection of the mine for the present study do not represent necessarily the practices that are projected for full-scale operations. This comment applies especially to the shaft-bottom activities.
As shown in Fig. 6 this mine bottom is wide and straight, about 1250 ft. long, and has storage capacity for 125 loads.

At present, and until the mine has been developed sufficiently to necessitate long haulage routes and large trips, there is and will be only one stage in the haulage. Eight-ton reel-and-trolley locomotives gather the loads and haul them, in trips of eight cars, to the bottom. About one-half of these locomotives are built purposely for a low speed—3.5 miles per hour—such locomotives having been proved, by tests, capable of handling the output of the mine at 25 per cent less power consumption than is demanded by the so-called high-speed (6 miles per hour) locomotives.

The mine cars are of a standard plan but of three different heights of body. The largest cars can be topped by hand to carry 6.5 tons. Much of the coal loading in this mine is mechanical so that high topping is not a general practice. Occasionally a machine-loaded car will not exceed 4 tons. The average carload is 5.17 tons.

Because of peculiar surface topographic features the shaft was necessarily placed near the southeastern corner of this large coal tract. Relatively little production will come from the south, a considerable production will come from the east, but by far the bulk of the future output of the mine will reach the bottom from the north and west. Figure 6 shows the unusual layout of this bottom to meet these conditions.

All loaded trips enter from the north. The locomotives may be uncoupled from their trips to pass through any of the numerous cross-cuts to the east or west and traverse the round-arounds to p, where they pick up their empty trips of eight cars each and counter-travel their respective back entries in returning to the working faces.
All of the mine-bottom entries are single-tracked with the exception of the main entry which has a second track along the west rib. In the north main entry a pusher locomotive handles the loaded trips and feeds them, without interruption, to the drag chain which, in turn, delivers the loads to the dumper. On the empty side another pusher locomotive assists in making up trips.

The procedure of dumping and weighing is precisely the same as at the Thermal mine (see p. 16). Each dump cycle includes 10 seconds for spotting and discharging cars and 6½ seconds for the forward and reverse rotations. There is no uncoupling of cars. The scale for each weighpan has two beams—one for each carload of coal.

Just as a skip is landing at the bottom of the shaft the weighman dumbs the corresponding weighpan which contains two carloads of coal. The coal slides down into the automatic skiploader, a specially-designed chute with a swinging or arc-shaped gate, as shown in Fig. 7. The opening (lowering) and closing of each chute is done by an electric motor. The opening occurs simultaneously with the landing of the skip. An electric device is set to regulate the period of loading to exactly 9 seconds. As the chute starts to close an electric contact gives the hoisting signal. Sometimes the closing occurs before all coal has slid from the loader, in this case the small quantity of coal that remains is retained until the following load into the same skip. Upon receiving the signal the hoistman starts his drum slowly and the loading-gate has time to close fully before the rising skip can strike it.

On the scale table in front of the operator are three banks of incandescent bulbs, each bank comprising a clear or white light at the bottom, a red middle light, and a green upper light. Current is furnished to these lamps through contacts made by each skip in its travel, the white light indicating that the skip is at its landing and that the weighpan may be dumped safely. The red light shows that the skip is away from its landing but is not above the main bottom floor, the green light that the skip is anywhere above that floor.

Shaft-bottom duties are performed by the following 6 men: 2 push motormen, 1 car-feeder and dumper operator, 1 weighman-pan-dumper, 1 checkpuller, and 1 recorder. This last man keeps the weight records, the weighman’s attention being fully required in counterpoising the loads on the scale beams, in following the movements of the two skips in the shaft, and in dumping the weighpans at the proper times. It is expected that the same crew of men will suffice when the mine reaches its projected production of 12 000 tons per day.

14. **Summary of Shaft-Bottom Practices.**—In all of these bottoms the tracks are of 42-inch gauge and of heavy construction, as would
The weigh-pan is discharging into the loading chute and into the skip. During hoisting the skip-loading gate is in the dotted position, clear of the skip.

FIG. 7. SKIP-LOADING STATION AT ORIENT NO. 2
### Table 2

**Handling of Coal at Shaft Bottoms**

<table>
<thead>
<tr>
<th>Mine</th>
<th>Mining Methods</th>
<th>Average Tonnage Per Day</th>
<th>Storage Capacity of Bottom</th>
<th>Coal Weighed in</th>
<th>Trip Feeding and Car Spotting</th>
<th>Kind of Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeigler No. 1</td>
<td>Room and pillar</td>
<td>7170</td>
<td>75 304 70</td>
<td>Cars, without uncoupling</td>
<td>Pusher locomotive to scales, Gravity to dumper</td>
<td>Automatic indicating</td>
</tr>
<tr>
<td>Valier</td>
<td>Room and pillar</td>
<td>7000</td>
<td>60 270 60</td>
<td>Cars, after uncoupling</td>
<td>Pusher locomotive; mechanical spotter</td>
<td>Automatic indicating</td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>Room and pillar</td>
<td>6000*</td>
<td>125 645 30</td>
<td>Weighpans</td>
<td>Pusher locomotive; drag-chain</td>
<td>Automatic indicating</td>
</tr>
<tr>
<td>Kathleen</td>
<td>Room and pillar</td>
<td>4650</td>
<td>85 319 83</td>
<td>Cars, without uncoupling</td>
<td>Drag-chain retarder</td>
<td>Ordinary manual beam</td>
</tr>
<tr>
<td>Schoper</td>
<td>Room and pillar</td>
<td>4200</td>
<td>82 390 120</td>
<td>Cars, after uncoupling</td>
<td>Drag-chain</td>
<td>Automatic indicating and recording</td>
</tr>
<tr>
<td>Thermal</td>
<td>Room and pillar</td>
<td>3400</td>
<td>36 93 40</td>
<td>Weighpans</td>
<td>Drag-chain</td>
<td>Double beams and automatic indicating</td>
</tr>
<tr>
<td>Wenona</td>
<td>Long-wall</td>
<td>100</td>
<td>10 9 10</td>
<td>Cars, after uncoupling</td>
<td>Tramming; gravity spotter</td>
<td>Ordinary manual beam</td>
</tr>
</tbody>
</table>

Averages for room-and-pillar mines: 77 67

* See note, p. 9.
### Table 2 (Continued)
**Handling of Coal at Shaft Bottoms**

<table>
<thead>
<tr>
<th>Mine</th>
<th>Cars per Dump</th>
<th>Dumps per Day</th>
<th>Time in Sec. Required to</th>
<th>Are Cars Uncoupled during Dumping?</th>
<th>Ave. Loads, Tons per</th>
<th>Carloads per Skipload</th>
<th>Ave. No Hoists per Day</th>
<th>Skip Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ziegler No. 1</td>
<td>2</td>
<td>885</td>
<td>10</td>
<td>9</td>
<td>Yes, alternately</td>
<td>4.05</td>
<td>9.5</td>
<td>2.35</td>
</tr>
<tr>
<td>Valier</td>
<td>1 then 2</td>
<td>1038</td>
<td>10</td>
<td>8</td>
<td>Yes</td>
<td>4.50</td>
<td>13.5</td>
<td>3</td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>2</td>
<td>581*</td>
<td>10</td>
<td>6.5</td>
<td>No</td>
<td>5.17</td>
<td>10.3</td>
<td>2</td>
</tr>
<tr>
<td>Kathleen</td>
<td>2</td>
<td>620</td>
<td>9</td>
<td>6</td>
<td>No</td>
<td>3.75</td>
<td>7.5</td>
<td>2</td>
</tr>
<tr>
<td>Schopen</td>
<td>1</td>
<td>2 dumper 441 each</td>
<td>...</td>
<td>...</td>
<td>Yes</td>
<td>4.76</td>
<td>11.0</td>
<td>2.31</td>
</tr>
<tr>
<td>Thermal</td>
<td>2</td>
<td>560</td>
<td>11</td>
<td>9</td>
<td>No</td>
<td>2.58</td>
<td>5.2</td>
<td>2</td>
</tr>
<tr>
<td>Wenon</td>
<td>1</td>
<td>117</td>
<td>...</td>
<td>...</td>
<td>Yes</td>
<td>0.86</td>
<td>1.7</td>
<td>2</td>
</tr>
<tr>
<td>Averages for room-and-pillar mines</td>
<td>1.5</td>
<td>778</td>
<td>10.2</td>
<td>7.9</td>
<td>...</td>
<td>4.08</td>
<td>9.2</td>
<td>...</td>
</tr>
</tbody>
</table>

* See note, p. 9.
be expected in mines of large production. In general the bottoms are wide, high, and lined with concrete, sometimes reinforced. Structural steel is used, both as column and beam members, in supporting the large chambers contiguous to the main shaft. Electric locomotives are employed exclusively for main haulage and almost exclusively in gathering.

Pusher locomotives are employed in the three mines with the largest daily production. In the four smaller mines the cars are fed by drag chains. Both a pusher locomotive and a car feeder are used only in the Orient No. 2 mine.

Coal is weighed before it is dumped in four of the mines. At three of these four mines it is necessary to uncouple the cars before they are weighed. In the two mines where the coal is weighed after dumping, each weighpan receives two carloads before it is unloaded.

Trips are completely uncoupled for weighing and dumping in two mines only. At one mine uncoupling is not required for carload weighing, but alternate uncoupling is required for dumping. At three of the mines there is no uncoupling whatever.

Two-car dumpers are installed in five of the six mines. In one mine the two-car dumper handles a single car every alternate dump. These dumpers make from 441 to 1038 dump cycles per day, the average per mine being 778 cycles. The duration of a complete dump cycle varies between a minimum of 15 seconds and a maximum of 22 seconds, the average being a trifle more than 18 seconds.

Carloads vary from a minimum average per mine of 2.58 tons to a maximum average of 5.17 tons. The average for the six mines is 4.3 tons per car. Similarly, skiploads vary between 5.15 tons and 13.50 tons. Two carloads make up a skipload in each of three mines, and three carloads in one mine.

The number of hoists per day varies from 382 to 755, according to the mine.

Skip loading is accomplished automatically in four of the mines. In three of these the loading gates are manipulated by the downward and upward movements of the skips themselves. In the fourth the loading period is started by the landing of the skip, but its duration is fixed by electrical control, so that a chute may close without the hoisting of the skip. In two mines the loading of the skip is controlled by hand.
IV. SKIP-HOISTING PLANTS

15. Skips.—The only bottom-dumping skips now used in Illinois are at the Wenona mine. These skips, designated by the name of their inventor, Robert Lee, have given complete satisfaction continuously since their installation in 1904. Among the interesting features of these skips are their comparative simplicity, lightness of construction, quick dumping, and ready adaptability to handling men, materials, and mine cars. If their use were more general or if they had greater capacity these skips would warrant detailed description.

All of the skips in the six large mines are of overturning designs. Those at the Schoper and Zeigler No. 1 are rectangular or box-shaped. Such skips prove adequate and satisfactory at mines where there is no objection to coal breakage. The skips in the other four mines described are known as Allen and Garcia skips. Figure 7 shows that such a skip has a semicylindrical bottom and a discharge side (front) that slopes 60 degrees when the skip is in its normal position. The claim is made that these skips receive coal during loading with a minimum amount of normal impact against the sides and bottoms and therefore with the least degradation thus far found in large-scale skip hoisting.

Every overturning skip comprises two essential units: the bucket and the assembled crosshead-bail. In a two-compartment shaft, hoisting in balance, the crosshead-bail units are in counterbalance continuously. The buckets are not in complete counterbalance during the overturning-and-righting cycle and there seems to be no practicable design that will obviate this disadvantage. Heavy steel rails are used, in every case, as shaft guides.

The center of gravity of this unsymmetrical type of skip, whether empty or loaded, cannot lie centrally with respect to the hoisting compartment. Therefore, to avoid undue pressure of the bails against the guides, both the bails and the guides are placed off-center a few inches—always toward the vertical side of the skip. With the Allen and Garcia skips this offset is from 10 to 14 in. depending upon the width of the shaft. While this nearly balances the gross load on the axis of the bails, there is a sufficient lack of equilibrium to cause the bucket to lean slightly against its bail at all times except when dumping. Simple automatic spring latches known as "keepers" lock the bucket to the bail throughout the vertical trip.

The bucket is supported by and pivots on a heavy horizontal shaft that passes through the lower ends of the bail. A guide wheel is attached to each end of the bucket near the top and on the outer side.
During the overturning cycle these wheels are engaged by long angle-iron guides, carefully curved to provide the correct dumping motion for the bucket. These guide irons are sometimes termed the "horns."

To effect a prompt, clean discharge of its load of coal a skip bucket must be overturned until its side slopes downward 45 degrees. The characteristic slant of the front side of the Allen and Garcia skip attains this position with an angular movement of only 105 degrees as contrasted with the movement of 135 degrees necessary with plain skips. A correspondingly smaller lift of the bail is necessary during the dumping process.

The average of the rated capacities of the skips at these six mines is $10\frac{2}{3}$ tons, but their working loads average only 9\frac{1}{2} tons. At the two mines that lead in daily production the skips are loaded to capacity—a significant fact. The average weight of the skips complete with bails is 8.55 tons. Under prevailing practice, then, about 0.9 tons of equipment (not including rope) are hoisted for each ton of coal. For cage-hoisting mines about 1.5 tons of equipment are hoisted per ton of coal. There are, on an average, per ton of coal hoisted, 0.9 tons of equipment with Allen and Garcia skips, and 0.75 tons with rectangular skips.

As a general average the bail member accounts for 30.6 per cent of the gross weight of a skip. For the Allen and Garcia skips this figure is 27.2 and for the rectangular skips, 38.4.

The average gross load of coal and skip varies from a minimum of 11.2 tons at the Thermal mine to a maximum of 24.7 tons at the Valier mine. For all the mines the average gross load on the ropes is 18.05 tons.

The hoisting ropes vary in diameter from a minimum of 1 in. at the Thermal mine to a maximum of 2 in. at the Orient No. 2 mine. The small rope used at the Thermal calls for a brief description of an interesting if not a unique feature. The drums are smaller in diameter than any of the others in this group. They are driven by first-motion, high-speed steam engines and carry twin sets of spiral grooves for the rope. Both ends of each rope are attached to its respective drum, the middle of its length resting around a 3-foot sheave that is mounted in the crosshead of its skip. This hoist attains a rope speed of 2640 feet per minute.

16. Headframes and Shafts.—At three of these large mines the headframes are of plain steel construction. The headframe at each of the three other mines is encased by concrete around three sides from the shaft collar up to the lip of the coal hopper. The headframe at Orient No. 2 is of this construction and its rigidity was subjected to an extreme test when it escaped, intact, the tornado of March 18, 1925.
TABLE 3

SKIP DETAILS

<table>
<thead>
<tr>
<th>Mine</th>
<th>Tons per Day</th>
<th>Skip</th>
<th>Weights</th>
<th>Total tons</th>
<th>Ratio Weight of Coal to Gross Load</th>
<th>Type</th>
<th>Diameter Rope in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeigler No. 1</td>
<td>7170</td>
<td>9.5</td>
<td>9.5</td>
<td>4.50</td>
<td>1.50</td>
<td>6.0</td>
<td>0.61</td>
</tr>
<tr>
<td>Vallier</td>
<td>7000</td>
<td>13.5</td>
<td>13.5</td>
<td>8.67</td>
<td>2.33</td>
<td>11.2</td>
<td>0.55</td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>6000*</td>
<td>13.0</td>
<td>10.3</td>
<td>5.65</td>
<td>2.85</td>
<td>8.5</td>
<td>0.55</td>
</tr>
<tr>
<td>Kathleen</td>
<td>4650</td>
<td>10.0</td>
<td>7.5</td>
<td>7.13</td>
<td>2.07</td>
<td>10.1</td>
<td>0.43</td>
</tr>
<tr>
<td>Schoper</td>
<td>4200</td>
<td>12.0</td>
<td>11.0</td>
<td>5.05</td>
<td>4.45</td>
<td>9.5</td>
<td>0.54</td>
</tr>
<tr>
<td>Thermal</td>
<td>3400</td>
<td>6.0</td>
<td>5.2</td>
<td>4.65</td>
<td>1.35</td>
<td>6.0</td>
<td>0.46</td>
</tr>
</tbody>
</table>

* See note, p. 9.
These headframes vary in height—from shaft collar to center of sheave—between 92.5 ft. and 123 ft. The average height is practically 100 ft.

The hoisting shafts are invariably lined with concrete and are used as upcasts for the mine ventilation. The inside dimensions vary from a minimum of 7 ft. by 17 ft. to a maximum of 9 ft. by 28 ft. In some instances there are minor compartments in addition to the two for hoisting.

At the Zeigler No. 1 and Schoper mines, the sheaves are parallel and at the same elevation. At each of the other mines the sheaves are set tandem and at different elevations, the difference in height ranging from 9 ft. to 12 ft. and varying roughly with the diameters. With the exception of the Thermal 6-ft. sheaves, which have twin grooves for 1-in. rope, the diameters vary between 8 ft. and 12 ft.

The curved guides for the skip rollers are set at different heights in the headframes. At the Schoper mine, where the skips are box-shaped and where no screening is done, the distance from the shaft collar to the points at which the horns engage the guide rollers is only 25 ft. The extreme is at the Zeigler No. 1 mine where, with box-shaped skips, the coal is dumped into a large (100-ton capacity) storage bin that is well above all the screens. Here the rollers are not engaged by the horns until they are 83 ft. 6 in. above the ground.

The rope travel during the overturning of skips varies from 19 ft. at the Thermal mine (6-ton skips) to 46 ft. at the Schoper mine (12-ton skips). The average for such lifts is 30 ft. 2 in. The skips in these mines, therefore, are dumped with about the same hoisting lift as are self-dumping cages when handling the larger sizes of mine cars.

When the skips are being loaded underground, they rest upon so-called landings which are usually massive timbers placed across the shaft. At such a time a skip’s pivot-shaft is at its lowest limit of travel. When the upper limits of travel are reached these pivots are from 51 ft. to 102 ft. above the shaft collars. The total hoisting distance is determined by these extreme positions of the skip pivots.

It is of interest to note the comparative lifts that are required to overturn box-type skips and the Allen and Garcia skips. The average of these lifts for the two pairs of box-shaped skips is 40 ft. 3 in. and for the four pairs of Allen and Garcia skips, 25 ft. 2½ in. The Allen and Garcia skips at the Orient No. 2 and the box skips at the Schoper are almost equal in height but their respective lifts during dumping are 23 ft. 6 in. and 46 ft.

A skip lands at a considerable depth below the floor of a mine. For the mines herein discussed this depth varies from 35 ft. 9 in. at the Zeigler No. 1 to 55 ft. at the Schoper mine. The average for the
six mines is 42 ft. 6 in. This distance is a function of numerous details of equipment or practice. One such detail is the height of the skip. Another is whether or not the coal is weighed in the mine cars—that is, whether it is weighed before or after dumping. A third is the type of chutes between the weigh-pans and the skips when loading is direct. A fourth detail is whether or not the coal is retained in storage pockets; and this, in turn, is modified by the addition or omission of measuring pockets.

At the Zeigler No. 1 the coal is weighed in the cars and is then dumped directly into a broad 100-ton storage pocket from which it is dropped into the skips through simple gates that are operated manually. Here the minimum depth of landing is possible because the skips are box-shaped and because there are no weigh-pans nor automatic skip-loading chutes.

The 55-foot depth of landing at the Schoper mine is due to the tall 100-ton storage pocket and to the measuring pockets, although the coal is weighed in the cars.

An average landing depth is at the Orient No. 2 mine where the coal is handled by weigh-pans and large, mechanically-operated loading chutes. The depth is 42 ft. 8 in.

The depth of sump below the skip-landing is as little as 2 ft. at the Orient No. 2 and Kathleen mines (where there is very little spillage) and as much as 15 ft. at the Schoper.

17. **Hoists.**—It happens that, among these six large mines, the only steam hoisting plants are at the Zeigler No. 1 and Thermal mines, which are respectively the largest and smallest producers in this group. The four other mines have electrical hoists.

The most powerful hoist is at the Orient No. 2 mine, its rating being 4000 h.p. The smallest hoist, rated at 670 h.p., is at the Kathleen mine. Both of these are electrical hoists.

Four of these hoists are first-motion, these including the two steam units. The two remaining hoists—the Kathleen and the Schoper—have herringbone-gear drives, the gear ratio in the former being 1 to 7.56, and in the latter, 1 to 12.58.

The Valier hoist is the only one that has a single plain cylindrical drum, its diameter being 9 ft. The drums at the other mines are various designs of the compound-cylinder, step-up type. The Orient No. 2 has the largest drums, the smaller diameter being 10 ft. and the larger 17 ft. The smallest drums are at the Thermal mine, the diameters of the cylinders being 5 ft. and 7 ft. These drums are doubly grooved (see p. 28). This hoist is of special interest because, despite its small drums, it has a rope-speed 75 per cent greater than that of its nearest competitor in this group.*

---

* Orient No. 2 will have a maximum rope speed of 4000 feet per minute when operating at capacity.
### Table 4
**Headframes and Shafts**

<table>
<thead>
<tr>
<th>Mine</th>
<th>Type of Skip</th>
<th>Head-Frame Construction</th>
<th>Inside Dimensions of Shaft</th>
<th>Dimension of Hoist Compartment</th>
<th>Height to Sheave</th>
<th>Diameter of Sheaves</th>
<th>Arrangement of Sheave</th>
<th>Height to Bottom of Horns</th>
<th>Lift during Overturn</th>
<th>Max. Elevation of Skip Pivot</th>
<th>Depth of Skip Landing Below Floor</th>
<th>Depth of Sump Landing ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeigler No. 1</td>
<td>Box</td>
<td>steel</td>
<td>7-1 X 18-3</td>
<td>7-1 X 6-1</td>
<td>123</td>
<td>8</td>
<td>parallel</td>
<td>83 1/2</td>
<td>34 3/4</td>
<td>102</td>
<td>35 3/4</td>
<td>4</td>
</tr>
<tr>
<td>Valier</td>
<td>A &amp; G</td>
<td>steel and reinf. concrete</td>
<td>11-0 X 18-2</td>
<td>11-0 X 8-4</td>
<td>83</td>
<td>10</td>
<td>tandem</td>
<td>38</td>
<td>30 1/2</td>
<td>52 3/4</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>A &amp; G</td>
<td>steel and reinf. concrete</td>
<td>9-0 X 28-0</td>
<td>9-0 X 9-5</td>
<td>104</td>
<td>12</td>
<td>tandem</td>
<td>56</td>
<td>23 1/2</td>
<td>68</td>
<td>42 3/4</td>
<td>2</td>
</tr>
<tr>
<td>Kathleen</td>
<td>A &amp; G</td>
<td>steel</td>
<td>11-0 X 18-0</td>
<td>10-0 X 7-6</td>
<td>85</td>
<td>10</td>
<td>tandem</td>
<td>37</td>
<td>28</td>
<td>53</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>Schoper</td>
<td>Box</td>
<td>steel</td>
<td>7-0 X 17-0</td>
<td>7-0 X 8-9</td>
<td>97</td>
<td>12</td>
<td>parallel</td>
<td>25</td>
<td>46</td>
<td>59</td>
<td>55</td>
<td>15</td>
</tr>
<tr>
<td>Thermal</td>
<td>A &amp; G</td>
<td>steel and concrete</td>
<td>9-0 X 21-0</td>
<td>9-0 X 7-9</td>
<td>83 1/2</td>
<td>6</td>
<td>tandem</td>
<td>43 3/4</td>
<td>19</td>
<td>51</td>
<td>41 1/2</td>
<td>3</td>
</tr>
</tbody>
</table>
A STUDY OF SKIP HOISTING AT ILLINOIS COAL MINES

The step-ups on these compound drums average only 3.7 turns. The number of turns varies from a minimum of 2 on the Thermal drum to a maximum of 6 on the Schoper drum.

The Schoper hoist is driven by electrical energy generated in the mining company’s power plant about one-half mile west of the hoist. This is the only instance of the use of high-voltage alternating current in a hoist motor; this motor operating at 2200 volts.

The Valier, Orient No. 2, and Kathleen hoists are driven by purchased energy. Such energy is received over the public-utility transmission lines as alternating current at 33,000 volts. This current is transformed directly to either 2200 or 2300 volts and then used to drive the motor of the Ilgner or flywheel set at each of these mines. The heaviest flywheel weighs 45 tons and is at the Orient No. 2. The generators in these sets deliver direct current having a voltage of 500 at the Kathleen mine, 550 at the Valier mine, and 600 at the Orient No. 2 mine. The speeds of the Ilgner sets are 575 r.p.m. at the Orient No. 2, 720 r.p.m. at the Valier, and 900 r.p.m. at the Kathleen. The Orient No. 2 set has one 2200-h.p. induction motor but two 1650-kw. generators. Each of these 600-volt generators supplies direct current for one of the two 2000-h.p. hoist motors.

Each of the other Ilgner hoists has but one d.c. motor, the Valier hoist being rated at 1350 h.p. when running at 55 r.p.m. and the Kathleen 600 h.p. when running at 235 r.p.m.

The post type of brake is found upon all of these hoists with the exception of the Zeigler No. 1 which has the band type. In most cases the hoistmen do not apply brakes, except when there is a pause in hoisting, but govern the hoisting speeds solely through the throttles or controllers.

Safety devices of many sorts are included in the hoisting equipments. The hoistman at Valier has little to do ordinarily. He turns on the power at the start of each hoist but thereafter the automatic devices control the cycle, bring the machine to rest, and reverse for the succeeding trip. These devices are capable of completely handling the hoisting cycle and rendering it strictly automatic. However, to provide against costly delays that might occur from irregularities in the loading of railroad cars under the tipple, a hoistman is maintained.

At the Orient No. 2, limit switches set in the headframe over the hoisting shaft are in series with the hoist motors and are operated by the skip bails. Traveling-nut switches are placed upon the bedplate of the hoist drum. If either a limit or a nut switch is released, the current is cut off and the brakes are set.

18. Hoisting Cycles.—A time study of the hoisting cycle was made at each of these mines. The observations covered many hoisting trips and average times, in seconds, were obtained for the periods
## Table 5
### Hoists

<table>
<thead>
<tr>
<th>Mine</th>
<th>Horse-power</th>
<th>Ave. Unbalanced Load tons</th>
<th>Steam or Electric</th>
<th>Hoisting Dist. ft.</th>
<th>Electric Hoists</th>
<th>Flywheel Set</th>
<th>Generator</th>
<th>Hoist Motors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Motor</td>
<td>Flywheel</td>
<td>Generator</td>
<td>No. and Kind</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Volts</td>
<td>H. p.</td>
<td>Wt. and Diam.</td>
<td>R.p.m.</td>
</tr>
<tr>
<td>Zeigler No. 1</td>
<td>1600</td>
<td>9.5</td>
<td>s</td>
<td>538</td>
<td>........</td>
<td>........</td>
<td>........</td>
<td>........</td>
</tr>
<tr>
<td>Valier</td>
<td>1350</td>
<td>13.5</td>
<td>e*</td>
<td>687</td>
<td>2200</td>
<td>1100</td>
<td>15.5 tons 114 in.</td>
<td>684</td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>4000</td>
<td>10.3</td>
<td>e*</td>
<td>608</td>
<td>2200</td>
<td>2200</td>
<td>45 tons 144 in.</td>
<td>575</td>
</tr>
<tr>
<td>Kathleen</td>
<td>600</td>
<td>7.5</td>
<td>e*</td>
<td>321</td>
<td>2300</td>
<td>500</td>
<td>10 tons 92 in.</td>
<td>855</td>
</tr>
<tr>
<td>Schoper</td>
<td>900</td>
<td>11.0</td>
<td>e†</td>
<td>475</td>
<td>........</td>
<td>........</td>
<td>........</td>
<td>........</td>
</tr>
<tr>
<td>Thermal</td>
<td>1000</td>
<td>5.2</td>
<td>s</td>
<td>305</td>
<td>........</td>
<td>........</td>
<td>........</td>
<td>........</td>
</tr>
</tbody>
</table>

* Purchased power.
† Generated at mine.
‡ These flywheels are all of the steel-plate type.
<table>
<thead>
<tr>
<th>Mine</th>
<th>Steam Hoists</th>
<th>Kind of Drive</th>
<th>Dist. from Hoist Shaft ft.</th>
<th>Cylinder diameters ft.</th>
<th>Active Turns</th>
<th>Turns, during</th>
<th>Max. Rope Speed ft. per min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeigler No. 1</td>
<td>28 × 42</td>
<td>direct</td>
<td>step-up 102</td>
<td>Small 6.0 Large 9.0</td>
<td>2.0</td>
<td>3.0</td>
<td>15.2</td>
</tr>
<tr>
<td>Valier</td>
<td>direct</td>
<td>plain cylinder</td>
<td>74</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orient No. 2</td>
<td>direct</td>
<td>step-up</td>
<td>119</td>
<td>10.0 Large 17.0</td>
<td>3.2</td>
<td>4.0</td>
<td>6.3</td>
</tr>
<tr>
<td>Kathleen</td>
<td>geared 16 to 121</td>
<td>step-up</td>
<td>80</td>
<td>7.0 Large 11.0</td>
<td>2.2</td>
<td>3.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Schoper</td>
<td>geared 19 to 239</td>
<td>step-up</td>
<td>90</td>
<td>8.5 Large 11.5</td>
<td>3.3</td>
<td>6.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Thermal</td>
<td>24 × 42</td>
<td>direct</td>
<td>step-up 85</td>
<td>3.0 Large 7.0</td>
<td>3.0</td>
<td>2.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

* See note, p. 31.
### Table 6

**Hoisting Cycles**

<table>
<thead>
<tr>
<th>Mine</th>
<th>Hoisting Dist.</th>
<th>Total Number of Drum Turns</th>
<th>Acceleration</th>
<th>Uniform Max. Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zeigler No. 1</td>
<td>538</td>
<td>20.2</td>
<td>108.4</td>
<td>311.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.0</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Valier</td>
<td>687</td>
<td>24.3</td>
<td>85.0</td>
<td>537.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.6</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>Orient No. 2*</td>
<td>608</td>
<td>13.55</td>
<td>273.0</td>
<td>213.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.0</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(5.0)</td>
<td>(6.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(31)</td>
<td>(19)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kathleen</td>
<td>321</td>
<td>10.75</td>
<td>140.0</td>
<td>86.0</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>46</td>
<td>27</td>
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<td></td>
<td></td>
<td>13.0</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td>13</td>
</tr>
<tr>
<td>Schoper</td>
<td>475</td>
<td>14.8</td>
<td>276.0</td>
<td>108.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>58</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21.9</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td>11</td>
</tr>
<tr>
<td>Thermal</td>
<td>305</td>
<td>15.0</td>
<td>173.0</td>
<td>44.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>57</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.1</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42</td>
<td>4</td>
</tr>
</tbody>
</table>

* Figures in parentheses apply to projected, full-scale operations.
### Table 6 (Continued)
#### Hoisting Cycles

<table>
<thead>
<tr>
<th>Mine</th>
<th>Retardation</th>
<th>Rest</th>
<th>Total Time</th>
<th>Hoisting Speed ft per min.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Travel</td>
<td>Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dist. ft.</td>
<td>per cent</td>
<td>sec.</td>
<td>per cent</td>
</tr>
<tr>
<td>Zeigler No. 1</td>
<td>118.8</td>
<td>22</td>
<td>5.0</td>
<td>15</td>
</tr>
<tr>
<td>Valier</td>
<td>65.0</td>
<td>10</td>
<td>5.5</td>
<td>12</td>
</tr>
<tr>
<td>Orient No. 2*</td>
<td>122.0</td>
<td>20</td>
<td>12.5</td>
<td>(6.0)</td>
</tr>
<tr>
<td>Kathleen</td>
<td>86.0</td>
<td>27</td>
<td>7.5</td>
<td>21</td>
</tr>
<tr>
<td>Schoper</td>
<td>91.0</td>
<td>19</td>
<td>11.6</td>
<td>24</td>
</tr>
<tr>
<td>Thermal</td>
<td>88.0</td>
<td>29</td>
<td>2.9</td>
<td>12</td>
</tr>
</tbody>
</table>

* Figures in parentheses apply to projected, full-scale operations.
of acceleration, maximum speed, retardation, and rest. Details are
given in Table 6.

For four of the five hoists that have step-up drums, the acceleration
components were deemed to terminate when the ropes, in winding,
entered the large cylindrical surfaces of their drums. The exception
is at the Thermal mine, where the hoisting practice shows a continuance
of rope-speed acceleration for about four turns on the large cylinder
of the compound drum. In this case 60 per cent of the drum turns,
57 per cent of the travel of the skip, and 72 per cent of the active-
hoist time occur during the acceleration period. These figures are
approximately equaled at the Schoper mine, where acceleration occurs
during 61 per cent of the drum turns, 58 per cent of the travel of
the skip, and 56.5 per cent of the active-hoist time.

The periods of rest during steady hoisting activities range from
9.4 sec. at the Valier mine to 13.5 sec. at the Zeigler No. 1 mine. The
average length of the rest periods (required really for loading and
dumping) is 10.6 sec. This period is exactly 10 sec. at the Orient
No. 2, Schoper, and Thermal mines. The total time per hoist, inclusive
of rest, varies from 24 sec. at the Thermal mine to 48.7 sec. at the
Schoper mine.

It is not a simple matter to note the instant at which uniform
high speed terminates and retardation begins. In fact, this instant
varies somewhat during successive hoists and the data in the table
possess value only because they cover many cycles and because the
utmost effort was made to catch this critical point in every cycle.
The full-speed part of the total rope travel varies from 14 per cent
at the Thermal mine to 78 per cent at the Valier mine where, also,
this component occupies 69.2 per cent of the total active-hoisting time.
Speaking generally, retardation prevails during less time and less
hoisting distance than does either acceleration or full speed.

The slow pick-up at the Schoper mine (21.9 seconds for acceleration)
is explained by the fact that this electric hoist is operated without
a flywheel set and utilizes energy from the company’s local
power plant.

As already mentioned, the data for Orient No. 2 represent condi-
tions in January, 1925, and not as they are contemplated for ultimate
activity. This is a new mine and the production has been held at
6000 tons per day on account of lack of market demand. Here is
the largest hoist in the group leisurely handling a large skipload from
the next-to-greatest depth. Its present hoisting cycle of 45 seconds
is to be reduced to 26 seconds and the various components will be
shortened although probably not in any definite proportion. The
acceleration and retardation components will no doubt receive the
greatest reductions. Probably the rest period cannot be decreased more than one second.

The Thermal hoist has features, such as first-motion drive, large cylinders, small drums and light rope, that enable the hoistman to drive at a rope speed of one-half mile per minute until within three seconds of the stop. The greatest hoisting speed is thus found, at present, at the mine of least depth. This speed will be exceeded eventually by the Orient No. 2.

The Zeigler hoist picks up quickly by drawing heavily, for a few moments, from an ample steam reserve—as does the Thermal. It then runs for 50 per cent of its active time at a comparatively high rope speed. With a hoisting depth that is 10 per cent greater than the average it maintains a hoisting cycle that is next to the shortest.

The Valier hoisting cycle is allotted chiefly to its full-speed component, which represents 78 per cent of the full hoisting distance and 69 per cent of the active time. The mine thus maintains a large production despite its maximum depth and greatest number of drum-turns. The deceleration and stoppage in 2.3 drum-turns is matched by the Orient No. 2.

The comparative features of these hoisting cycles are many. General averages may mean little. These data emphasize the fact that in skip hoisting there is as great a variation in the cycle components as in cage hoisting. This is to be expected for variables, such as hoisting, daily output, and capacity of skip, are certain to be reflected in the hoisting cycle.

Some appreciation of the striking dissimilarities in the cycles may be derived from Fig. 8, which shows graphs of the approximate rope speeds at these six large mines.
Fig. 8. Speed—Time Curves for Skip Hoisting
V. GENERAL CONSIDERATIONS

19. Handling Men, Supplies, Waste, and Air.—At the Wenona, a very small skip mine, the main shaft is used not only for coal but for men, supplies, and waste. As stated, the skips here are easily and promptly convertible into cages.

However, at only one of the large skip mines is the main shaft used for handling anything but coal. It is improbable that any material change will be made from this general practice of restricting the main shaft to the single function of hoisting coal.

The main shaft, in these large Illinois mines, is always an upcast and, usually, is the only upcast. At the Zeigler No. 1 mine there are three shafts two of which serve as upcasts.

Ordinarily the mine fan is placed at the so-called auxiliary or men-and-materials shaft, the downcast compartment occupying a major portion of the shaft while cage hoisting is done in the open compartment that serves also as an upcast on one mine split. The Zeigler No. 1 fan is at a third shaft that is exclusively a downcast airshaft.

The handling of men, supplies, and waste can be presented best by a brief description of the practices at these six mines.

Zeigler No. 1 Mine

A small hoist, in its own house between the main hoist and the shaft, operates a double-decked man-cage in the third compartment of the main shaft. Men are lowered or hoisted here only when coal is not being skip hoisted in the adjacent compartments. Most of the 1050 underground men are handled by the single large counter-balanced cage in the auxiliary shaft, operated by a third hoist in a third house. This shaft is used constantly during working shifts not only in handling men but in lowering timbers and supplies. Waste is raised in the skips at the main shaft, on idle days only, and is dumped directly into railroad cars.

Valier Mine

An electric hoist handles the cages for men and supplies in the auxiliary shaft. Although in balance, these cages are unlike, one being large enough to hold a mine locomotive, as well as all sorts of supplies, while the other is a very narrow one used only for men and as a counterbalance. Waste is hoisted in the skips at the main shaft on idle days.
Orient No. 2 Mine

The auxiliary shaft is of sufficient size and equipment to serve as a main shaft, if need be, at reduced capacity. It has two large overturning cages upon which loaded mine cars are handled. All supplies are lowered and all waste is raised here. All men are handled here exclusively. An inclined belt-conveyor system leads from the auxiliary tipple to the main tipple. The hoist is an interesting feature. The drums are driven normally by a 400-h.p. induction motor with single-reduction gears. A 200-h.p. motor with double-reduction gears may be quickly substituted if the 400-h.p. motor, when used at night, should cause power surges on the line that might annoy the public service company's domestic consumers. In case of failure of electric service a 14 in. by 16 in. second-motion steam hoisting engine may be used. Neither of these emergencies has occurred up to this time.

Kathleen Mine

All of the usual auxiliary functions are handled by the men-and-materials shaft. One feature of the tipple over this shaft is the one-car rotary dump for handling carloads of waste, as well as coal for wagon-trade.

Schoper Mine

Besides handling all men and supplies, the auxiliary shaft, with its overturning cages, hoists all waste, which is dumped directly into railroad cars.

Thermal Mine

The hoist for the auxiliary shaft is in the same building as the main hoist. The ropes run over two sheave towers between the engine room and the headframe, a distance of nearly 300 feet.

Wash-houses, lamp-houses, and check-stations are always conveniently near the auxiliary shafts. As explained in Section 24, coal docking is usually done at these shafts.

Modern large cage mines also have auxiliary shafts in order to prevent interruptions in coal hoisting when hoisting men, supplies, and waste during working shifts. Such a shaft, then, although not a unique feature of skip hoisting, is, nevertheless, an absolute necessity in the practice. If market demands do not keep cage mines continually hoisting coal, the idle times may be utilized in handling materials and waste through the main shaft. Men may be lowered and hoisted only at the beginning and end of a shift and at other fixed times. Skips permit no such practices. If, to effectively fulfill its purposes, an auxiliary shaft at a skip mine must be larger or more expensively equipped than would be required at a cage mine, the extra plant cost is properly chargeable to the skip-hoisting practice.
20. Coal Dust on Mine Bottom.—Objection to the skip hoisting of coal has been based upon the so-called dust trouble that is experienced by some operators. The word "some" is used advisedly; the trouble is not universal. In three of the mines studied, dust proves an important matter, whereas in the other three mines no attention is given to dust. Attempts have been made to recognize the real causes of the dust in those mines where it is an objectionable feature, and measures have been taken or proposed to minimize it. Fortunately, the coal dust arises close to the shaft, from the dumping of cars and while loading the skips. If there be intermediate dumping, as from the weighpans into loading hoppers, there is correspondingly more dust.

As has been said, the hoisting shafts are invariably upcasts. They may convey ventilation currents of high or medium velocities. Normally most of the dust is carried with the ventilation current into and up the shaft. In this respect much depends upon the volume and the velocity of the current of air. If the air velocity be only moderate more of the dust that ascends from the weighpan at dumping will be deposited upon workmen, scale-sheets, and in the immediate vicinity of the shaft bottom than if the current be strong.

The greatest amount of dust occurs in the shaft just above the skips as they are being loaded. This is especially true at Zeigler No. 1, where the man who loads the skips is stationed in a recess in the wall of the shaft opposite the loading chutes. While each skip is being loaded dense dust clouds are directed straight at him. Although he wears a respirator and is protected greatly by a partition, his work is indeed unpleasant. In the Schoper shaft the loader’s station is upon the same side as, and between, the chutes, this proving a better position. Inasmuch as automatic skip loading has been proved successful it is unnecessary to continue the practice of manual loading and to employ men at the loading stations in shafts where the dust is always the most disagreeable. In neither the Zeigler No. 1 nor the Schoper is dust a real nuisance upon the shaft bottom. The explanation is that the dust produced during the rotary dumping of the cars is largely stifled within the large storage hoppers where there is little movement of air. In contrast, the dust similarly produced at Valier or the Orient No. 2 is swirled by the ventilation eddies as the air from different directions flows into the shaft.

Fortunately, skip loading is automatic at the Orient No. 2 where dust is a decided nuisance. The dumpman, checkpuller, and weighman are bothered constantly by dust clouds that are not only unpleasant but litter the scale-sheets and obscure the signal lights. The management contemplates the installation of an exhaust system to allay this trouble.
There is no more dust apparent on the bottoms of the Kathleen and Thermal mines than on the bottoms of most cage mines. At Valier the dust is almost eliminated by numerous fine water sprays that play upon the rotary dumper and the weigh-hoppers whereby the coal becomes damp before it reaches the skips.

In any two-compartment, balanced-hoisting shaft the upcast air has a complex flow. The movement of air is a maximum when the cages or skips are at the top and bottom and it decreases as these conveyances approach one another until, as they pass, there is an actual momentary stoppage throughout the shaft before the increasing section of the cycle starts. This interesting fact is markedly manifest in the Orient No. 2 mine by a short stagnation at the middle of every hoist trip. It is usually just at this moment that dust is thrown up into the entry from the dumping, into the weighpans, of two large carloads of coal.

A storage pocket reduces the dust nuisance on a mine bottom, especially if the level of the stored coal be maintained not too close to the top. Such a pocket being adjacent to the shaft, any clouds of dust that may arise when the pocket is well filled are promptly swept into the shaft or away from the workmen, who are materially protected also by the flooring over the pocket.

If water be available it should be used to spray the coal in advance of the rotary dumping and the treatment continued until the coal is in the skips ready for hoisting. The sprays into the skips could be regulated by automatic valves.

21. Sump Cleaning.—Just as, during hoisting, much more coal is spilled at some cage mines than at others so is it at skip mines. Probably, on the average, a smaller proportion of coal is spilled during skip hoisting than during cage hoisting. Certainly the cleaning of sumps is essential in both practices and is no more a problem with skips than with cages.

Table 4 shows that, with the exception of the Valier and the Schoper mines, little sump space is provided in these shafts. The Valier skips are gauged to be loaded automatically to capacity and, since the loads are occasionally excessive, there is considerable overflow. The deep sump at the Schoper is provided simply to permit infrequent clean-ups, the average spillage being light.

The shallowness of the Orient No. 2 sump below the skip landing proves that skip hoisting can be conducted with very little spillage.

Various practices are followed in cleaning the sumps. A skip is made, sometimes, with a small door in the side that faces the opposite shaft compartment. At times of clean-up, the skip can be lowered close to the bottom of the sump and the door opened so that workmen can shovel the coal through the door into the skip. This practice
prevails in Illinois only at the Zeigler No. 1 (box skips) and at the Kathleen (Allen and Garcia skips).

At the Valier, where the spillage is heavy, a bucket elevator is erected at one end of the shaft. Men in the sump shovel the coal into the boot of this elevator, whence it is delivered into mine cars on the main bottom.

The Orient No. 2 sump is cleaned by one man who shovels the coal into buckets of a special design. When a bucket is loaded it is suspended from a skip, lifted to the main bottom, and there detached and dumped into a weighpan. It is planned to replace this bucket with a conveyer that will automatically deliver the coal from the floor of the sump into a weighpan.

Formerly the sump of the Schoper mine was fitted with square skips which were left in place throughout the regular hoisting. At times of clean-up each such sump-skip could be attached to the bottom of its respective hoisting-skip and hoisted to the surface. At present, however, ordinary mine buckets are loaded by hand and hoisted underneath the skips.

The Thermal spillage, small in amount, is thrown with shovels up to a floor from which it can be shoveled into the regular skips.

Cleaning up is always done at night or on idle days.

Much of the spillage at the Valier shaft occurs when the skips overturn in the tipple. There is a similar heavy spillage at the Zeigler No. 1 but most of the spilled coal strikes parts of the headframe or the outside of the screening house. In both of these cases, coal is thrown from the tops of the loads as the skips change abruptly from their upright attitudes in entering the horns of the dump.

VI. COAL PREPARATION

22. Standard Coal Sizes and Markets Served.—This study disclosed that 12 prepared sizes of coal were being produced at five of the six large skip mines, these grades being in addition to the unsized coal or "mine-run" which is shipped in varying quantities from each mine. The Schoper mine, the exception, ships 1¼-in. screenings only, its entire output being crushed to this size at the collar of the shaft. Table 7 is presented to show the diversity of practice in the screening of coal at these skip-hoisting mines. A table giving corresponding data for large cage mines would reveal similar diversities.

One phase of the present study was to secure screen analyses of the productions from these mines for comparison with similar data for cage mines. To this end it was hoped that each of these productions could be analyzed into a few standard sizes such as 6-in. lump,
**Table 7**

**Sizes of Coal Shipped**

<table>
<thead>
<tr>
<th>No.</th>
<th>Screen Sizes</th>
<th>Trade Names</th>
<th>Mine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zeigler No. 1</td>
</tr>
<tr>
<td>1</td>
<td>Over 6-in.</td>
<td>6-in. lump</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Over 3-in.</td>
<td>3-in. lump; No. 2 lump</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>Over 2-in.</td>
<td>2-in. lump; No. 3 lump</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>3-in. × 6 in.</td>
<td>No. 1 egg; furnace</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>2-in. × 6-in.</td>
<td>No. 2 egg</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>2-in. × 3-in.</td>
<td>No. 1 nut; small egg</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>Through 2-in.</td>
<td>2-in. screenings</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>1 1/4-in. × 2-in.</td>
<td>No. 2 nut; stove</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Through 1 1/4-in.</td>
<td>1 1/4-in. screenings</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>5/4-in. × 1 1/4-in.</td>
<td>No. 3 nut; chestnut</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>5/4-in. × 5/4-in.</td>
<td>No. 4 nut; pea</td>
<td>X</td>
</tr>
<tr>
<td>12</td>
<td>Through 1 3/8-in.</td>
<td>No. 5 nut; carbon</td>
<td>X</td>
</tr>
<tr>
<td>13</td>
<td>Unsized</td>
<td>Mine-run</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Number of sizes shipped</td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>
3-in. by 6-in. egg, 2-in. by 3-in. nut, and 2-in. screenings. The table indicates how impossible this proved to be for every mine. Screening practices at the Zeigler No. 1, Orient No. 2, Kathleen, and Thermal mines produce all of these sizes, or their equivalents, but figures for the tonnages of these different sizes are not obtainable for every mine.

At the Zeigler No. 1, sizes 1, 4, 6, and 13 (see Table 7) are loaded into railroad cars at the main screening plants. All of the product through a 2-in. screen is conveyed to the re-screening plant where it is prepared into sizes 8, 10, 11, and 12. This mine thus prepares every grade that the open Chicago market can desire. Complete figures for the percentages of the numerous grades were obtained.

There being no 3-in. screens in the Valier plant, sizes 2, 3, and 6 are lacking. The sizes made ordinarily are 6-in. lump, 2-in. by 6-in. egg, and 2-in. screenings. Run-of-mine is shipped in large tonnage. The Valier Coal Company is a subsidiary of the Chicago, Burlington and Quincy Railroad and the coal is used chiefly as fuel for its locomotives, stations, and office buildings. Here we find an anomaly—lump coal is an undesired product. Data are not available for the relative amounts of the few prepared sizes.

At the Orient No. 2 the coal is prepared in sizes to satisfy a general open market. In addition to the four standard sizes which are screened in the main plant, all of the 2-in. undersize may be put through a re-screening plant to be separated as desired into sizes 8, 10, 11, and 12 (see Table 7). Much of the output of the mine is consumed in Chicago.

Beside the four standard sizes sought in this investigation, the Kathleen plant prepares odd sizes—3-in. lump and 2-in. by 6-in. egg. Comparatively little mine-run is shipped. Complete statistics of shipments, by sizes, were obtained. This mine is owned by the Union Colliery Company, a subsidiary of the Union Electric Light and Power Company of St. Louis, Mo. The production of the mine is consumed chiefly by the Power Company and by the St. Louis domestic trade.

The Schoper mine is owned by the Standard Oil Company of Indiana and its function is to furnish fuel to the numerous oil refineries of that corporation. Such fuel must be of small size, hence the whole output is reduced purposely to 1¼-in. as previously stated. There are no screens at this mine. This case is even more anomalous than that of the Valier.

The Thermal mine finds its chief market in the St. Louis district. Nine sizes of coal are shipped. Here we find reflected the influence of a local demand, such as was indicated in the sizes produced at the Kathleen, with the addition of still another odd size—2-in. lump.

Of these six mines three only may be said to supply an open competitive market. A fourth mine depends partly upon such a market.
One mine is owned by a common carrier, another by a great petroleum producer, and a third by a public utility corporation.

The Zeigler No. 1 and Orient No. 2 sizes reflect the market requirements of northern Illinois and the middle Northwest, whereas the Kathleen and Thermal sizes reflect those of southern Illinois and Missouri. It is the hope of progressive operators that consumers of coal will gradually become convinced that all fuel needs can be satisfied with a very few standard sizes.

23. **Screening, Picking, and Loading.**—There is no intrinsic relationship between the method used in hoisting coal and the practice in screening it. The mines herein discussed have large screening plants, some of them of the very latest and most efficient designs, but they are no more typical of skip hoisting than of cage hoisting. A stranger, even an experienced coal operator, visiting one of these plants, would find nothing essentially different from what he would expect in a cage mine of the same capacity and supplying the same markets.

As has been said, no screening whatever is done at the Schoper mine. At the five other mines all of the primary screens are shakers. On these are prepared the first seven sizes of coal listed in Table 7.

At the Zeigler No. 1 mine the mine-run coal issues from the tipple storage-bin directly to the upper screen. At the Valier, Orient, Kathleen, and Thermal mines the skips dump their loads into the hoppers of feeder conveyors which deliver a nearly uniform feed continuously to the screens. From this stage on, the coal is prepared exactly as it would be in any tipple of equivalent proportions.

The Zeigler No. 1 and the Orient No. 2 have re-screening plants as separate structures to which, when desired, the 2-in. undersize from the main screens is conveyed and prepared into sizes 8 to 12 inclusive. At the Thermal mine sizes 8 and 9 are prepared by secondary screens in the main plant. At the Schoper the coal, after being crushed by rolls at the ground level close to the main shaft, is conveyed by an inclined belt conveyor to the top of a huge steel structure and stored in bins having an aggregate capacity of 4500 tons. From these bins the railroad cars are loaded quickly.

24. **Coal Inspection.**—As stated in Chapter I, one of the arguments advanced against skip hoisting is the difficulty of maintaining any sort of inspection of the coal as it is loaded by the miners. There is no doubt regarding the validity of this objection. At some mines it has such force as to preclude practically all docking. At any skip mine miners gamble with themselves upon being caught loading dirty coal. Varying schemes are adopted at different mines for a rather perfunctory sampling of the coal. Such inspection is done much more effectively at some mines than at others.
The Kathleen is the only mine in the group at which the coal to be inspected is hoisted in the skips. A few times each day, whenever time can be spared, single carloads are hoisted and passed over the screens and picking tables. With each carload from the bottom is a large wooden block upon which the weighman underground has chalked the miner’s check number. The refuse and wooden block are deposited together in an ordinary washtub for docking.

At each of the other mines the cars to be inspected are cut out from their trips on the main bottom, hauled to the auxiliary shaft, and hoisted on a cage. From the shaft collar at the Valier each car after being weighed is horse-hauled about 200 ft. to a metal sheet upon which the coal is dumped. After inspection it is shoveled back into the same car, hauled a considerable distance, and dumped into a railroad car standing on the empty track.

When a loaded car reaches the surface at the Zeigler No. 1 materials shaft it is hauled by a horse about 400 ft. The coal is dumped in a rotary dump on an inspection platform from which, after picking, it is shoveled into another mine car standing upon a lower track. The mine car is then hauled back to the shaft, lowered, and joined to the other loaded cars.

When a test car is received at the collar of the Thermal airshaft it is trammed a very short distance to a floor upon which the coal is dumped. After inspection the coal is hand-loaded into the same mine car and sent below.

The air-and-materials shaft at the Schoper mine is fitted with overturning cages. When a weighed carload is hoisted the coal is dumped directly into an empty railroad car, where it is picked and left.

The auxiliary shaft at Orient No. 2 also is equipped with overturning cages. As a car for inspection is received the coal is dumped into a weighpan which discharges it into the feeder-hopper. From here it is spread out on a broad belt conveyor to be inspected, and then the conveyor carries it to the main tipple where it joins the coal hoisted by the skips.

The usual requirements in regard to the preservation of each batch of refuse are observed at every mine. At mines where systematic inspection is practised the miners produce a much cleaner coal than at the mines where they are aware that inspection is lax. The Orient No. 2 mine is best equipped to do such work regularly. In fact inspection and docking were items that were particularly considered and satisfactorily taken care of in the design of the plant. The overturning cages are primarily for this function.
VII. DEGRADATION OF COAL

25. Significance of Degradation to Illinois Coal Industry.—
The breakage of coal throughout all of its mining stages is a live topic among Illinois operators. It has been asserted that skip hoisting is responsible for more breakage than is cage hoisting, and operators wish to know whether or not this is true.

In a pamphlet issued in August, 1924, by "The Coal Operators of Southern Illinois," the statement is made that, during a continuous four-year period, 20 companies sustained an actual loss that averaged more than 50 cents per ton on more than 12,000,000 tons of screenings. This indicates the economic significance of degradation.

Statistics indicate that approximately 6 per cent of the coal shipped from the southern Illinois field is mine-run. It has already been pointed out that there are about even amounts of 2-in. screenings and 2-in. oversize, the latter covering nut, egg, and lump sizes. Screenings and prepared sizes, therefore, each constitute 47 per cent of all shipments. Further, actual mine records indicate that the prepared sizes are divided roughly into lump, 34 per cent, egg, 38 per cent, nut, 28 per cent. Multiplying these percentages by the factor 0.47 would give lump, 16 per cent, egg, 18 per cent, nut, 13 per cent. One hundred tons of average mined coal in the southern field, therefore, will be shipped approximately as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine-run</td>
<td>6</td>
</tr>
<tr>
<td>2-in. screening</td>
<td>47</td>
</tr>
<tr>
<td>6-in. lump</td>
<td>16</td>
</tr>
<tr>
<td>3-in. x 6-in. egg</td>
<td>18</td>
</tr>
<tr>
<td>2-in. x 3-in. nut</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

In an endeavor to answer the question as to whether or not skip hoisting produces more degradation than cage hoisting, an effort was made to obtain complete figures for the tonnages of the several standard grades of coal prepared at these skip mines. The Schoper mine was not considered at all because all of its coal is crushed before shipment, and therefore no data were available. The Valier records are not kept in a manner to furnish the desired data, nor does the production enter the public market. The Orient No. 2 mine is in the development stage as yet, with a substantial portion of its total production coming from narrow work, so that its prepared-coal data are deemed non-representative of normal production. Reliable data cover-
ing large productions were secured for the Zeigler No. 1, Kathleen, and Thermal mines. Table 8 gives such data for the four standard sizes discussed in Section 22. Tonnage factors indicate the relative tonnages for which the percentages apply.

Table 8

Comparison of Prepared Sizes at Skip and Cage-Hoisting Mines

<table>
<thead>
<tr>
<th>Mines</th>
<th>6-in. Lump per cent</th>
<th>3-in. × 6-in. Egg per cent</th>
<th>2-in. × 3-in. Nut per cent</th>
<th>2-in. Screenings per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip mines:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>19.44</td>
<td>18.52</td>
<td>12.96</td>
<td>49.08</td>
</tr>
<tr>
<td>Kathleen</td>
<td>16.68</td>
<td>15.77</td>
<td>17.43</td>
<td>50.10</td>
</tr>
<tr>
<td>Zeigler No. 1</td>
<td>14.91</td>
<td>21.15</td>
<td>12.37</td>
<td>51.37</td>
</tr>
<tr>
<td>Averages</td>
<td>17.01</td>
<td>18.48</td>
<td>14.26</td>
<td>50.25</td>
</tr>
<tr>
<td>Cage mines:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Majestic</td>
<td>16.96</td>
<td>21.98</td>
<td>12.31</td>
<td>48.75</td>
</tr>
<tr>
<td>Old Ben</td>
<td>20.29</td>
<td>19.74</td>
<td>11.85</td>
<td>48.12</td>
</tr>
<tr>
<td>Zeigler No. 2</td>
<td>16.67</td>
<td>21.56</td>
<td>11.35</td>
<td>50.42</td>
</tr>
<tr>
<td>Averages</td>
<td>17.97</td>
<td>21.09</td>
<td>11.84</td>
<td>49.10</td>
</tr>
</tbody>
</table>

Illinois coal operators in general have a custom of gauging the efficiency of their coal-handling by the percentage of their coal that will not pass through a screen having 2-in. round holes. With cage mines in the southern field, this percentage is just about 50, as assumed earlier in this section. Operators therefore watch this feature closely and consider their operating efficiency to be greater as their production of screenings falls below 50 per cent. This 50-50 relationship represents mining practice in which practically all of the coal is undercut before it is shot.

Table 8 gives also the percentages of sized coal shipped from cage mines in the same field. The Majestic mine is close to the Zeigler No. 1, while the seven Old Ben mines are scattered in the field. All of these skip and cage mines are in the same seam. From the averages of the two groups it appears that the cage mines have a very small advantage as producers of coarse coal. According to this tabulation the cage mines have an advantage of 3.57 per cent in the two coarser sizes of coal while the skip mines have an advantage of 2.42 per cent in the nut size. The difference between these two represents the net advantage—1.15 per cent—in favor of cage hoisting.

26. Influencing Factors.—The two Zeigler mines afford probably as fair a comparison between cage-hoisting and skip-hoisting practices as can be found anywhere. Both mines are under one general super-
intendent and one engineer. They adjoin, are in the same seam, and are exceptionally large producers. Table 8 indicates that the gross production of the cage mine includes 1.15 per cent more coarse coal than does the gross production of the skip mine. Certain facts, however, bear upon this matter and should be duly considered in formulating a final opinion.

In the first place, the Zeigler No. 1 is an old mine. Its skips, which have been in use since 1904, are plain, rectangular, square-bottomed, deep boxes. The first portion of each skipload of coal drops about 14 feet and meets the bottom with normal impact. The average vertical drop of the coal during loading is about 7 feet. The bulk of the degradation is produced probably in the first half of each skipload. Breakage is inevitable and, in the light of more recent skip designing, is perhaps excessive. The practice here represents the most adverse conditions in so far as the type of skip is concerned.

Again, despite the common ownership and management, the mining practices are not really alike in these two mines. In the skip mine, all room coal is undercut 5.5 feet while in the cage mine it is undercut 6.5 feet. In the No. 1 mine the coal is mined 8 ft. 4 in. high, and in the No. 2 mine, 7 ft. 5 in. high. The rooms being of uniform width, the cubic amounts (tons) of coal broken per round are as $5\frac{1}{2} \times 8\frac{1}{2}$, or 45.8, to $6\frac{1}{2} \times 7\frac{3}{12}$, or 48.2. In other words only 95 per cent as many tons are broken per round in the No. 1 mine as in the No. 2 mine, and it would seem reasonable to conclude that the No. 1 coal may consequently contain a somewhat greater proportion of 2-in. screenings than does the No. 2 coal.

Third, accurate statistics during a busy five-months period showed that, in shooting undercut coal, 2.3 per cent more powder per ton was used in the No. 1 mine than in the No. 2 mine. There is a logical inference that at least part of the 1.15 per cent difference in fine coal produced might be accounted for in this variation in powder consumption.

Fourth, in the cage (No. 2) mine all the coal is undercut before it is shot, whereas 8.3 per cent of the coal from the skip-mine is shot from the solid, especially in narrow work. With shooting from the solid the Zeigler statistics prove that the quantity of powder used per ton is three times the quantity used in shooting undermined coal. Altogether the total powder consumptions per ton in these two mines were: No. 1 mine, 0.209 lb.; No. 2 mine, 0.177 lb.

If we now turn to mines that have modern skips the screen-sizing data at the Kathleen and Thermal mines may be compared with those at the Majestic and Old Ben mines (see Table 8). The averages for the respective percentages of screenings in these two groups are 49.59 and 48.44. This advantage of 1.15 per cent for the cage mines over
the Allen and Garcia skip mines happens to be just the same as the advantage of the Zeigler cage mine over the Zeigler skip mine.

The figures are all close, however, and there is one fact especially that bears upon the comparisons. The two skip mines in question have the smaller sizes of Allen and Garcia skips. The average load in these skips is only 6.3 tons as against an average for the four sets of Allen and Garcia skips of 9.1 tons. Breakage is probably a direct function of the number of impacts and therefore the relative amount of degradation would increase as the size of load decreases. Coal dropping on steel will break to a greater extent than when it falls on coal. Hence it would appear that the greatest breakage occurs in the portion of the coal that strikes the bottom of the skip, and that the upper portion of the skip-load suffers less degradation. Perhaps the additional ton and a half of coal in the larger skips is scarcely affected by the slight drop on a cushion of coal. Unfortunately, data are not available for the other two Allen and Garcia skip mines. It seems rational to assume, however, that an increase in average skip-load of from 6.3 tons to 9.1 tons might not only offset the adverse differential of 1.15 per cent but even turn it into a slightly favorable one.

VIII. COST FEATURES

27. Initial Costs of Plants.—It is regrettable that data could not be secured covering the initial costs of these skip-hoisting plants. In one case the owners themselves do not know the detailed costs. In two cases the figures are withheld. In another instance the round numbers quoted by the operators seem excessive and, since they are unitemized, they probably include equipment that does not belong exclusively to hoisting.

The question of first costs was referred to prominent consulting engineers but they were unable to supply exact information. Their opinion is that the costs of mechanical equipment are considerably greater for skip hoisting than for cage hoisting, but that the cost of shaft sinking, especially for relatively deep mines, is less for skips than for cages. On the whole, it was believed that, if the investment be considered as a function of tons of production per day, there is advantage in favor of the skip-hoisting plant.

Tipples are of nearly the same construction in both systems except that a head-frame for skips must be stronger than one for cages. Hoisting rope must be somewhat more expensive with skip hoisting, due to the larger sizes of ropes used.

Most of the shaft-bottom equipment needed with skip hoisting but not with cage hoisting may be regarded as a disadvantageous
initial expense. This applies to dumpers, measuring and loading pockets, skip loaders, and the motive units therefor. It does not apply to chain-hauls and only partially to scales, of which there are often two.

Regarding the cost of shaft-sinking, it must be remembered that a shaft for skip hoisting averages about 42 feet deeper than one for cage hoisting, regardless of the depth of the coal seam. The additional sinking will cost several thousand dollars and this may offset the saving in the smaller cross-section in the case of a shallow mine.

Figures covering the initial costs of all the equipment pertaining to hoisting, as discussed herein, were obtained for three of these mines. These did not include shaft sinking. The average cost per mine was $212,500, this being at the rate of $27.40 per ton-day capacity. These figures must not be accepted as correct for any mine. They are presented merely to convey a rough idea concerning their magnitude.

28. Labor Costs for Hoisting Only.—As a rule coal-mine accounts do not afford information regarding the operating costs for either haulage or hoisting, these distinct activities being combined into one item, Transportation.* Segregated hoisting costs, therefore, are not available.

Since there is nothing connected with preparation or loading of coal that, in any degree, is peculiar to either cage hoisting or skip hoisting, estimates of the relative hoisting costs should include no activities subsequent to the delivery of the hoisted coal to the first set of screens.

Table 9 is prepared upon this basis. It covers the labor cost in handling the coal from its arrival and delivery on the mine bottom to its delivery to the screens in the tipple. Hoisting engineers are here included as top employees—in fact, except for one man, who is retained constantly to watch the dumping of coal into the large receiving bin at the Zeigler No. 1 tipple, hoist enginemen are the only top employees considered. The average labor cost per ton is 1.35 cents, this amount covering the wage for an average of 9.5 men per mine. The average daily labor cost per mine is $73.16. One laborer is required for every 550 tons of coal produced. The wage-scale is that of the so-called Agreement† between the mine operators and the miners' union.

During the preparation of a preceding bulletin‡ equivalent data

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* In the first coal report blank of the Federal Trade Commission (1917), "Transportation" included both haulage and hoisting. In the form recommended by the Cost Accounting Committee of the National Coal Association (1919), Item 8 was called "Haulage and Hoisting" and no attempt was made to separate these costs.

† Agreement By and Between the Illinois Coal Operators' Association, the Coal Operators' Association of the Fifth and Ninth Districts of Illinois, and the Central Illinois Coal Operators' Association and the United Mine Workers of America, District No. 12. Effective until March 31, 1927.

### Table 9
**Labor Costs* in Skip Hoisting**
From Delivery on Mine Bottom to Screen-Feeding

<table>
<thead>
<tr>
<th>Mine</th>
<th>Tons</th>
<th>Bottom Employees</th>
<th>Top Employees</th>
<th>Total Wages</th>
<th>Cents per Ton</th>
<th>Tons per Man Top and Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zeigler No. 1</td>
<td>7170</td>
<td>14</td>
<td>3</td>
<td>2390</td>
<td>1.75</td>
<td>422</td>
</tr>
<tr>
<td>Valier</td>
<td>7000</td>
<td>12</td>
<td>1</td>
<td>7000</td>
<td>1.37</td>
<td>538</td>
</tr>
<tr>
<td>Orient No. 2†</td>
<td>6000</td>
<td>6</td>
<td>2</td>
<td>3000</td>
<td>1.01</td>
<td>730</td>
</tr>
<tr>
<td>Kathleen</td>
<td>4650</td>
<td>6</td>
<td>1</td>
<td>4650</td>
<td>1.12</td>
<td>664</td>
</tr>
<tr>
<td>Schoper</td>
<td>4200</td>
<td>6</td>
<td>1</td>
<td>4200</td>
<td>1.25</td>
<td>600</td>
</tr>
<tr>
<td>Thermal</td>
<td>3400</td>
<td>6</td>
<td>1</td>
<td>3400</td>
<td>1.54</td>
<td>480</td>
</tr>
<tr>
<td>Weighted average</td>
<td></td>
<td></td>
<td></td>
<td>3602</td>
<td>1.36†</td>
<td>550</td>
</tr>
</tbody>
</table>

* Engineers at $7.95; other top men at $6.86; bottom men as follows:
  (a) dumper, weighmen, motormen, drag operators, skiploaders, winding engineer, at $7.50;
  (b) couplers, spraggers, blockers, switchers, checkpullers, recorders, at $7.25;
  average wage per man $7.44.
† See note, p. 9.
† 1.14 cents per ton, bottom; 0.22 cents per ton, top; total, 1.36 cents.

### Table 10
**Labor Costs* in Cage Hoisting**
From Delivery of Coal on Mine Bottom to Screen-Feeding

<table>
<thead>
<tr>
<th>Mine†</th>
<th>Tons</th>
<th>Bottom Employees</th>
<th>Top Employees</th>
<th>Total Wages</th>
<th>Cents per Ton</th>
<th>Tons per Man Top and Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>5200</td>
<td>13</td>
<td>4</td>
<td>1300</td>
<td>2.41</td>
<td>306</td>
</tr>
<tr>
<td>D</td>
<td>5000</td>
<td>8</td>
<td>4</td>
<td>1250</td>
<td>1.77</td>
<td>417</td>
</tr>
<tr>
<td>A</td>
<td>4500</td>
<td>7</td>
<td>4</td>
<td>1125</td>
<td>1.80</td>
<td>409</td>
</tr>
<tr>
<td>C</td>
<td>4500</td>
<td>5</td>
<td>4</td>
<td>1125</td>
<td>1.48</td>
<td>500</td>
</tr>
<tr>
<td>E</td>
<td>4000</td>
<td>6</td>
<td>3</td>
<td>1333</td>
<td>1.64</td>
<td>444</td>
</tr>
<tr>
<td>F</td>
<td>3800</td>
<td>11</td>
<td>3</td>
<td>1267</td>
<td>2.75</td>
<td>271</td>
</tr>
<tr>
<td>H</td>
<td>3600</td>
<td>7</td>
<td>3</td>
<td>1200</td>
<td>2.03</td>
<td>360</td>
</tr>
</tbody>
</table>

Weighted average 540 1214 1.97† 374

* Engineers at $7.95, top weighmen at $7.25, top checkpullers at $6.86, cagers, helpers, at $7.50; other bottom men at $7.25; average wage per man $7.37.
† The key letters refer to mines described in Bulletin 132, Eng. Expt. Sta., Univ. of Ill.
† 1.36 cents per ton, bottom; 0.61 cents per ton, top; total, 1.97 cents.
were collected for a number of large representative cage mines. By selecting mines each of which has a daily production of not less than 3400 tons, the labor data for hoisting are comparable to those in Table 11. Such figures, as well as the shaft-bottom figures for eight cage mines, are given in Table 10. Here the topmen include hoistmen, checkpullers, and weighmen. The total labor cost, per ton, varies from 1.47 to 2.75 cents, the weighted average being 1.97 cents, for an average of 11\% men per mine.

Table 11 is a compilation of labor-cost data for the two classes of mines. These comparisons cover the progress of the coal from the time it is received on the shaft bottom until it enters the tipple screens.

Although none of the cage mines has a daily production equal to the larger skip mines, they are nevertheless big mines, as their average daily tonnage, 4250 tons, indicates. The aggregate production from the eight cage mines is nearly the same as that from the six skip mines.

Table 11 shows the following advantages for skip hoisting:

(a) About one or two less hoisting employes per mine
(b) About $10 per day less wage per mine
(c) Nearly 50 per cent more coal per hoisting employe
(d) A wage saving of $6.19 per thousand tons

**Table 11**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cages</th>
<th>Skips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. tons per day</td>
<td>4250</td>
<td>5403</td>
</tr>
<tr>
<td>Ave. no. bottom employes</td>
<td>71</td>
<td>81</td>
</tr>
<tr>
<td>Ave. no. top employes</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>Ave. total no. employes</td>
<td>11%</td>
<td>9%</td>
</tr>
<tr>
<td>Ave. wage per man</td>
<td>$ 7.37</td>
<td>$ 7.44</td>
</tr>
<tr>
<td>Ave. bottom wages, per mine, per day</td>
<td>$57.81</td>
<td>$61.42</td>
</tr>
<tr>
<td>Ave. top wages, per mine, per day</td>
<td>$26.03</td>
<td>$11.74</td>
</tr>
<tr>
<td>Ave. total wages per day</td>
<td>$83.84</td>
<td>$73.16</td>
</tr>
<tr>
<td>Ave. no. tons per man, bottom</td>
<td>540</td>
<td>648</td>
</tr>
<tr>
<td>Ave. no. tons per man, top</td>
<td>1214</td>
<td>3602</td>
</tr>
<tr>
<td>Ave. no. tons per man, bottom and top</td>
<td>374</td>
<td>550</td>
</tr>
<tr>
<td>Ave. cost per ton, bottom labor</td>
<td>1.36c</td>
<td>1.14c</td>
</tr>
<tr>
<td>Ave. cost per ton, top labor</td>
<td>0.61c</td>
<td>0.22c</td>
</tr>
<tr>
<td>Ave. total cost per ton for labor</td>
<td>1.97c</td>
<td>1.36c</td>
</tr>
<tr>
<td>Gross tonnage per group, per day</td>
<td>34000</td>
<td>32420</td>
</tr>
</tbody>
</table>

29. **Power Costs in Hoisting.**—Hoisting is a mechanical operation which would seem to offer the highest possibilities in efficiency in the utilization of power. It is essentially the simple lifting of definite masses through definite vertical distances and the theoretical work involved is easily calculated. With allowances for frictional resistances
and mechanical inefficiencies, the power demands in hoisting can be estimated for any mine. However, such calculations prove only relatively useful because many variations from the assumed cycle of operations affect the actual power consumption.

The notion prevails generally that all mechanical processes are performed more economically as their scales of magnitude increase. This opinion is not correct unless plants are maintained active continuously regardless of scales of operation. If machines must necessarily stand idle at times, the cost of operation per unit of accomplishment is generally considerably greater for a large machine than for a small one. This is true in hoisting, regardless of whether it be with cages or skips. Other conditions being equal, the hoist in each system that is kept busiest will show the greatest efficiency in power consumption.

During the preparation of preceding bulletins under the Cooperative Agreement it was learned that few coal operators know their hoisting power demands. In one bulletin* it was shown that, although operators often are careful to determine their total power requirements, they seldom allot such requirements to the various distinct mechanical activities. Another bulletin† proposed a scheme that would enable mine officials to apportion their total power consumptions between the chief activities.

As a consequence of this lack of segregation of total power requirements many operators know less about their hoisting demands than about the power consumption of any other coal-mining activity. When the energy is in the form of steam, drawn from a battery of boilers that is simultaneously supplying machines other than the hoist, figures are invariably lacking. With complete electrification, ignorance concerning the hoisting power demand is unnecessary.

Complete power-consumption data were not obtainable during the present study; therefore the omission of such desirable information is unavoidable. However, it is well to remember that the absence of such data is not due to anything that is inherently pertinent to skip hoisting but rather to the systems of accounting in coal mining. In place of figures of an enlightening character we may consider certain comparisons between the two systems of hoisting, as they affect the relative power demands.

Mention has already been made of the ratios of coal loads to gross loads. For the six skip mines herein discussed coal constitutes from 42.6 to 61.3 per cent of the gross load, the average being 52.2 per cent (see Table 3). Corresponding percentages for 12 representative cage mines varied from 29.7 to 34.1 per cent, the average being

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31.9 per cent. Since no cage hoist in the group considered handles such large loads of coal as do these skip hoists, direct comparisons are impossible. However, one of the cage mines hoists 5 tons of coal per trip or very nearly the same amount as does the smallest of the skip mines, the Thermal. For the cage mine in question, the car and cage together weigh 9.65 tons. The Thermal skip, complete, weighs 6 tons and holds 5.15 tons. The ratios of coal load to gross load for the cage mine are, therefore, 5 to 14.65 or 34.1 per cent; and for the skip mine, 5.15 to 11.15 or 46.2 per cent. In this particular comparison the skip hoist shows a distinct advantage.

Throughout every hoist period, whether with cages or overturning skips, the dead loads (exclusive of hoisting ropes) are in balance except for a brief period at starting. At the moment of starting a hoist, the dead weights of overturning skips are not in complete counterbalance. When an Allen and Garcia skip is dumped from 35 to 39 per cent of its weight is supported by the dumping horns in the headframe, thus leaving this same amount of unbalanced dead load at starting. With plain rectangular skips the loss of counterbalance is less, being about 25 per cent.

Self-dumping cages, also, are not in balance when one of a pair is in the dumping position. Calculations covering six such installations that handle comparatively large mine cars gave an average of 25.9 per cent as the weight of the cage and car that is supported by the headframe at time of full-dump.

This argument about counterbalancing may be summed up by saying that there is no difference when comparing rigid cages with bottom-dumping skips, very little difference when comparing self-dumping cages with overturning rectangular skips, and a difference of about 11 per cent when comparing self-dumping cages with the Allen and Garcia skips. A comparison of one particular skip plant with one particular cage plant might show an advantage either way.

Excess dead weight calls for heavier rope, decreasing the counterbalance as well as increasing the frictional resistances. These facts are important. Friction is a substantial resistance that must be overcome in hoisting. It is a function of gross load, not of net load.

To hoist a given weight of coal on a self-dumping cage will mean a greater dead weight than if the coal is hoisted in a skip. Therefore less power will be required for acceleration and during the uniform-speed period when using a skip than when using a cage. The saving in power will be decreased somewhat with some designs of skips due to their greater lack of counterbalance when in the dumping position, but as this condition lasts for only about one drum-turn the effect on the power consumption is very small.
Because the amounts of power consumed in hoisting are difficult to determine, it follows that the power costs must be even more difficult to determine. Two of these skip mines—the largest and the smallest—hoist with steam power, the others by electric energy. The boilers that supply the main hoists supply also various other important power units. The demands of the units drawing steam from the boiler plants are so complicated that even rough guesses are not attempted regarding the proportionate cost of the steam that is used by the main hoists.

No power is purchased at either of these mines. On the other hand, the Zeigler No. 1 power house supplies the town of Zeigler with light and operates the waterworks.

Eugene A. McAuliffe, former president of the Union Colliery Company, states that the average power demand for hoisting at the Kathleen mine* during one year was 0.4768 kw-hr. per ton. Details are lacking for the monthly power bills. The power for hoisting was not purchased separately and the net rate for this energy was therefore affected by the variable consumptions of activities other than hoisting. However, it appears from the figures for the entire year that the average cost per kw-hr. for all consumptions was 2.59 cents. The average cost of the hoisting power, therefore, was approximately 0.4768 \times 2.59 \text{ cents or } 1.235 \text{ cents}.

During the month of January, 1922, the Kathleen mine produced 43,330 tons and hoisting consumed 19,400 kw-hr. This was at the rate of 0.448 kw-hr. per ton. During the month of January, 1924, the Orient No. 2 hoist used 143,000 kw-hr. in handling 161,496 tons, this being at the rate of 0.885 kw-hr. per ton. The cost of this energy is not at hand. The hoisting distances are: Kathleen, 321 ft., Orient No. 2, 608 ft. The power demands per foot-ton were thus as 1 to 1.04; the tonnages were as 1 to 3.72. In other words, despite radical differences in tonnage and hoisting depths, there was a difference of only 4 per cent between unit performances of the hoists at these two skip mines. This finding indicates a close relationship between hoisting distances and hoisting costs.

Four electrically-equipped cage mines in Illinois, with an average daily production of 3529 tons and an average hoisting distance of 485 ft., showed an average power consumption for hoisting of 0.765 kw-hr. per ton.

If the six large skip mines be listed in the order of increasing depths, the Kathleen mine will be next to the top and the Orient No. 2 mine will be next to the bottom. The average hoisting depth of these two mines is 465 ft. The simple average of the amounts of energy demanded at these two mines is 0.667 kw-hr. per ton.

* Coal Age, v. 21, pp. 817-819.
With the cages the average amount of energy used per foot-ton is $0.765 - 485 = 0.00157 \text{ kw-hr.}$; with the skips it is $0.667 - 465 = 0.00143 \text{ kw-hr.}$ It thus appears that the cages demand about 10 per cent more power than do the skips, per unit of work. This would mean a difference of about 0.2 cent per ton.

Although the foregoing data are authentic they are, of course, only examples taken at random. As explained, full data were not obtainable for the six skip hoisting plants. Data from other cases might have shown different relative power consumptions for skips and cages.

30. **Total Hoisting Costs.**—The determination of average costs in any branch of coal mining is not a simple matter. Even if average costs could be ascertained they would mean little, for it has been found that no coal mine in Illinois measures up to the average of all of the mines. This matter is fully discussed in Bulletin No. 144, "Power Studies in Illinois Coal Mining." No two mines are alike even in a single condition. The major activities of coal production, such as mining (undercutting), haulage, ventilation, hoisting, and pumping, have varying relative costs in every mine. The variations in total hoisting costs are as great as are the variations in the other costs. It is therefore impossible to submit figures that could be applied to a specific mine to obtain a dependable estimate of the hoisting cost.

The total hoisting expense includes the costs of labor and power as well as the costs of maintenance and the investment charge. In Table 9 it is seen that the cost of labor connected with hoisting at these skip mines varies with the average daily production but has no relation to the hoisting depth. On the other hand, as noted in Section 29, the power cost per ton is intimately related to hoisting depth but not to tonnage. With the innumerable variations that do and may arise in these governing factors it is obvious that the hoisting cost for any mine is an individual problem.

Hoisting cost will differ considerably with the form of power consumed. At a given mine the cost will be different when using, respectively, steam, home-generated electrical energy, or purchased public-utility energy; and if electrical energy be used the cost will vary somewhat, depending on whether direct current or alternating current is employed. As has already been said the power cost with skip hoisting is somewhat lower than with cage hoisting. The labor cost also being less with skip hoisting, the combined costs for power and labor are of course less, on the average, with skip hoisting.

If an operator desires an approximate figure for the operating skip-hoisting cost at a proposed mine, he may feel assured that it will be somewhat less than the actual hoisting cost at a cage mine having
A STUDY OF SKIP HOISTING AT ILLINOIS COAL MINES

comparable tonnage and hoisting depth. Here one must bear in mind that skip hoisting demands a greater hoisting distance than cage hoisting.

Eleven electrified cage mines, of an average hoisting depth of 495 ft. (practically equal to the average for these six skip mines), showed an average power consumption of 0.173 kw-hr. per 100 foot-tons. Each hoist is provided with a flywheel set and every effort is made to obtain efficient performance of the plant. This factor, therefore, appears to represent good practice in electrical hoisting and to be serviceable in reaching preliminary estimates.

Arbitrary figures must be assumed for the cost of a kilowatt-hour before the cost per ton for hoisting can be determined. Whether the power be purchased or generated, its cost will be less per unit as the scale of consumption increases. Purchased power cannot be quoted in flat terms per kilowatt-hour even though the vendors publish open schedules. The price per unit of energy will, in every case, be the least when the mine is operated exclusively upon electrical energy, because the monthly bills are based upon the gross consumption of the entire installation, that is, upon the record of the primary-intake watt-hour meter. The power input to the mine will be several times the energy demanded by hoisting.

In the future skip hoisting will be practised at all large mines. Such mines will take advantage of the lower average cost per kilowatt-hour. The mines studied herein are of such size as to power requirements as might perhaps secure public-utility energy at around 2.2 cents per kw-hr. If cage hoisting requires 0.173 kw-hr. per ton per 100 feet of lift, and assuming that the power consumption for skip hoisting may be as great, then the power cost per ton at these six skip mines might vary from a minimum of 1.16 cents to a maximum of 2.62 cents, depending on the hoisting distance. The average power cost is probably around 1 1/4 cents per ton.

Table 11 indicates an average advantage for skips in the labor cost of about 0.62 cent per ton. The labor cost per ton at the six big skip mines varies between 1 and 1 3/4 cents per ton and averages 1.35 cents per ton. The average combined power and labor cost, then, is 1.75 cents plus 1.35 cents, or 3.10 cents per ton.

A short distance from the Zeigler No. 1 mine, the owners, the Bell & Zoller Mining Company, operate the Zeigler No. 2, a cage mine with an average production of about 6400 tons per day. It is in the same seam as, and has natural conditions comparable to those in the No. 1 mine. Accounting at these mines being according to the same system, the company keeps a close check on relative performances. However, haulage and hoisting costs are combined into the single item, Transportation, although these two activities are radically dif-
ferent, especially at these mines. Nevertheless the statistics for the total costs per ton for hoisting-haulage prove interesting. No. 1 mine is old and its workings are so remote from the main bottom as to make the haulage distances very long, whereas No. 2 mine has been at its best production for only three or four years.

During the nine busy months of the calendar year 1924 the production of No. 2 mine was about nine-tenths that of No. 1 mine. Combined hoisting-haulage costs per ton averaged 2.4 cents higher in the No. 1 mine, which has skip hoisting, but this difference is readily explained by the more costly haulage. During the year 1923 there was a difference of only 0.4 cent in favor of the cage mine and this might well be interpreted as an advantage for skip hoisting in view of the long haul; while, during January, 1925, these relative costs were actually 0.8 cent in favor of the skip-hoisting mine. These data, therefore, are significant in tending to prove that skip hoisting is upon a par with cage hoisting in so far as operating costs are concerned. Further than this, they show a favorable comparison between an old-fashioned skip mine and a comparatively recent cage mine.

Because data could not be obtained, this bulletin cannot include any discussion of such costs as maintenance, replacement, amortization, or other costs that properly are chargeable against hoisting.

IX. Summary

31. Résumé of Advantages and Disadvantages of Skip Hoisting.

—Most of the advantages of and the objections to skip hoisting mentioned in Chapter I have been discussed in the succeeding chapters; a few of them are so obvious as to require little or no discussion. A summary of these claims is given below. The principal advantages claimed for skip hoisting are:

(1) Greater capacity for a given size of shaft.—This argument applies to proposed mines only; it does not suggest the alteration of an old cage mine into a skip mine. With the ordinary single-deck cage the load per hoist is limited to a single carload which, in turn, is limited in its height. With a double-deck cage the hoist load can be doubled, but this practice is not suited to large production. A skip can have a horizontal cross-section as great as that of a cage and its depth can be designed for any desired capacity, the minimum practical capacity being two carloads.

(2) Easy enlargement of hoisting capacity.—Whenever the enlargement of the production of a skip-hoisting mine is required, the capacity of the hoisting shaft can be correspondingly enlarged by increasing the length of the skips.
(3) Lower costs of power.—Since, in comparison with cages, skips give a higher ratio of coal load to dead load and more nearly balanced dead loads, advantages that result in a lesser power consumption, it is obvious that skips show lower power costs per ton. This is true particularly with low rates of acceleration. With high hoisting speeds and high acceleration rates the cost of power per ton of coal hoisted will be greater than with slow-speed hoisting, but this additional cost will be more than balanced by other economies.

(4) Lower labor cost per ton.—Skip hoisting has an actual although small advantage in labor cost, both in the shaft-bottom and the top activities. Labor is not a heavy item, however, in either system of hoisting. A fraction of one cent per ton is not particularly important.

(5) Use of solid-end cars.—An important advantage possessed by skips over cages is the attendant use of rotary dumpers which, in turn, permit the use of solidly constructed mine cars. Bottom-dumping cars have not been adopted in Illinois. Overturning cages could handle solid-end cars but such cages have not been adopted for full-scale hoisting, probably because of the fear of a serious breakage of coal when dumping.

Among the benefits in the use of solid-end cars are: a lower initial cost of cars, a lower upkeep cost for the cars, no spillage of coal through car bodies and end-gates and therefore less dust along roads, no derailments due to accidental opening of end-gates, less expense in track upkeep, fewer accidents to workmen, possibility of turning cars end for end if coupling device permits.

(6) Reliability of dumping.—No trouble is experienced at any of these mines in the prompt and complete emptying of skips into the tipple. Trouble from cars “missing the hook” is eliminated, for the skip requires no hook for dumping. This advantage may be claimed also, however, for overturning cages.

The principal objections urged against skip hoisting are:

(1) Greater initial cost and maintenance.—No general comparison between the first costs of plants for the two systems of hoisting is possible with present data. One cannot assert offhand that either system is the cheaper in first cost, even when equal capacities are considered. This cost, as well as the maintenance cost, will vary with many details. Each instance is an engineering problem in itself.

(2) Greater breakage of coal.—The logical deduction from all the evidence at hand is that skip hoisting is, but need not be, responsible for more degradation than attends cage hoisting.
With improvements in practice it would probably produce less fine coal. Such improvements might well be made in changing the design of the chutes from the dumper to the weighpans, from the weighpans to the skip-loaders and, in the tipple, from the skips to the screen feeders, so as to lessen the distances that the coal is dropped and to reduce the number and severity of impacts of the coal upon steel surfaces.

(3) Complication in the handling of men, supplies, and waste.—It is true that men or materials other than coal cannot and should not be handled in most types of skips. When an eight-hour shift is required for hoisting the production of the mine and no time can be spared for handling men or materials through the main shaft, it makes no difference whether cages or skips are used. Hence operators of large mines, skip or cage, find it desirable to use a separate shaft for all hoisting and lowering of men, supplies, and waste.

There are several compensating advantages in the separate hoisting. The main bottom is free from workmen who have no duties therein. There is no switching on the main bottom of incoming supplies and outgoing waste. Officials and workmen may enter or leave the mine at any necessary time.

(4) Difficulty in inspecting coal for docking.—This is a frequent objection to skip hoisting. It has been accepted without debate. However, it is losing ground and is of little force at the very new mines, as at Orient No. 2, for example. Not every carload of coal can be inspected, it is true. But even at cage mines it is usually impossible to keep different earloads separated so as to identify accurately offending miners without the undue slowing down of production. Docking is essential under prevailing conditions and it calls for ingenuity in the design of skip-hoisting plants. Any scheme that permits the inspection of loads in sufficient number to discourage the infraction of loading regulations will prove effective. Possibly a way will yet be devised for underground inspection.

(5) Dust.—Study of the dust problem on skip-hoisting mine bottoms warrants the assertion that it can be rendered of little consequence in future installations. Inevitably dust must be produced every time a quantity of coal is transferred from one container to another. The remedy lies in so confining the dust or in so shielding it from air currents as to prevent it from rising into the mine bottom in sufficient amount to prove a nuisance.

Bulletin 2. Coal Mining Practice in District VIII (Danville), by S. O. Andros. 1913. None available.


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

Bulletin 8. Coal Mining Practice in District VI (Mines in bed 6 in Franklin, Jackson, Perry and Williamson counties), by S. O. Andros. 1914. Free upon request.


Bulletin 27A. Analyses of Illinois Coals, compiled by G. W. Hawley. 1923. **Fifteen cents.**


Bulletin 91. Engineering Experiment Station, University of Illinois, Subsidence Resulting from Mining, by L. E. Young and H. H. Stock. 1916. **None available.**

Bulletin 100. Engineering Experiment Station, University of Illinois, The Percentage of Extraction of Bituminous Coal, with Special Reference to Illinois Conditions, by C. M. Young. 1917 **Free upon request.**

Bulletin 113. Engineering Experiment Station, University of Illinois, Panel System of Coal Mining, A Graphical Study of Percentage of Extraction, by C. M. Young. 1919. **Free upon request.**

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