

PROCEEDINGS  
*of the*  
ILLINOIS MINING INSTITUTE

---

FOUNDED FEBRUARY, 1892

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*Fifty-Sixth Year*

1948

Annual Meeting  
SPRINGFIELD, ILLINOIS  
November 5



HARRY M. MOSES

President, 1948

## In Loving Remembrance

WILLIAM ORTMAN, Feb. 22, 1931  
S. W. FARNHAM, March 12, 1931  
H. C. PERRY, April 13, 1931  
A. J. SAYERS, Oct. 11, 1931  
C. E. KARSTROM, March 24, 1932  
JOSEPH D. ZOOK, May 28, 1932  
EDWARD CAHILL, Aug. 4, 1932  
JOSEPH VIANO, Dec. 12, 1932  
JOHN ROLLO, Feb. 6, 1933  
DAVID I. ROCK, Aug. 2, 1933  
WM. HUTTON, Aug. 18, 1934  
FRED K. CLARK, Oct. 24, 1934  
ERWIN CHINN, April 16, 1935  
ADAM CURRIE, June 12, 1935  
W. H. SLINGLUFF, Sept. 10, 1935  
CHAS. B. SPICER, Oct. 26, 1935  
NELSON P. MORRIS, Sept. 3, 1936  
DON WILLIS, Dec. 9, 1936  
T. E. COULEHAN, Jan. 11, 1937  
ALBERT WEBB, March 5, 1937  
H. B. COOLEY, March 23, 1937  
C. W. SWANSON, July, 1937  
JOSEPH McFADDEN, Sept. 15, 1937  
E. G. LEWIS, Sept. 21, 1937  
E. L. STEVENS, Sept. 28, 1937  
W. C. ARGUST, Dec. 17, 1937  
H. H. TAYLOR, SR., Dec. 28, 1937  
E. L. BERGER, May 27, 1938  
J. I. THOMPSON, June 24, 1938  
P. W. MacMURDO, July 11, 1938

J. A. EDE, July 26, 1938  
M. C. MITCHELL, Sept. 11, 1938  
C. F. HAMILTON, Sept. 22, 1938  
H. C. LONGSTAFF, Oct. 12, 1938  
JOHN JOHNSON, Jan. 2, 1939  
C. A. BLOMQUIST, Jan. 9, 1939  
JOHN WHITE, April 15, 1939  
CHARLES HAFFTER, May 21, 1939  
BRUNO F. MEYER, July 21, 1939  
JOHN A. GARCIA, Aug. 11, 1939  
A. J. MOORSHEAD, Oct. 16, 1939  
HARVEY E. SMITH, Nov. 6, 1939  
C. W. McREACKEN, Nov. 30, 1939  
C. C. HUBBART, March 4, 1940  
SAMUEL HANTMAN, Sept. 13, 1940  
SIMON A. BOEDEKER, Oct. 12, 1940  
JOHN H. DAVIS, Oct. 21, 1940  
S. J. WILLS, Oct. 22, 1940  
HARRY HANTMAN, Nov. 5, 1940  
J. W. GLENWRIGHT, Nov. 27, 1940  
J. C. WILSON, Dec. 18, 1940  
NICHOLAS CHRISTENSEN, Dec. 26, 1940  
JOHN W. POLING, Jan. 31, 1941  
JOHN T. RYAN, Feb. 20, 1941  
M. F. PELTIER, April 2, 1941  
F. M. BEAN, April 30, 1941  
F. M. SCHULL, Aug. 20, 1941  
C. J. SANDOE, Aug. 29, 1941  
F. F. SCHLINK, March 15, 1942  
FRED F. GERMANN, March 31, 1942

# In Loving Remembrance

JOHN MENTLER, April 28, 1942  
HUGH MURRAY, June 5, 1942  
G. D. COWIN, June 14, 1942  
JAMES M. ROLLO, June 15, 1942  
SYDNEY A. HALE, Aug. 12, 1942  
BYRON BROWN, Sept. 17, 1942  
J. E. SEYMOUR, Nov. 21, 1942  
OTTO AWE, Dec. 6, 1942  
A. F. ALLARD, Dec. 29, 1942  
THOMAS R. STOCKETT, Feb. 15, 1943  
A. R. JOYCE, April 7, 1943  
W. S. BURRIS, April 9, 1943  
A. H. MALSBERGER, May 7, 1943  
J. B. FLEMING, May 19, 1943  
H. T. MORGAN, May 29, 1943  
E. W. HASENJAEGER, July 29, 1943  
C. W. WATERMAN, Aug. 7, 1943  
J. R. HURLBURT, Sept. 6, 1943  
JAMES S. ANDERSON, Sept., 1943  
F. F. JORGENSEN, Nov., 1943  
E. W. BEARD, Jan. 5, 1944  
W. M. ELDERS, Jan. 22, 1944  
THOMAS ENGLISH, April 3, 1944  
FRANK TIRRE, May 22, 1944  
\*J. K. CHILDS, June 10, 1944  
W. S. STINTON, Dec. 6, 1944  
E. W. HAWLEY, Jan. 29, 1945  
J. C. ANDERSON, July 7, 1945  
F. A. FLASKAMP, Aug. 12, 1945  
JOHN M. DILLAVOU, Aug. 19, 1945

STANLEY A. TRENGOVE, Dec. 28, 1945  
H. A. ZELLER, Jan. 22, 1946  
M. K. HERRINGTON, May 11, 1946  
L. W. BALDWIN, May 14, 1946  
C. P. HOY, May 30, 1946  
STUYVESANT PEABODY, June 7, 1946  
PETER A. CASSADY, June 18, 1946  
JOHN F. GOALBY, July 7, 1946  
OSCAR WINTER, Sept. 21, 1946  
GEORGE HOOK, Sept. 29, 1946  
E. J. KRAUSE, Sept. 30, 1946  
H. E. MABRY, Nov. 8, 1946  
J. R. PEARCE, Dec. 10, 1946  
E. R. ARMSTRONG, February 17, 1947  
JOS. P. LENZINI, February 20, 1947  
JOHN H. BAUER, March 12, 1947  
ARTHUR PHILLIPS, June 27, 1947  
LEE HASKINS, September 19, 1947  
C. H. BURKHALTER, October 18, 1947  
JETT J. WEST, November 11, 1947  
THOMAS MOSES, Feb. 20, 1948  
W. H. HUBELI, April 3, 1948  
G. E. LYMAN, April 27, 1948  
WALTER M. DAKE, May 13, 1948  
ARLEN "ZACK" JENNINGS, July 30, 1948  
ERNEST L. STEPPAN, Aug. 7, 1948  
KENNETH DONALDSON, Aug. 18, 1948  
PAT HEAP, Sept. 23, 1948  
F. E. FINCH, Nov. 2, 1948  
J. E. BARLOW, Nov. 5, 1948

\* Killed in Action



# OFFICERS 1948

## PRESIDENT

HARRY M. MOSES

Pittsburgh, Pennsylvania

## VICE-PRESIDENT

J. ROY BROWNING

Chicago, Illinois

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\* Term expires 1948

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L. A. WASSON \*

\* Term expires 1949

\*\* Term expires 1950

\*\*\* Term expires 1951

# PAST PRESIDENTS OF ILLINOIS MINING INSTITUTE

FOUNDED FEBRUARY, 1892

1892-3	JAMES C. SIMPSON, Gen. Mgr., Consolidated Coal Co., St. Louis, Mo.
1893-4	JAMES C. SIMPSON, Gen. Mgr., Consolidated Coal Co., St. Louis, Mo.
1894-5	WALTON RUTLEDGE, State Mine Inspector, Alton, Ill.
1895	} Institute inactive.
1911	
1912-3	JOHN P. REESE, Gen. Supt., Superior Coal Co., Gillespie, Ill.
1913-4	THOMAS MOSES, Supt., Bunsen Coal Co., Georgetown, Ill.
1914-5	J. W. STARKS, State Mine Inspector, Georgetown, Ill.
1915-6	WILLIAM BURTON, V. P., Illinois Miners, Springfield, Ill.
1916-7	FRED PFAHLER, Gen. Supt., Superior Coal Co., Gillespie, Ill.
1917-8	PATRICK HOGAN, State Mine Inspector, Carbon, Ill.
1918-9	WILLIAM HALL, Miners Examining Board, Springfield, Ill.
1919-20	WILLIAM HALL, Miners Examining Board, Springfield, Ill.
1920-21	FRANK F. TIRRE, Supt., North Breese Coal & Mining Co., Breese, Ill.
1921-22	PROF. H. H. STOEK, Mining Dept., University of Illinois.
1922-23	JOHN G. MILLHOUSE, State Mine Inspector, Litchfield, Ill.
1923-24	D. D. WILCOX, C. E., Superior Coal Co., Gillespie, Ill.
1924-25	H. E. SMITH, Gen. Supt., Union Fuel Co., Springfield, Ill.
1925-26	E. G. LEWIS, Supt., Chicago-Sandoval Coal Co., Sandoval, Ill.
1926-27	WM. E. KIDD, State Mine Inspector, Peoria, Ill.
1927-28	JAMES S. ANDERSON, Supt., Madison Coal Corp., Glen Carbon, Ill.
1928-29	JOHN E. JONES, Safety Engineer, Old Ben Coal Corp., West Frankfort, Ill.
1929-30	PROF. A. C. CALLEN, University of Illinois, Urbana, Ill.
1930-31	JOSEPH D. ZOOK, Pres., Illinois Coal Operators' Assn., Chicago, Ill.
1931-32	GEO. C. McFADDEN, Asst. Vice-Pres., Peabody Coal Co., Chicago, Ill.
1932-33	CHAS. F. HAMILTON, Vice-Pres., Pyramid Coal Co., Chicago, Ill.
1933-34	HARRY A. TREADWELL, Gen. Supt., C. W. & F. Coal Co., Benton, Ill.
1934-35	C. J. SANDOE, Vice-Pres., West Virginia Coal Co., St. Louis, Mo.
1935-36	T. J. THOMAS, Pres., Valier Coal Co., Chicago, Ill.
1936-37	W. J. JENKINS, Pres., Consolidated Coal Co., St. Louis, Mo.
1937-38	H. H. TAYLOR, JR., Franklin County Coal Corp., Chicago, Ill.
1938-39	PAUL WEIR, Consulting Mining Engineer, Chicago, Ill.
1939-40	ROY L. ADAMS, Old Ben Coal Corp., West Frankfort, Ill.
1940-41	DR. M. M. LEIGHTON, State Geological Survey, Urbana, Ill.
1941-42	J. A. JEFFERIS, Illinois Terminal Railroad Co., St. Louis, Mo.
1942-43	CARL T. HAYDEN, Sahara Coal Co., Chicago, Ill.
1943-44	BEN H. SCHULL, Binkley Mining Co., Chicago, Ill.
1944-45	GEORGE F. CAMPBELL, Old Ben Coal Corp., Chicago, Ill.
1945-46	JOSEPH E. HITT, Walter Bledsoe Co., St. Louis, Mo.
1946-47	ROBERT M. MEDILL, Dept. Mines & Minerals, Springfield, Ill.
1947-48	HARRY M. MOSES, H. C. Frick Coal Co., Pittsburgh, Pa.

## CONTENTS

President Harry M. Moses.....	3
In Memoriam.....	4
Officers 1948.....	6
Officers 1949.....	7
Past Presidents.....	8

### FIFTY-SIXTH ANNUAL MEETING

Meeting called to order by President Harry M. Moses.....	11
Secretary's Report.....	11
Nominating Committee Report.....	13

#### PAPERS PREPARED & SPONSORED BY ILLINOIS SOCIETY OF COAL PREPARATION ENGINEERS & CHEMISTS Chairman: J. W. MacDonald

"Centrifugal Drying":	
(a) "McNally-Carpenter Dryer," by John Wilson.....	15
(b) "C.M.I. Centrifugal Dryer," by Laning Dress.....	18
"Cleaning Plants I Have Known," by William C. McCulloch.....	22

\* \* \*

Report of Scholarship Committee by H. L. Walker.....	31
Report of Advisory Committee to the Dept. of Mining & Metallurgical Engineering, University of Illinois, by Henry C. Woods.....	35
RESOLUTION .....	38

#### PAPERS PREPARED & SPONSORED BY MINING ELECTRICAL GROUP (of Southern Illinois). Chairman: W. J. Jenkins II

"A.C. Power and Its Use for Strip Mining," by E. T. Groat.....	41
"Service Units for Trackless Mining," E. M. Arentzen.....	52
"Roof Support with Suspension Rods," C. C. Conway.....	59

\* \* \*

### Evening Session

Meeting Called to Order by President Harry M. Moses.....	74
Introduction of Guests and Officers.....	74
Presentation of Honorary Life Certificate to J. W. Starks.....	76
Acceptance by J. W. Starks.....	77
Presentation of Honorary Life Certificate to Dr. L. E. Young.....	78
Acceptance by Dr. L. E. Young.....	79
Introduction of Strickland Gillilan, Guest Speaker.....	80
(Reprint of Mr. Gillilan's address omitted at his request)	

Introduction of President-Elect J. Roy Browning.....	81
Adjournment of Meeting by President-Elect J. Roy Browning.....	81

\* \* \*

ACTION TAKEN ON RESOLUTION ADOPTED NOVEMBER 5, 1948.....	83
Mining Advisory Committee Message to Illinois Mining Institute.....	85
Letter from Marion B. Walls, Former Scholarship Student.....	86
Reply to Letter from Marion B. Walls.....	87

## REPRINTS

"Coal Conservation," by James Boyd. Reprinted from June, 1948 issue of "Mining Congress Journal" by permission of the author and the American Mining Congress.....	88
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----

REPRINTS from 1948 Yearbook "Coal Mine Modernization"  
through courtesy of The American Mining Congress,  
papers presented at The American Mining Congress, Cincinnati, Ohio,  
April 26-28, 1948:

"Drilling and Breaking Down Coal with Airdox," by R. L. Adams.....	94
"Haulage System for Track-Mounted Equipment," by Joe Bose and Joseph Anstead .....	101
Discussion: J. B. Haskell.....	108
"Belt Care and Maintenance," by J. A. Bottomley.....	110
"What's New in Coal Preparation," by Henry O. Erb.....	115
"The National Scope of Reclamation," by Thomas C. Cheasley.....	130
"Progress in Coal Haulage," by Lester E. Briscoe.....	132
"Land Reclamation by Illinois Coal Strippers," by J. W. Bristow.....	143

REPRINTS from "Opinion and Comment," Vol. 10, No. 2, May 17, 1948,  
thru courtesy of the University of Illinois Bureau of Economic & Business Research

"Trends in Railroad Fuel," by Nina T. Hamrick.....	150
"Synthetic Liquid Fuels," by Frank H. Reed.....	160

REPRINT from April 1946 issue of "Scientific Monthly"  
thru courtesy of the author and American Association for the Advancement of Science

"Coal Balls—a Key to the Past," by Henry N. Andrews.....	173
----------------------------------------------------------	-----

CONSTITUTION AND BY-LAWS.....	188
-------------------------------	-----

MEMBERSHIP LIST.....	191
----------------------	-----

Life Members.....	191
Honorary Members.....	193
Scholarship Members .....	194
Complete List of Membership.....	194

ADVERTISING SECTION.....	136
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# PROCEEDINGS OF ILLINOIS MINING INSTITUTE FIFTY-SIXTH ANNUAL MEETING

Held in Springfield, Illinois

FRIDAY, NOVEMBER 5, 1948

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## MORNING SESSION

10 O'clock A.M.

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The 56th Annual Meeting of the Illinois Mining Institute convened in the Hotel Abraham Lincoln, Springfield, Illinois, November 5, 1948, at 10:10 o'clock, President Harry M. Moses presiding.

President Moses: The meeting will come to order, please.

As our normal order of business, the first item will be the reading of the minutes of the last meeting of the Illinois Mining Institute. Due to the fact that the minutes are published in the yearbook every year, and are now in your possession, the Chair would entertain a motion to dispense with the reading of the minutes.

Secretary Schonthal: I so move, Mr. Chairman.

(The motion was regularly seconded, was put to a vote, and carried.)

President Moses: At this point, departing from our catalogued order of business, it has been suggested that we move immediately into the Secretary's Report. Mr. Secretary?

## SECRETARY'S REPORT

The activities of our Institute for the year just ended have been quite numerous, as noted from the communications our members received during the year and our participation in the meetings and activities of other groups during the year. The Secretary attended a number of meetings of these other organizations and was glad to see our Institute membership well represented, as interest in the activities of other organizations is always helpful and beneficial.

Our membership at the close of the year is 1085 including regular, honorary, and life members. This also includes nine scholarship students who are in attendance at the University of Illinois under mining scholarships issued by this Institute, Peabody Coal Company, Old Ben Coal Corporation, and Mr. and Mrs. Alfred E. Pickard.

It is hoped that during the coming year many others will become interested in the education of our younger people and will cooperate

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with our Institute in establishing scholarships at the University of Illinois. An Advisory Committee to the Department of Mining and Metallurgical Engineering at the University has recently been established. You will hear further about this committee, as well as the scholarship program, from Professor Harold L. Walker, Head of the Department.

Our financial position remains rather constant. We have on hand interest-bearing bonds amounting to cash value of \$10,000; and cash in the bank of \$1064.92.

During the year we had the misfortune to lose eight members by death. The usual messages of condolence were sent to the families.

Our 1948 Proceedings is now in process of preparation. The suppliers are being solicited for advertisements at this time, and we hope we may have their continued support. Depending on delays caused by printers and binderies, we expect to distribute the yearbook shortly after the first of the year.

I should like to express special appreciation for the cooperation received from the members at last year's meeting, after my appeal for elimination of disturbance in and around the meeting halls during both the business sessions and the evening meeting. There was considerable favorable comment about this improvement last year, and we hope this cooperation will continue during today's and future meetings. We have arranged to have the public address system set up so that those in the back rooms can hear what is going on. This, along with your willingness to cooperate, helps solve our problem.

In closing another year of activity the Secretary wishes to thank the officers, executive board, committees, and general membership for their readiness to assist at all times.

Respectfully submitted,

B. E. SCHONTHAL, *Secretary-Treasurer*

\* \* \*

President Moses: A motion to adopt the report of the Secretary is now in order.

(Motion was regularly made and seconded that the report of the Secretary be approved as read; the motion was put to a vote, and carried.)

President Moses: The next thing on our agenda is a report of the Scholarship Committee. Is Professor Harold Walker here?

Secretary Schonthal: He is downstairs, Mr. Chairman, getting his students lined up.

President Moses: We'll pass over that for the moment. The next in the order of business is the report of the Nominating Committee.

Secretary Schonthal: I have Mr. Weir's report. He said he might be delayed.

President Moses: Will you please present it, sir?

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## NOMINATING COMMITTEE REPORT

Springfield, Illinois  
November 5, 1948

Mr. Harry M. Moses, President,  
Illinois Mining Institute.

The undersigned, appointed by you to membership on the Nominating Committee, have unanimously agreed to recommend to the membership the nomination of the following members for the offices shown:

## PRESIDENT:

Mr. J. Roy Browning, Vice-President,  
Illinois Coal Operators Association.

## VICE PRESIDENT:

Mr. T. G. Gerow, Executive Vice-President,  
Truax-Traer Coal Company.

## SECRETARY-TREASURER:

Mr. B. E. Schonthal of  
B. E. Schonthal and Company, Inc.

There are four to be elected for a three-year term to membership on the Executive Board. The Nominating Committee recommends the nomination of:

Mr. George F. Campbell,  
President of Old Ben Coal Corporation.

Mr. Fred S. Pfahler,  
President of Superior Coal Company

Mr. W. J. Jenkins,  
President of Consolidated Coal Company

Mr. H. H. Taylor,  
President of Franklin County Coal Corporation

Respectfully submitted,

Paul Weir, *Chairman*  
D. H. Devonald  
Carl T. Hayden

\* \* \*

President Moses: You have heard the report of the Nominating Committee. The adoption of this report by this body constitutes the election of those recommended by the Nominating Committee to the job. Are there any questions, or any nominations from the floor? If not, the Chair will entertain a motion to approve the report.

(Motion was regularly made and seconded that the report of the Nominating Committee be adopted.)

*Buyer meets Seller in the back of this book.*



President Moses: It has been regularly moved and seconded that the report of the Nominating Committee be adopted.

(The motion was put to a vote, and carried.)

President Moses: The "ayes" have it, and the gentlemen named — Mr. Browning, Mr. Gerow, Mr. Schonthal, and the four Directors, Mr. Campbell, Mr. Jenkins, Mr. Pfahler and Mr. Taylor — are elected to the Executive Board of the Institute.

I think we have maybe not the biggest group we are going to have but a very representative group here now. At this time the Chairman of the Advisory Committee of the Department of Mining and Metallurgical Engineering at the University of Illinois, Mr. Henry Woods, would like to have three or four minutes of your time to present a proposition that he has to you.

I guess the meeting is stalemated. Well, there will be time later in the day for the report of Professor Walker and the little talk that Henry Woods wants to make to us. At this time I think it is wise to proceed with our regular program. We will turn the meeting over to Mr. J. W. MacDonald, the chairman of this morning's session. Mr. J. W. MacDonald, of the Old Ben Coal Corporation.

Chairman MacDonald: Mr. Chairman, and Gentlemen: As you will notice from your program, the forenoon session is sponsored by the Illinois Society of Coal Preparation Engineers and Chemists. That might occasion a question in the minds of some of you gentlemen. A word of explanation is possibly in order.

This is a group of engineers, chemists and those interested in inspection of coal, organized eight years ago this month. We meet in southern Illinois at the Benton Country Club, monthly except for the summer period. Our meetings are confined to problems and discussions relative to coal preparation. We do not encroach on the field of production or operation for this particular group. To those of you who might be interested in attending such a meeting, we extend a welcome to join us on the third Friday of each month throughout the year. In the event you intend to meet with us, our principle difficulty would be arranging for reservations, and we'd like to have you contact our secretary, Carl E. Campbell, Shell Building, St. Louis.

I might add that the programs in general are very good. The service is excellent at the dinner meeting, and the Benton Country Club is one of the finest in southern Illinois. On behalf of the Preparation Engineers organization, we extend you gentlemen an invitation to meet with us, join us when and if you care to do so.

With that preliminary comment, we will proceed with the program as outlined.

The first paper, entitled, "McNally-Carpenter Dryer," will be presented by Mr. John Wilson, of the Union Colliery Company, DuQuoin, Illinois. Mr. Wilson.

## CENTRIFUGAL DRYING

### THE McNALLY-CARPENTER DRYER

By JOHN WILSON

Union Colliery Co., DuQuoin, Illinois

---

The McNally-Carpenter is a continuous, centrifugal dryer used for reducing moisture of coal having a topsize of  $\frac{3}{8}$ " and under. Size ranges as small as  $\frac{1}{2}$ mm. x 0 have been handled fairly successfully, and we ourselves are doing a highly acceptable job on a 10 M x  $\frac{1}{2}$ mm. feed. Generally speaking, however, this dryer gives best performance when the feed has a topsize approaching the largest size the dryer is equipped to handle.

The dryer is designed in the form of a truncated cone rotating on a vertical shaft. The wet feed is admitted at the top onto a vaned, circular, distributor plate which rotates with the basket and distributes the wet coal evenly around the smallest periphery of the cone. The basket consists of three rows of perforated stainless steel screens having a system of bed strips and adjustable impact plates which allows close regulation of depth on the screens. The combined gravitational and centrifugal forces cause the coal to, literally, creep down the basket, and as the peripheral speed increases with the gradual increase in circumference, the wet coal is subjected to constantly increasing centrifugal force, thus flinging off the adherent surface moisture.

The principal disadvantage of the McNally-Carpenter dryer is relatively short screen life and consequent maintenance and replacement costs. Careful study of the worn screens has shown that most of the wear is due to the abrasive fines passing *through* the screens rather than the abrasive action of the bed moving *over* them. This situation can be alleviated to a great extent by carrying a heavy bed on the screens to act as a filter for these fines; however, this also tends to retard drying and reduce the slight beneficiation which is usually evident with this type dryer. A better solution of the problem of abrasive fines is to condition the feed by pre-screening and rinsing on a vibrating screen having about  $\frac{1}{2}$ mm. openings. Experience has shown that, with moderately good screening and rinsing, the ash in the dryer feed can be reduced as much as four or five percent as the result of reduction in the amount of fireclay and abrasive fines. This serves to increase screen life tremendously since it leaves the dryer very little abrasive material to handle.

The key to successful operation of the McNally-Carpenter seems to be constant and careful inspection and maintenance, together with regular sampling of the feed and dried product. The mechanism is virtually trouble free so long as abrasive wear is caught and remedied before serious damage is done to the machine. The screens can be

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checked for holes during operation by observing the effluent for oversize particles and this should be done several times each working shift, in order to avoid any excessive loss of salable coal. Sampling for product moisture and ash will show evidence of flush ring overflow, usually due either to excessive coal loss or plugged drainout.

Idle shift maintenance determines almost entirely, the results obtained from the dryer. A daily visual inspection of the machine will show screens in need of patching, evidence of uneven bed thickness, and any excessive abrasive wear on any part of the unit. Holes should be patched as soon as they are large enough to pass the larger sizes of coal being dried and each screen may be patched two or three times before it is necessary to replace it. All other wearing parts should be checked at least every third operating day and replaced whenever they are worn to the point where efficiency is impaired. Both bearings should be flushed and refilled every week and at this time the grease seals, pressure relief fittings, and dust covers should be carefully checked.

Closely associated with maintenance and perhaps actually a part of it, is the ordering and stocking of spare parts. It is highly advisable, in the design of a new plant, to incorporate one machine in addition to those absolutely necessary to handle the estimated tonnage of material to be dried. The initial cost of the extra dryer will be quickly offset by the tremendous savings in maintenance labor costs made possible by having an idle unit which may be repaired on shift instead of on the overtime or double time days required otherwise. The spare unit also reduces the possibilities of lost time due to dryer failure, and permits a lower inventory of miscellaneous parts in the warehouse. Should the cost of an extra machine not seem justified, an extra rotor assembly will serve practically the same purpose.

The two items most interesting to operators and preparation men are, of course, cost and results. Both are variable with variations in seam characteristics and there seems to be a sufficiently direct correlation to enable us to predict both cost and result trends in many installations. Perry county Number 6, for example, contains considerable fireclay and pyritic sulfur as free impurities in the minus 48 mesh and, as a consequence, screen and wearing parts replacements are high, while the fireclay makes dewatering rather more difficult than average.

We find that, as a general rule, the moisture in a 10M x 0 feed, presized over  $\frac{1}{2}$ mm screen cloth, is roughly 50%. In other words, a wet feed having 33% total moisture will be reduced to about 16½% in the centrifuge. This doesn't necessarily hold true for all cases—if either the top or bottom size of the feed were increased we would probably make a greater moisture reduction.

These dryers operating in West Virginia No. 2 Gas seam are delivering a product having 4-5% surface moisture, but 8% may be considered good performance as a general rule.

The manufacturer, some years ago recognized the fact that maintenance costs on the dryer were rather high, and, have been working constantly with the operators in an effort to increase efficiency in both

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operation and maintenance. Wedgewire and Bixby-Zimmer screen have both been adapted for use in this dryer and are being experimented with at various places at the moment, but, thus far results are inconclusive.

Labor expenditures represent a great portion of maintenance cost and can be reduced by better accessibility of parts and ease of replacement. The current production models of the McNally-Carpenter dryer are the result of a recent redesign of the rib structure and screen assembly and show promise of cutting replacement labor costs as much as 50%. This new design also does away with the old framed screens thereby reducing parts cost considerably. Another feature of the new model will probably be substitution of rubber for some of the steel wearing parts. The useful life of the rubber parts is less than the steel, but lower initial cost and more expedient replacement will probably make these rubber parts more desirable.

This paper, being chiefly concerned with maintenance problems, may have left you with the impression that the McNally-Carpenter dryer is an inefficient unit, costwise. I should like to conclude by saying that our own experience with these machines has proven them to be reliable, efficient, and economical.

\* \* \*

Chairman MacDonald: Mr. Wilson, we thank you for that excellent paper on centrifugal dryers.

Gentlemen, the second paper is quite similar in character, other than with regard to applying to a different type of centrifugal dryer. With your permission we will proceed with the reading, and the discussion that will follow, common to both units, questions that you may ask, may be referred to either of the two gentlemen after the second paper.

The next paper will be "C. M. I. Centrifugal Dryer," by Mr. Laning Dress, Binkley Coal Company, Pinckneyville, Illinois.

Mr. Laning Dress (Binkley Coal Company, Pinckneyville, Illinois): Mr. Chairman, and Gentlemen: The centrifuge that I will explain is the C. M. I. machine, made in St. Louis. C. M. I. means Centrifugal Mechanical Industry. I am going to confine my talk mostly to the machine that is used for drying slurry.

## THE C. M. I. CENTRIFUGAL DRYER

By LANING DRESS

Binkley Coal Co., Pinckneyville, Illinois

We will all concede that a centrifugal dryer is one of the top favorites in fine coal drying equipment. To briefly outline some of the C. M. I. operating principles; it's a vertical continuous type dryer.

There are two rotating units, an outside conical screen frame and an inside solid cone which carries spiral flights. The screen frame is driven by the hollow shaft and the solid or inner cone is driven by a spindle shaft passing through the hollow shaft. The screen frame shaft travels 750 R.P.M. while the inner cone which carries the spiral flights travels slightly slower.

The wet material enters the top of the machine, falls on the inner cone where the centrifugal force throws it against the screen. It slides down the screen until it meets the upper end of the spiral flights, and while doing so the liquids begin to pass through the perforated screen. The flights spiral downward, and as the screen moves slowly around them in the direction of their downward pitch, the solids move down the screen toward the bottom, tending to remove all liquids from the surface of the solids.

The effluent, after passing through the screen flows around the main casting into a pipe for disposal. The solids leave the rotating screen and fall into a circular conveyor within the unit. The unit conveyor discharges the product from the bottom of the machine from one or two openings which ever the design may be. From this point the dry solids may be conveyed to any desired point.

The particular machine I will discuss is the C. M. I. slurry type dryer that's in operation at Pyramid Mine near Pinckneyville, Illinois. This installation is used to salvage fine coal from the washery sludge. Theoretically there should be no plus 28 mesh material in the sludge, but practically it is impossible to accomplish that fact. The fine coal gets into the sludge through spillage, leaks, worn dewatering screens, etc. You will note that the feed to the centrifuge is approximately all minus 8 mesh. The coal seam is No. 6 Illinois with a 10% seam moisture. This machine is of the latest design with two discharge openings in the bottom.

The feed to the Dryer is piped from the bottom of the washery settling cone. The ratio of solids to water is from 15% solids to as high as 50% solids. Sometimes fresh water is added when the sludge gets too thick. The fresh water is to thin out the feed to permit a certain amount of fine solids to be extracted along with the liquids.

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## OPERATIONAL DATA

The average screen life for drying this slurry is 62 hours. The average life for the spiral cone flights is 275 hours.

Flights and screens are the only two items that have been replaced since the unit went into operation May, 15, 1948. The machine operates on a single shift five and six days a week. Two men can change a set of screens in two hours.

The Dryer handles approximately 50 T.P.H. of feed which 15 T.P.H. is reclaimed fine coal and 35 T.P.H. is effluent that is pumped to waste. These tonnage figures are based on dry coal weights.

## OPERATING COST OF DRYER

*COST PER TON OF DRYER PRODUCT*

Screens	.0247
Spiral Flights	.0286
Power—65 H.P.	.0433
Maintenance Labor	.0086
<b>TOTAL</b>	<b>.1052</b>

The slurry type machine with a spare basket cost approximately \$20,000.00.

One set of screens cost \$23.00.

One set of 7 spiral flights cost \$118.00.

## SUMMARY

The five months that this dryer has been in operation is no criterion for the total operating cost. It will probably take three to five years to get a complete picture. We don't know how long a main rotor for the inner cone or the basket will stand up under these conditions. However, we have come to the conclusion that it is economical to use as a reclaiming machine in connection with preparation plant slurries, providing the oversize material in the sludge has satisfactory quality.

## SETTLING CONE UNDERFLOW WHICH IS FED TO THE C. M. I. DRYER

<i>Size</i>	<i>Wt. %</i>	<i>Ash %</i>	<i>Accumulative Wt. % Ash %</i>	
Plus 8 mesh	6.13	10.60	6.13	10.60
8 x 10	2.78	11.08	8.91	10.75
10 x 14	5.43	11.35	14.34	10.98
14 x 20	12.00	11.44	26.34	11.19
20 x 28	19.27	14.98	45.61	12.79
28 x 35	11.68	20.53	57.29	14.37
35 Minus	42.71	46.10	100.00	27.92

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CENTRIFUGAL DRYER PRODUCT  
USING A  $\frac{1}{16}$ " APERTURE SCREEN IN THE DRYER

Size	Wt. %	Ash %	Accumulative	
			Wt. %	Ash %
Plus 8 mesh	10.62	11.37	10.62	11.37
8 x 10	5.39	12.23	16.01	11.66
10 x 14	9.61	12.47	25.62	11.96
14 x 20	22.03	12.64	47.65	12.28
20 x 28	21.17	14.97	68.82	13.10
28 x 35	12.28	17.98	81.10	13.84
35 Minus	18.90	27.01	100.00	16.33

EFFLUENT FROM DRYER WITH  $\frac{1}{16}$ " APERTURE SCREEN

Size	Wt. %	Ash %	Accumulative	
			Wt. %	Ash %
Plus 14 Mesh	1.21	11.23	1.21	11.23
14 x 20	11.07	15.43	12.28	15.02
20 x 28	22.03	18.59	34.31	17.30
28 x 35	11.84	25.71	46.15	19.46
35 Minus	53.85	50.71	100.00	36.29

CENTRIFUGAL DRYER PRODUCT USING A  $\frac{3}{32}$ " APERTURE SCREEN

Size	Wt. %	Ash %	Accumulative	
			Wt. %	Ash %
Plus 8 Mesh	16.96	11.42	16.96	11.42
8 x 10	8.89	11.96	25.85	11.60
10 x 14	12.01	11.23	37.86	11.49
14 x 20	18.26	11.62	56.12	11.53
20 x 28	18.16	12.53	74.28	11.77
28 x 35	9.82	15.52	84.10	12.21
35 x 0	15.90	23.58	100.00	14.02

Average surface Moisture 7.00%

EFFLUENT FROM DRYER WITH  $\frac{3}{32}$ " APERTURE SCREEN

Size	Wt. %	Ash %	Accumulative	
			Wt. %	Ash %
Plus 14 Mesh	7.36	16.10	7.36	16.10
14 x 20	16.32	14.91	23.68	15.28
20 x 28	18.21	16.50	41.89	15.81
28 x 35	12.16	22.71	54.05	17.36
35 Minus	45.95	51.03	100.00	32.83

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Chairman MacDonald: Mr. Dress, we thank you for a most interesting description of the C. M. I. Centrifugal Dryer.

Gentlemen, you have heard the two outlines on dryers. I know there are a number of questions in your mind. May I suggest that this may be the opportune time to clarify those questions? We'll be glad to have any inquiry that you care to make at this time.

Are there any questions from the floor, gentlemen? If not, we will proceed to the third number of the forenoon session, entitled, "Cleaning Plants I Have Known," by William C. McCulloch, Roberts & Schaefer Company, Chicago, Illinois.





## CLEANING PLANTS I HAVE KNOWN

By WILLIAM C. McCULLOCH

Roberts and Schaefer Company, Chicago, Illinois

Mr. Chairman, and Members of the Illinois Mining Institute: When the Illinois Society of Coal Preparation Engineers and Chemists was organized some eight years ago, I was one of the charter members, and was considered a sort of daddy of coal preparation in southern Illinois. From the age of the members of the society who preceded me on the program today, I think I am now qualified to call myself the granddaddy of coal preparation engineers.

The title of my paper is "Cleaning Plants I Have Known," and the aforementioned remarks entitle me, I believe, to reminisce a little. I hope you'll bear with me in my discourse, taking you through a number of plants that I have been engaged in, in the past, and I'll try to give you some short description of the various types of plants that have developed through the years.

Some of these plants I have known only vicariously; in others I have had an active part in the operation and construction.

The initial plants in which I became interested were in the state of Washington. The Pacific Coast Coal Company operated several mines with Faust jigs on fine coal and Shannon jigs on coarse coal. Both types were mechanically operated with no automatic control and the results were only as good as the operator. Even constant attention could not produce uniform results. Sludge was no problem because water was wasted to the streams constantly. One feature that seemed important at that time was the longest picking table in the World. The number of men employed at this task would certainly not be economically possible in present day operation. Froth flotation was being studied in a laboratory process but was abandoned because of the difficulty of showing a practical method of handling the wet fine coal in the existing markets.

Subsequently, my work continued progressively to include Campbell bumping table plants with drainage pit recovery of fine coal and the ever present sludge drain to the creek, chloride washers, and to quote the late J. R. Campbell, with a skull and crossbones over the door bearing the caption "Death to Slate," and anthracite plants with their peculiar problems and the tremendous quantities of silt disposed of in the Susquehanna River.

Later, in Alabama, typical plants of that coal field which in general are not comparable with other regions received special attention. Small plants, mechanically operated, are characterized by the moderate climate so that little attention is paid to drying coal or sludge recovery.

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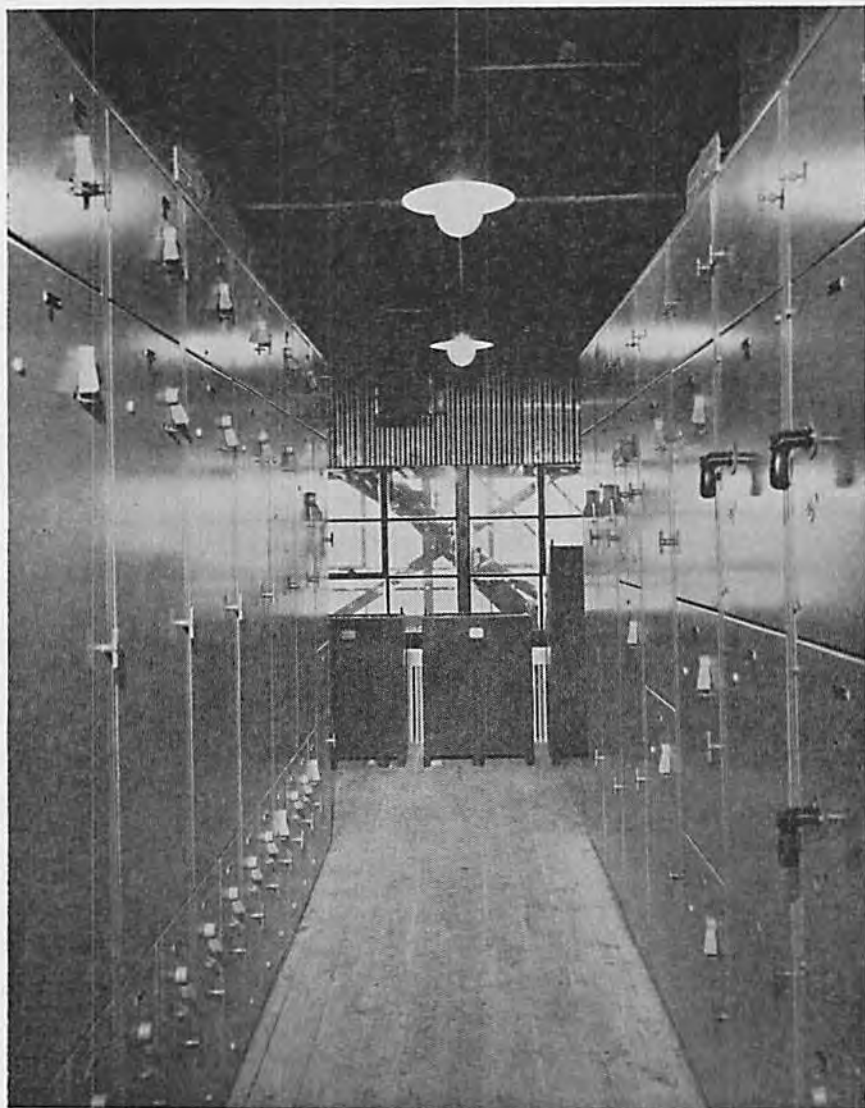
Recent plants incorporate all modern developments but they are not typical of the field.

Following the resurgence in coal preparation in Illinois in the early thirties the large modern plants typical of present day practice became numerous. Heat drying of washed coal was required in many instances. Closed water circuits, whether with thickeners and vacuum filters or solid bowl centrifugal filters, were demanded because of legislation pertaining to stream pollution. Pneumatic cleaning plants gained favor because of the inherent problems of drying coal and recovering sludge. Crushing and screening facilities for the preparation of stoker coal increased.

As an outgrowth of these somewhat rambling remarks, I want to take you on a tour by means of slides of one of the most modern plants for the production of coal for present day markets. In this plant sludge problems which have been the bugbear of previous operations have been practically eliminated. Pneumatic cleaning of all coal that might require heat drying has been included. Crushing and screening facilities for the preparation of stoker coal from all larger sizes are a part of the plant. I trust the pictures that are presented with the following commentary will give you a clear conception of this truly modern plant based on growing specialized fuel markets and the minimum of operating and maintenance problems.



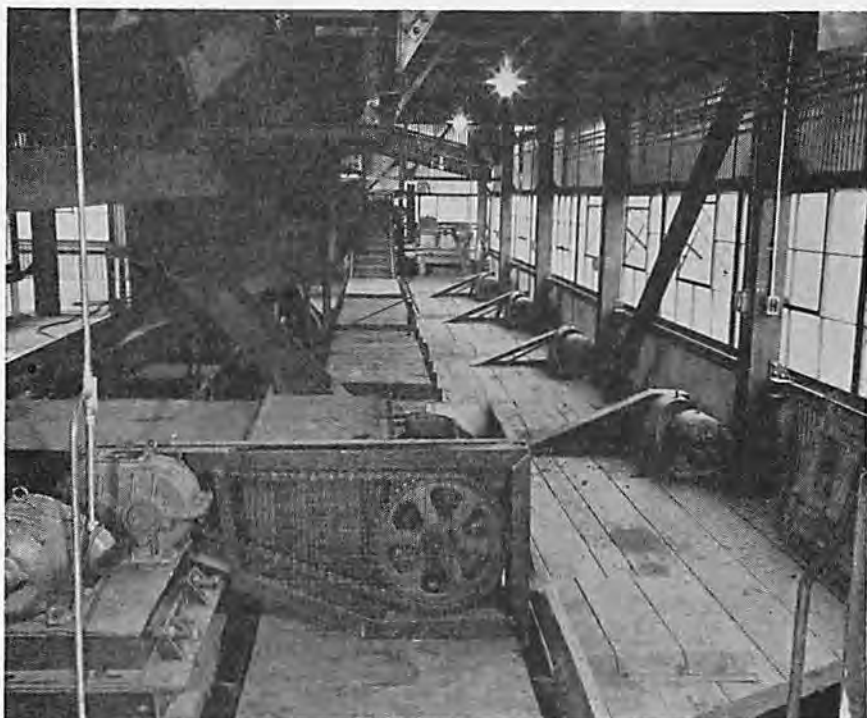
*Over-all view of the plant*



*Interior of electrical control room*

The Freeman Coal Mining Corporation operates two mines in Franklin County in Southern Illinois and maintains ordinary tippie facilities at each mine. During the year 1946, they contracted to build a coal preparation plant and after several changes in planning, decided to locate this plant at a new shaft opening more centrally located to their coal reserves. The new shaft operates with skip hoisting and

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*Mixing Conveyors and Drives for loading booms*

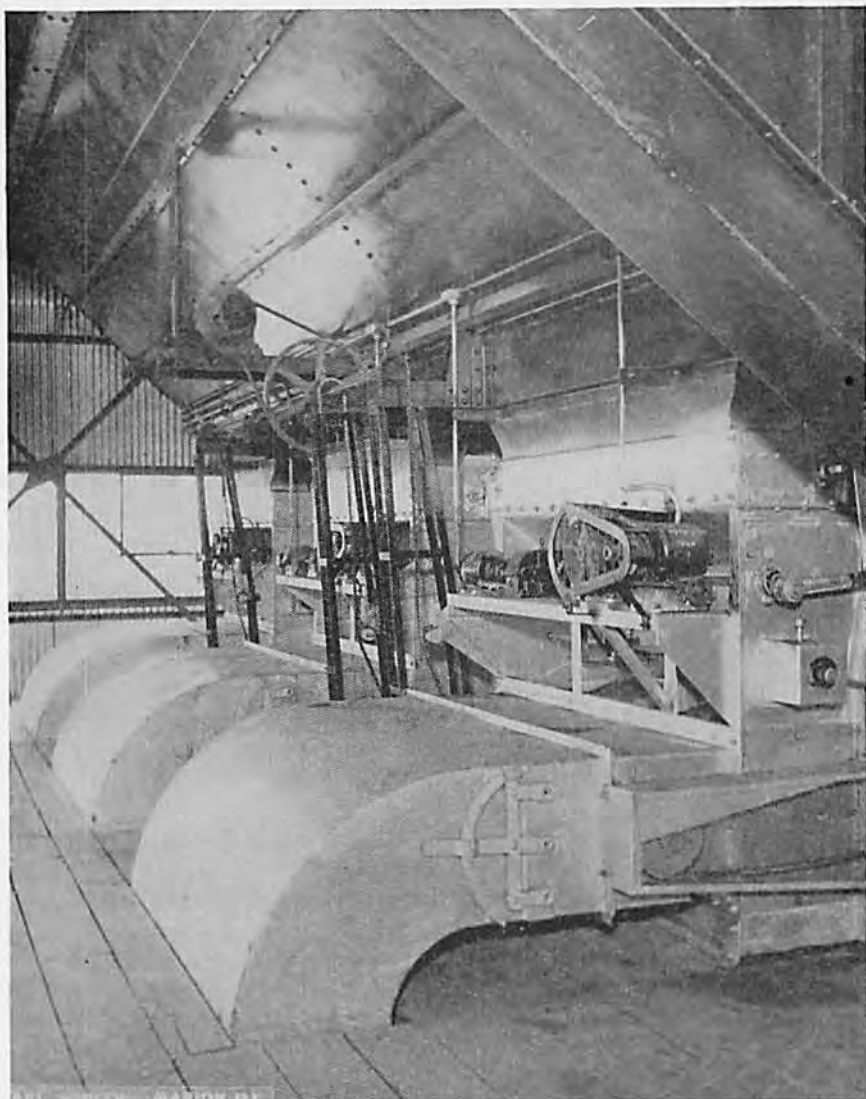
has auxiliary facilities for dumping raw coal from the other mines in a railroad car pit hopper for final preparation. Coal from the shaft is dumped into a surge bin from which the preparation plant feed is obtained.

The preparation plant which has been called an all-stoker plant is a combination type. That is, the coarse coal is prepared in water-washing units and the smaller coal is prepared in pneumatic cleaning units. Facilities are provided to crush any or all of the larger sizes to stoker coal with subsequent screening to remove the oversize and under-size from the prepared coal.

The flow sheet follows the accepted practice of presizing before cleaning with the separation being made at  $1\frac{1}{2}$ " round hole to divide the wet-washing part of the process from the dry-cleaning section.

Coal is fed from the storage hopper onto a belt conveyor which delivers it to a raw coal reciprocating screen where it is separated into plus 6" lump,  $6" \times 1\frac{1}{2}"$ , and  $1\frac{1}{2}" \times 0$ . The plus 6" lump is inspected and any impurities or foreign matter that would be objectionable in the crusher are picked out. Such foreign matter would consist of wooden mine props or slabs or any iron material that would be injuries to the

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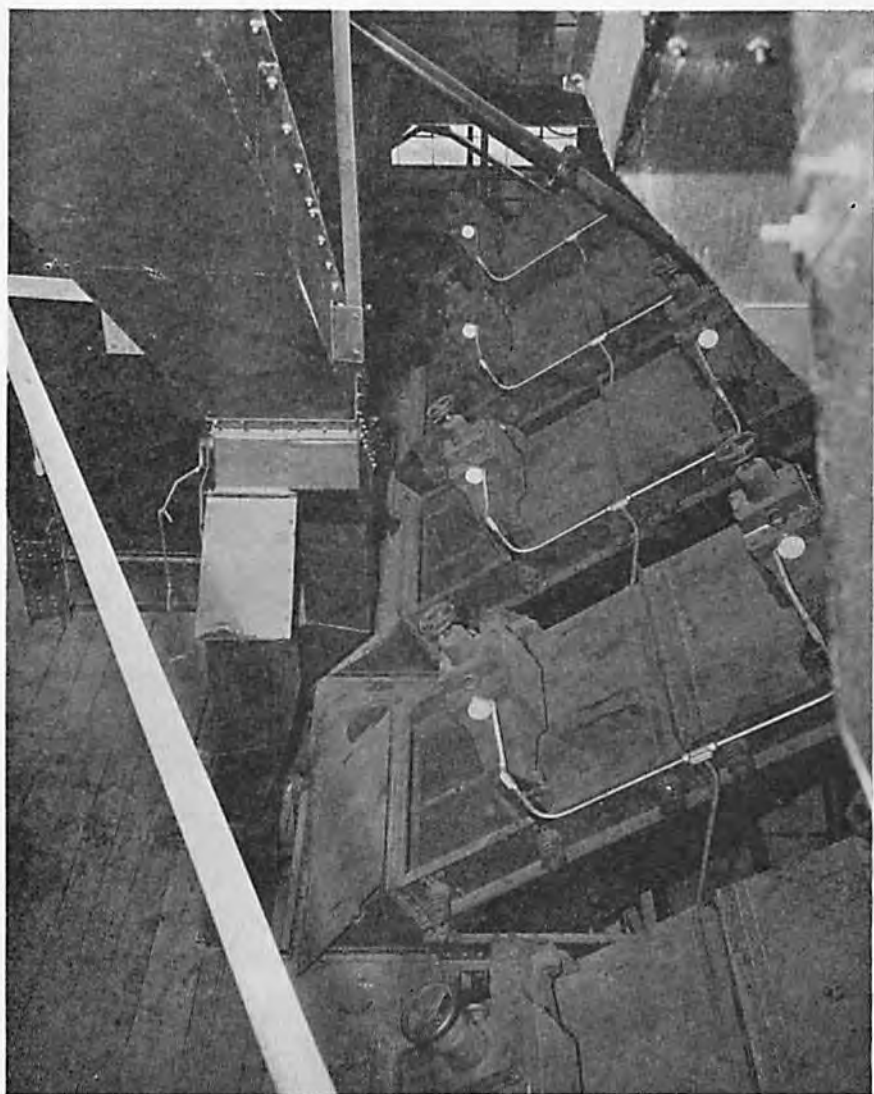
*Feed end of Stump Air-flow units*

crusher. The crushed lump is returned to the 6" x 1-1/2" coal and this combined product constitutes the feed to a single tandem Hydroseparator. The first cell of the Hydroseparator removes pure reject which is delivered to the refuse bin. The second cell removes bony or laminated material that is crushed and returned to the raw coal feed.

The washed coal is delivered to a draining and sizing screen from which the coal is delivered either to loading booms or to crushers for

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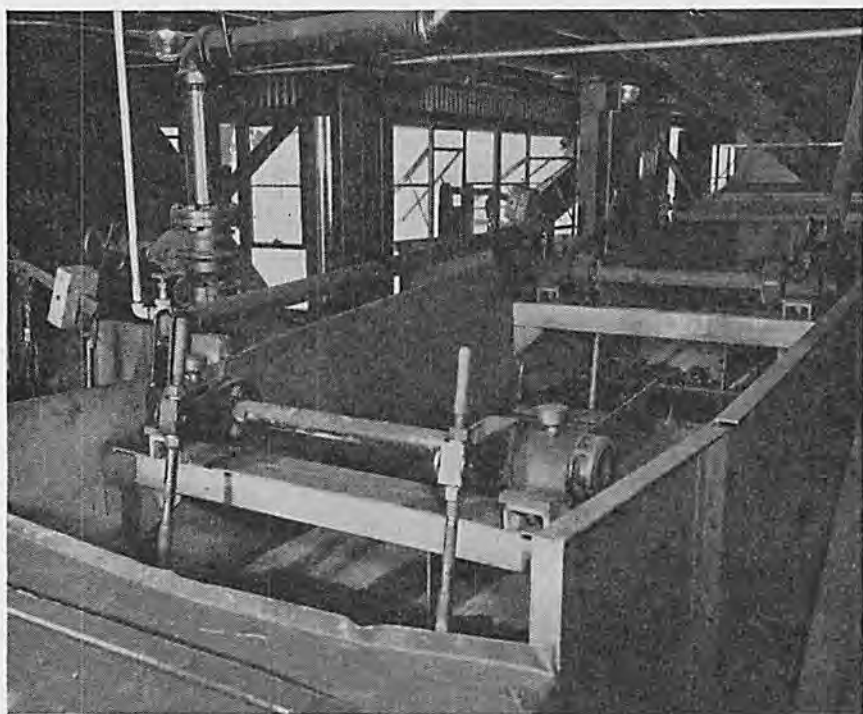


*Battery of electric vibrating screens*

further preparation. The water from the draining screen flows to a Hydrotator settling tank from which the clarified overflow water is pumped back in closed circuit to the Hydroseparator cells. The underflow from the settling tank is pumped to a vibrating sludge screen in the top of the plant and the recovered wet sludge is mixed with the dry dust and returned to a bin for loading. The underflow from the sludge screen is returned to the settling tank in closed circuit.

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The  $1\frac{1}{2}$ " x 0 raw dry coal from the main shaker screen is delivered to a set of vibrating sizing screens to be sized into  $1\frac{1}{2}$ " x  $\frac{3}{4}$ ",  $\frac{3}{4}$ " x  $\frac{5}{16}$ ",  $\frac{5}{16}$ " x 10 mesh, and 10 mesh x 0 sizes. The  $1\frac{1}{2}$ " x  $\frac{3}{4}$ " is delivered to a standard single-pack Stump Airflow for separation into a clean coal, middlings, and reject. The reject may be delivered to the refuse bin or it may be delivered to the Hydroseparator washer for recovering any coal that it might contain. The middlings product is delivered to a crusher for reduction to  $\frac{3}{4}$ " top size after which it is delivered to the raw coal vibrating screen for resizing. The clean coal, after rescreening to remove degradation, is delivered to the loading booms or to crushers for subsequent stoker coal preparation. The  $\frac{3}{4}$ " x  $\frac{5}{16}$ " size from the primary screens is delivered to a standard two-pack Stump Airflow which separates it into clean coal, middlings, and reject. The reject is delivered to the refuse bin and the middlings is returned to the feed for retreatment. The clean coal following screening to remove degradation is delivered to the mixing conveyor. The  $\frac{5}{16}$ " x 10 mesh raw coal is fed to a standard three-pack Stump Airflow to be separated into one or more reject products, middlings, and clean coal. The reject is delivered to the same refuse bin with the larger sizes; the middlings is recirculated to the feed; and the clean coal is delivered to the clean coal bin or to other loading or mixing points. The 10 mesh x 0 undersize is delivered to a bin for loading in combination with the



*Hydro-Separator Cells and Launder*

sludge product previously mentioned and the cyclone dust which is recovered from the dust recovery units associated with the Stump Airflows.

Any one of the washed egg or nut sizes or the  $1\frac{1}{2}$ " x  $\frac{3}{4}$ " clean coal from the Stump unit may be delivered to a crusher set at an approximately  $1\frac{1}{2}$ " opening. The crushed coal is elevated to a battery of sizing screens for sizing into the stoker coal sizes previously mentioned. In turn any of the stoker coal sizes larger than  $\frac{3}{4}$ " may be delivered to a second stoker coal crusher set at  $\frac{3}{4}$ " and this crushed product similarly is returned to the battery of screens by the elevator. A third step in the stoker coal process includes returning any of the sizes larger than  $\frac{7}{16}$ " size to a third stoker coal crusher set at  $\frac{7}{16}$ " and this product likewise is returned to the battery of screens by the elevator. In the aforementioned manner, all the coal may be cleaned, sized, crushed, and resized so that the final market product conforms to the above-mentioned description of an all-stoker plant, the final products being stoker coal or 10 mesh x 0 fine coal.

Facilities have been provided to oil treat any of the stoker coal sizes or the larger nut sizes that are prepared for domestic fuel. Several by-pass and mixing arrangements permit the loading or combination of any or all of the various sizes prepared. Blending facilities include special mixing facilities to combine the wet sludge with the dry 10 mesh x 0 and cyclone dust. Other mixing conveyors permit loading these several sizes on the several loading tracks either through chutes or through the loading booms provided for the larger sizes. In turn, the several products that have been delivered to the clean coal storage bin may be recombined in any predetermined ratio for railroad car loading.

\* \* \*

Chairman MacDonald: Thank you very much.

Gentlemen, this paper is open for discussion, if you have any questions — as Mr. McCulloch has invited. Are there any questions with regard to this paper? If not, Mr. McCulloch, thank you for a most excellent outline.

I believe that completes the program in so far as we have the responsibility for it, so I will turn the meeting back to Mr. Moses or Secretary Schonthal.

May I add one further comment? We have reprints of that article which appeared in Mining Congress Journal, and also bulletins describing the various equipment that is in use in this plant. If any of you are interested, we have the bulletins and reprints available in the back of the room.

Secretary Schonthal: Gentlemen, I would like to have everybody stay here. We are going to be through in just a little while, but we have a very interesting subject now that we want to present.

Before we got into the war, this Institute was starting to get very active on the matter of education. Unfortunately, the war upset our program. We are well on the way now to something that I

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think is going to be very helpful to the coal mining industry, and I would like to have now a report from Professor Walker, head of the Department of Mining and Metallurgical Engineering at the University of Illinois, to give you an outline on the plan that we now have working and which we have in prospect.

After that we have something that I think will be very interesting, so if you will just bear with us, we'll adjourn in a very short time.

Professor Walker, will you please come up here?



## ANNUAL REPORT OF THE SCHOLARSHIP COMMITTEE

By H. L. WALKER

Professor and Head of the Department of  
Mining and Metallurgical Engineering  
University of Illinois

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Each year at the annual meeting of the Institute I have been asked to make a short report on the status of mining engineering scholarships at the University of Illinois. During the war years and including last year my report was brief, was pessimistic and rather discouraging with respect to student enrollment in mining engineering. Great numbers of students were returning from the wars and taking up curricula in which they had previously had some training under government sponsorship in the army or navy. The student enrollments in mechanical, electrical and civil engineering skyrocketed to several times any previous student enrollment at the University. The student enrollment in mining, agricultural, ceramic, metallurgical, and sanitary engineering courses was diametrically opposed to the trend in the other curricula and showed a considerable decrease below enrollments prior to the war. This trend in student enrollment in mining engineering was discouraging to the University administration and to the mining industry. To the mining industry it meant a decline in the interest of engineers in the industry, and indicated that a sufficient number of technically trained engineers would not be available for the industry in the future. They were already understaffed because of the low numbers of engineers entering the industry.

I am therefore particularly enthusiastic about this year's report of student enrollment in mining engineering, and scholarship holders at the University, for I am able to report to you an increase of 350 per cent in the number of students matriculating in mining engineering. There are now 47 or more students in the mining engineering curriculum, and as shown by the records for the past 20 years this figure is substantially above the enrollment for any individual year during that period. The distribution of students for this semester is 18 freshmen, 16 sophomores, 9 juniors and one senior. You will note that there is only one graduating senior for this school year but since the bulk of the enrollment is at the freshman and sophomore levels I consider this to be encouraging. In addition to this number of students there are a number of students in other curricula on the campus who have indicated their desire to transfer to mining engineering during the second semester of the school year. This is all very encouraging and we are hoping the trend will continue to higher enrollments and we should like to think that in the future we shall

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be graduating 50 to 60 mining engineers each year, and I believe the mining industry in the state of Illinois can support this number of engineers without undue saturation.

The increase in mining enrollment is probably due to a number of factors, among which one might mention the excellent opportunities for employment upon graduation and employment at a very satisfactory salary. During the past two years we have had a great number of requests for graduating engineers which we have not been able to furnish to the industry. We also believe that the increased enrollment is due to the fact that the department has prepared and distributed a brochure entitled CAREERS IN MINING ENGINEERING to graduating high school students, high school principals, and high school vocational advisers. Many students are also aware of the very great enrollment in other engineering curricula and that the opportunities of employment and good salaries may be greatly diminished in those fields in the next few years.

I should like also to report to the Institute the establishment of a Mining Advisory Committee representing the mining industry in the state of Illinois. This committee is working in close harmony with the faculty at the University and they will act in an advisory capacity on the problems of the mining industry as they may affect our educational program. I consider the establishment of the Mining Advisory Committee to be a distinct forward step and I have high hopes that much good work will result from our cooperative efforts in the future years. The personnel of the Advisory Committee is as follows:

#### Representing Industry:

J. Roy Browning	H. H. Taylor
Ill. Coal Oper. Assn.	Franklin County Coal Co.
George F. Campbell	H. A. Treadwell
Old Ben Coal Corporation	Chicago, Wilmington and
D. H. Devonald	Franklin Coal Company
Peabody Coal Company	Paul Weir
Miles Haman	Paul Weir Company
Crystal Fluorspar Company	Henry C. Woods, Chairman,
B. E. Schonthal	Sahara Coal Company
Secretary-Treasurer	
Illinois Mining Institute	

#### Representing University:

W. R. Chedsey, Prof. Min. Eng.
G. B. Clark, Asst. Prof. Min. Eng.
W. H. Voskuil, Prof. Mineral Economics.
H. L. Walker, Head of Dept. Min. and Met. Eng.,
Secretary of Comm.

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These men are giving their time, and in many instances finances, toward the work of the department of mining and metallurgical engineering.

The number of holders of mining engineering scholarships has greatly increased this year, there now being a total of 15 scholarship students. It gives me a great deal of pleasure this morning to be able to introduce these young men to you. I should appreciate it if the students will stand as their names are called.

## ILLINOIS MINING INSTITUTE

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Alfred J. Webster

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Wayne A. Baker

Bruce W. Gilbert

William N. Dixon

Charles R. Mitchell

George R. Eadie

Michael F. Zaskalicky

I should also like to introduce five students not holding scholarships:

Robert L. Baird

William R. Hippard

William C. Campbell

Charles Jomkowsky

Frank J. Padavic

\* \* \*

Dr. Walker: Thank you, gentlemen, for standing.

I am very proud of all these boys, gentlemen, and I'm glad they could come over and attend this meeting. I know that they will get a lot out of it.

I should like to tell you how these scholarships work. The Illinois Mining Institute offers a new scholarship each year to entering freshmen, which means they are supporting four. We have now two men activated, and next year there will be two more. The Old Ben sponsors

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two; Peabody sponsors two each year, so they will have 8 scholarships. Mr. Pickard is sponsoring one boy. Sahara Coal Company has a grant at the University, and they are now supporting six, and have taken on graduate scholarships.

Thank you very much for your attention.

(President Moses resumed the chair)

President Moses: At this point we will have the discussion we asked for earlier in the meeting, when we found the crowd wasn't big enough and our friend had not arrived. I want to introduce at this time the Chairman of the Advisory Committee on the Mining and Metallurgical School at the University of Illinois, Mr. Henry Woods.



## REPORT OF ADVISORY COMMITTEE TO THE DEPT. OF MINING AND METALLURGICAL ENGINEERING, UNIVERSITY OF ILLINOIS

By HENRY C. WOODS

Chairman of the Board, Sahara Coal Co.

---

I doubt that there is a man within sound of my voice who doesn't believe in insurance. This should make it fairly easy to present my message, because insurance is what I want to talk about—insurance for the coal industry.

Coal is the second largest industry in Illinois—and insurance for its future progress could well rest in the hands of sixty young men—the sixty young mining engineers we hope to graduate each year from the University of Illinois.

Considering the six thousand students graduated annually from our State University, sixty coal mining engineers seem but a drop in the bucket, yet we are now getting but half a dozen such graduates.

What's wrong—and what can be done to remedy such a situation? To answer both questions, we need but take a brief glance at the facts.

In the past 10 years, the economic value of coal has increased to an almost unbelievable degree. No longer is it employed only as a direct source of heat and power. From it, gas and other fuels are extracted.

It is used for medicines, flavors, dyestuffs, plastics, explosives, fertilizers, disinfectants. Over 200,000 chemicals are derived from coal—it is truly a nugget of science.

The mechanics of modern mining have become highly complex; the modern mine has almost entirely mechanized, extending from a maze of underground tunnels up to the surface and on to cleaning, washing and sizing—then to the automatic loading of freight cars on the railroad sidings. All this involves much planning and engineering; great investments in machines, safety devices and methods.

In eight years the mechanical loading of coal has jumped from 26 to 56 percent of the bituminous coal mined. Mechanical shearing and cutting has jumped to 91 percent. A new cutting machine eliminates the work of shoveling bug dust and minimizes the coal dust problem at the same time. Another combines under-cutting and loading into a single continuous job.

The increase in man-hour output is yet more amazing. In 1936 some 477,000 bituminous coal miners produced 439,000,000 tons of coal. In 1947, just eleven years later, 405,000 miners turned out 620,000,000 tons. Consider that progress. The widespread use of machines instead of hand labor has been responsible for increasing annual pro-

duction by 181,000,000 tons—with 72,000 fewer men. And all in the short span of eleven years.

How was such an increase accomplished? It was accomplished through modern mining methods and equipment — developed by graduate engineers.

Yes, we have made great progress in the mechanization of mines—in the development of machines and methods to increase the output of every miner; but in the development of coal mining engineers to direct the operation of these giant projects and to conduct intelligent and intensive research, we have been woefully inadequate.

Two tasks are before us:

1. We must provide proper facilities for training young men and
2. We must show them the special advantages of such a career.

Significant work has already been started on one phase of this program. Last month the Department of Mining and Metallurgical Engineering at the University of Illinois joined with representatives of the Illinois coal industry in forming the "Coal Mining Advisory Committee" one of whose primary purposes it is to review the curriculum in mining engineering at the University of Illinois, with a view to changing courses, deleting old or adding new ones, which will properly prepare young men for this modern day in the coal mining industry.

The Advisory Committee will also advise in the research program of the University, on the new mechanical devices being built for the industry and on matters of safety, and accidents in the mines. There will be research in improved explosives and in improved methods for drying the coal, as well as many other things that the industry believes are most needed at the present time—including an intensive study of methods for the underground gasification of coal.

The Committee proposes a campaign to all the High Schools in the State, to interest the principals in mining engineering courses at the University. High school principals and vocational advisors will be invited, expenses paid, to the campus for an entire week each year during the summer vacation.

In the near future, the Committee plans to print a booklet entitled "Careers in Mining Engineering" which will show high school faculties and students and the public the enviable future which the coal industry has in store for young engineers.

These are but some of the activities undertaken by the Coal Mining Advisory Committee.

All these activities are excellent, BUT we cannot look for deserved results until the big obstacle to the entire enterprise is overcome. We need ADEQUATE INSTRUCTIONAL AND RESEARCH FACILITIES AT THE UNIVERSITY OF ILLINOIS. The University has never been provided with a building for the mining engineering curriculum. The only building we have is a modest little laboratory that cost \$25,000 and was built in 1912. None of the staff has offices in the

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laboratory, and the building is limited to the use of the staff in laboratory instruction of students in mining engineering. Strange as it may seem, there has never been a mining building on the campus. The departmental staff are scattered about the grounds, some in the Ceramics Building, some in the Mining Laboratory, others in the Metallurgy Laboratory.

Because of the pitifully inadequate facilities, the instructional and research programs have suffered greatly; young men intent on engineering careers have turned to the already-overcrowded chemical, electrical and other courses. Coal mining courses are being noticeably avoided. The second largest industry in Illinois is being by-passed by students of a great university—and the lack of one building must shoulder a great share of this blame. Bear in mind also that Indiana, Iowa, Wisconsin and Michigan Universities offer no coal mining engineering course. Think what the addition of such a building will mean to the student, the mining industry, the University, and the State of Illinois itself.

For the student, it will open up a career where his services are immediately in demand. The coal industry in Illinois and all adjoining States offers great opportunity for employment at good pay with steady jobs. And in the meantime the University in conjunction with coal operators in Illinois and adjoining States will attempt to find summer jobs for those students who desire it. In this manner he may combine practice with theory and be well equipped to assume his duties upon graduation. It also should be remembered that Union coal miners make from \$400 to \$500 a month. Foremen of necessity get more than this.

For the mining industry, it will mean specially trained men to develop better machines and methods—in production and in safety—to get coal out of the ground at less cost so that substantial savings can be effected for the consumer. It will mean getting the maximum out of stupendous investments already made in modern mechanization.

For the University, it will mean a mining course even better than their other outstanding courses—that they may lead in research in a great industry and in preparing students for successful careers. For the State of Illinois itself, it will mean safeguarding the future of our second largest industry.

To accomplish all this, we need ONE BUILDING to graduate 60 young men annually. Can we afford NOT to provide it?

\* \* \*

President Moses: Thank you, Mr. Henry Woods. That is an inspiring report of your Advisory Committee.

Is there any other business to come before us at this time?

Mr. George F. Campbell (Old Ben Coal Corporation, Chicago, Illinois): Regarding the remarks of Mr. Woods, I would like to propose a resolution to this meeting, which I will read.

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## A RESOLUTION

WHEREAS, a continued supply of minerals and mineral fuels is the key to our national industrial economy, and

WHEREAS, the training and education of mining engineers competent to handle the complex problems of a mining industry which is continually becoming more mechanized and which also is developing and producing from more difficult ore bodies and coal seams, and

WHEREAS, the State of Illinois has within its borders, some of the important mine districts of the United States and the Middle West, and

WHEREAS, the physical facilities at the University of Illinois for the proper training of mining engineers is extremely inadequate

BE IT RESOLVED, that the Illinois Mining Institute urge the University Board of Trustees to provide a suitable and adequate building for instruction and research in Mining and Metallurgy.

BE IT FURTHER RESOLVED, that the Illinois Mining Institute use all of its good offices in properly achieving this objective and in securing the cooperation of all of the mineral industries, engineering organizations, and other related interests in the State, whose support will be helpful toward this end; and

BE IT FURTHER RESOLVED, that a copy of this resolution be spread upon the minutes of the Institute and a copy sent to His Excellency, the Governor of the State of Illinois, to the President of the University, to the President of the University Board of Trustees, and to other interested parties.

THE ILLINOIS MINING INSTITUTE

Mr. Campbell: I move the adoption of the resolution, Mr. Chairman.

President Moses: You have heard the resolution, and the motion to adopt. Is there a second?

[The motion was regularly seconded.]

President Moses: It has been regularly moved and seconded that this resolution, which was presented by Mr. Campbell, be adopted by the Illinois Mining Institute. Is there any discussion?

[The motion was put to a vote, and was carried.]

President Moses: The "ayes" have it, and the resolution is adopted, Mr. Secretary.

First I would like to thank, in the name of the Institute, all of the participants on the program this morning—you gentlemen who gave the inspiring papers, and you, Mr. MacDonald, for the conduct of the meeting, and particularly Professor Walker, for the inspiration he has given us by bringing these fine young men for us to see.

President Moses: Our afternoon session begins promptly at two o'clock. I ask you all to be back at that time, as I am sure there is much of interest in store for you this afternoon in the technical program.

Thank you very much for being here.

[The meeting recessed at 12:00 o'clock.]

See page 83 for action taken  
on resolution as adopted.

## AFTERNOON SESSION

November 5, 1948

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The meeting reconvened at 2:05 o'clock, President Moses presiding.

President Moses: The meeting will come to order, please.

I want to remind you of the dinner at 6:30 tonight, and to request you to be as prompt as you possibly can, in the interests of keeping the meeting interesting and getting the dinner over with in time for the people who want to leave tonight and get away.

At this time we'll turn the meeting over to the Chairman for the afternoon—Mr. W. J. Jenkins, II, the third of three generations who have contributed so much to the Illinois Mining Institute. Mr. Jenkins.

[Mr. Jenkins assumed the chair.]

Chairman Jenkins: Mr. President, Mr. Schonthal, and Gentlemen: The second half of today's program is presented by the Mining Electrical Group. As an explanation, the Mining Electrical Group consists of engineers and suppliers who are particularly interested in mining and electrical problems pertaining to mining.

The Mining Electrical Group meets at West Frankfort Country Club, West Frankfort, the first Thursday of every month. There is a recess in the summer.

The Mining Electrical Group cooperated this year with the manufacturer's show which was held at West Frankfort Country Club, and we all feel it was a great success, both to the industry and to the manufacturers.

On behalf of the Mining Electrical Group I'd like to extend an invitation to any of you who might be in the West Frankfort area to join us at any of our meetings, which, as I said, are on the first Thursday evening of each month. I'm sure it will be worth your time, and you are all welcome.

Now to get on with our scheduled program. Our first paper is "A. C. Power, And Its Use for Strip Mining," by Mr. E. T. Groat, Kelso-Burnett Electric Co., Chicago, Illinois.

## A. C. POWER AND ITS USE FOR STRIP MINING

By E. T. GROAT

Vice President Kelso-Burnett Electric Co.  
Chicago

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Mr. Chairman, Mr. Schonthal, and other friends of the Illinois Mining Institute: As I look out over this crowd and see many of the men with whom I have worked—you men in the mining industry who know plenty about AC power—I do so with some trepidation. I am not going to bring out a lot of the technical aspects but am going to try to cover this subject in general as I have seen it in the relatively short time that I have covered the mining game.

Alternating Current Power is the life blood of the Strip Mining Industry. In fact the industry could not have expanded year after year to reach its present state of development without central station generated A. C. Power and an abundance of it. Without it the cost of operation would have long since forced abandonment of stripping operations as the more accessible seams were worked out.

Due credit must be given to those courageous men among the operators, the shovel builders, and the electrical manufacturers who pioneered this important application of electric power and have since expanded it to its present state of refinement. One hears rumors of larger and larger buckets. Time and the simple economics of the problem will alone determine the future developments in major stripping units for this industry. Certainly if unit sizes become larger, electric power will play an even more important and indispensable part. We shall certainly be forced to change our present concept of distribution systems for supplying power to the pit machines, possibly going to a higher voltage. I shall not usurp the position of the real experts in this field. However, I sincerely believe that the talent is available among you operators, shovel builders, and electric equipment manufacturers, to solve any problem of application as the necessity of mining deeper and deeper seams confronts you. Surface stripping and mining represents the acme of mechanization in the Coal Mining Industry, and in the face of rising labor costs is certain to assume ever increasing role in the over-all coal producing picture.

Most of us were born when the electrical era was already well established. For this reason we are inclined to take our electric power for granted. It is true that the electric power industry is relatively new, historically, going back as it does a matter of only 60 years. In this country, based on free enterprise, great strides can be made and have been made in these relatively few decades. The power system supplying your mine today is a far cry from the sources of say 25 years ago, or even 10 years ago. It is startling to realize that the use of electric

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power as represented in billions of kilowatt hours consumed has doubled since 1940. The total generating capacity has increased rapidly throughout the years, except during the restricted war years, in an effort to keep pace with the ever expanding use of electricity in all walks of life. We are today cognizant of the need for—and the actual existence—of stable, continuous power. Over the years the power companies have cooperated to better supply this increasing need by interconnecting their systems and by constructing parallel and tie lines.

Let us consider for a moment some of the developments in progress at the present time by power companies serving your areas, to more fully supply your needs for power. We recall the war time curtailment of expansion of generating and distribution facilities by the power companies. However, with the advent of V.-J. Day, wheels were set in motion in an attempt to catch up with the accumulated demand and the upsurge in use of electricity which was known to be in the offing. Plans were released and orders for units of generating equipment, transformers, etc., were placed upon manufacturers in unprecedented volume and it is only today, after three years, that delivery schedules are being slightly improved.

You men, as you have been faced with shortages of power in some localities, have recognized, even if impatiently, the tremendous handicap under which your suppliers of power were working in their attempts to increase the amount available for your use.

Two power company representatives have cooperated in giving me information for presentation today. Mr. William L. O'Brien of the Illinois Power Company at Belleville has given detailed information concerning increased generating capacity available during 1949 and 1950, increased sub station capacity, and new trunk and tie lines which will serve to increase available capacity and provide more stable power both immediately and in the years to come. Of immediate interest is the recent installation of additional 69,000 to 34,500 volt transformer equipment and 34,500 volt regulators at the Pinckneyville sub station. I wish that I had time to give full details as transmitted by Mr. O'Brien but I am sure that he will gladly inform you on the complete situation.

Mr. D. D. Wright of Central Illinois Public Service Company, Marion, Illinois, tells me of increased generating capacity to the extent of 50,000 KW available this month, and points out that 138,000 volt transmission lines will connect all four of the company's generating plants to allow greater utilization and stability of power at all points on the system.

This brings me to the first specific point that I desire to bring out in this talk. Namely, that the great development in power generation and distribution systems throughout the years, and including those steps now in progress, bring mixed blessings to all users of power. You get greater stability in your power supply but you must give more thought to proper protection of your equipment and distribution systems.

You electrical men will recall that manufacturers' representatives have been preaching interrupting capacity for the past several years. Much of the pleading fell upon deaf ears in the beginning because it

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was hard to see why a circuit breaker, if properly applied from the thermal or current carrying ability standpoint, would not carry all of the current that might flow through it under some abnormal condition such as a short circuit on the load side. An old friend of mine, and of many of you, told me of his personal experience as the importance of adequate interrupting capacity finally dawned upon him. It seems that in the old days his power company served off the same line all types of users in that area, including his mine, the small industries, and several wired homes. A. C. Power was used at that particular mine to drive motor generator sets and some motors about the top works. Our friend used to notice that on Monday morning, wash day, the voltage dropped to such an extent that it became difficult to keep the motor generator sets on the line. In contrast, he notes that his present day source dips only slightly on washday and, in fact, hardly varies at all even when a large motor is thrown on the line. It was obvious to our friend that the lines and source which dipped on Monday morning had lots of "rubber" and lacked "oomph". Today most power sources have plenty of kick and that's where adequate interrupting capacity enters the picture.

Sometimes we electrical men have a hard time explaining interrupting capacity to our superiors, since most of them did not come up the electrical way. Most electrical engineering courses, although recognizing interrupting capacity as a potent factor, have not provided a suitable analogy in every day terms that all of us can understand. I shall give you a simple analogy and hope that you find it useful:

Picture a dam with a penstock leading to the water turbine; the waterhead in feet represents potential power and is therefore analogous to voltage of a power system. The water impounded back of the dam may be compared to the total generating capacity feeding an electrical system. A large valve placed somewhere in the penstock allows the flow of the correct amount of water to supply the load on the waterwheel. The waterwheel governor functions to operate the valve to allow just enough water to flow to supply the wheel to run at the proper speed to obtain the desired frequency. The flow of water is analogous to the normal flow of current in a circuit to a motor for instance, the amount of current flowing depending upon the impedance in the motor, limiting the flow of current to that required only to pull the load and supply the losses.

Now going back to the dam, the normal flow of water out of the tail race below the water wheel causes no destruction but allows normal uses of the water course. For some unknown reason a leak occurs at the bottom of the dam, we'll say around a penstock, and no one is there to repair it. A break develops rapidly, due to the head, and a tremendous flow of water occurs, creating destruction to all in its path, and this flow is restricted only by the drop in head, or the ultimate restriction of the break in the dam.

Likewise on a power system a short circuit occurs and the instantaneous flow of current is limited only by the impedance of the entire system and of the generating source, until the short circuit is cleared by an interrupting device such as a fuse or breaker. But here's one

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important point to note; in the case of the dam, an inadequate plug would fail to stop the break in the dam, and so on the electrical system, if the interrupting device doesn't have the ability to clear the short circuit current which is flowing, it is as good as nothing, destroys itself, and causes more general system shutdown and costly shutdown of the productive plant until new equipment can be procured and service restored. So I say, proper consideration to your interrupting capacity is good business even if it costs you money. Many installations in all kind of plants have become so obsolete as to be positively dangerous.

With our ever increasing capacity of generating equipment, transmission lines and tie lines, the required interrupting capacity of all protective devices is steadily increasing. I recommend that you start a survey of your own power system and its protective devices, by determining from your power company what the interrupting capacity requirement is at your service location, and also what it will be in the foreseeable future. And don't stop there; go on to be sure that you have co-ordinated protection throughout your system so that some inadequate device, even down the line, will not disrupt service in a part of your plant by destroying itself and perhaps stopping the entire plant by tripping the main service breaker.

You are all aware of the necessity of considering the items of voltage drop and losses, when laying out a distribution system. We have noted the trend toward purchase of power at 33 KV with primary metering, involving the ownership of stepdown transformers—many of them portable—by the coal companies. The advantages of this trend are obvious; one metering point, lower 12R losses, less voltage drop and, above all, reduced power costs. These savings will pay for the cost of ownership of the sub stations in a relatively short time and you thereafter have the advantage of continuing lower power costs and control over the location and use of your sub station.

The economics of this development are simple, and it is only a matter of arithmetic to figure out the advantages accruing to you from the purchase of power at 33 KV and ownership of your sub stations.

Let's discuss for a moment the familiar subject of power factor. You are all cognizant of the detriment of low power factor and would be, even if it were not a factor in your power bills. Low power factor results in higher system losses, excessive voltage drop and, in some instances, decreased productivity. I believe that there are many transformers, lines, and breakers about your properties which are overloaded because of uncompensated wattless current flowing in those circuits. This is particularly true around washers.

*Figure 1* shows the possible location of capacitors for correction of wattless current incident to the use of inductive devices such as induction motors. It is obvious that the greater advantages can be obtained from installation of capacitors as near as possible to the load at locations C1 in the illustration.

You may some time be called upon to explain to your superiors just what power factor is, in order that you may justify a relatively small expenditure for correction of a low power factor condition.

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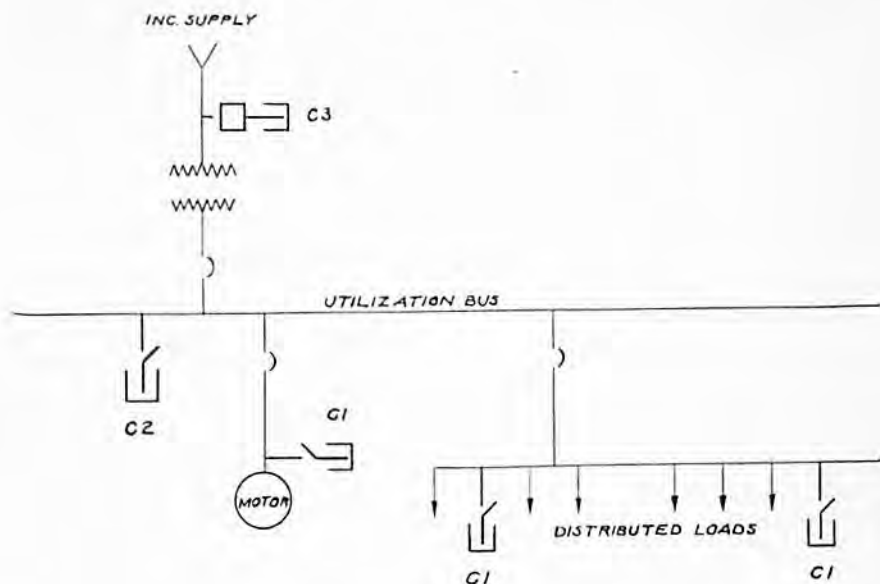


Fig. 1. Location of Capacitors

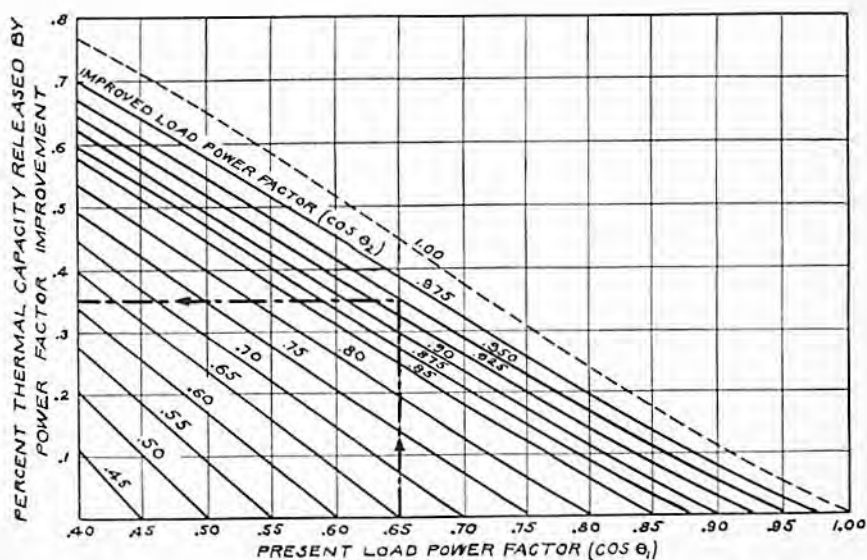


Fig. 2. Per Cent Thermal Capacity Released by Improving Load Power Factor

Again we resort to an analogy which in my experience has been very effective. By careful manipulation, it is possible to pour a glass of beer so that the liquid comes to the top of the glass. In another glass, foam may occupy the top one-third. The foam on the second glass of beer takes up considerable useful capacity of the glass without producing any noticeable benefit. Likewise the wattless current flowing in a conductor, transformer winding, switch, and, yes, even in generator windings as a result of low power factor uses up current carrying capacity without producing any good. In fact, the wattless current actually is of detriment because it causes increased  $I^2R$  losses. So wattless current incident to low power factor is just as useless and, in fact, as detrimental to full use of the elements in an electric circuit as is the foam on this glass of beer.

Figure 2 illustrates that it is possible to add 35% more load at 65% power factor by improving the power factor of the original load from 65% to 95% without exceeding the net K.V.A. before the power factor was improved.

I fear that some of you may consider the synchronous motors on large stripping units as suitable power factor corrective devices. I, therefore, repeat the admonition that these synchronous motors on large electric shovels and drag lines should not be considered as power factor corrective devices for the entire mine load, but are used instead of induction motors to maintain the power factor of the shovel load as high as possible. Let's consider the characteristics of the synchronous motor with constant field excitation driving the motor generator

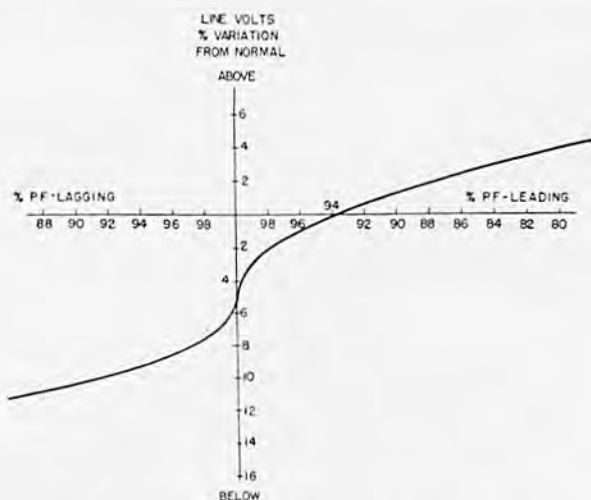


Fig. 3. Example of Power-Factor on Line Voltage at Receiver End for Typical Shovel Line at 200 Per Cent Load

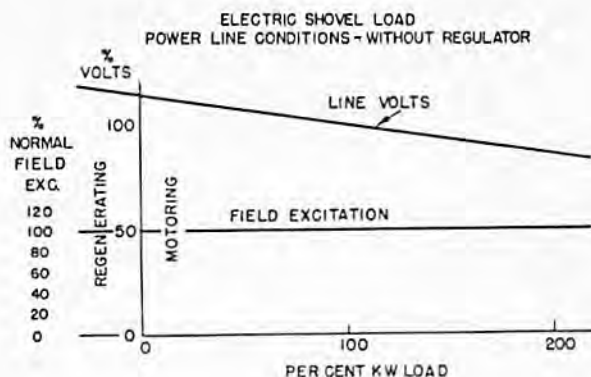


Fig. 4

set on a shovel or drag line. The motor draws a heavy leading current, at light load, acting as a condenser, thereby raising the terminal voltage, and it draws a rapidly increasing lagging current at heavy loads, causing low voltage.

Figures 3 and 4 illustrate the resultant variation in line voltage.

Now it is possible to regulate the motor field automatically, even on shovel and drag line synchronous motors with rapidly changing loads by using a synchronous motor field regulating equipment to regulate for unity power factor throughout the range of loads or, even better, to regulate for some lagging KVA at low load to leading KVA at maximum loads, within the limits of motor characteristics. Figure 5 shows the nearly ideal condition. Desirable results obtained from the use of such automatic equipment are improved load power factor, higher pull-out torque, elimination of over-voltage at light loads, and reduced heating of synchronous motor field and stator windings.

So, in general, we should correct for low power factor at the point of use and not rely upon the assumed corrective capacity of synchronous motors, particularly where they are located at great distance from the sources of wattless current. True, modern washing plants include capacitors as standard equipment, but it is a fact that many of the older plants are not properly equipped.

In my travels about the stripping fields during the past few years I have noted particularly the lack of standardization of equipment in certain phases of your operations. Many of you have purchased identically equipped stripper and loader units, enabling you to pool your stock of parts. Within the past few years the system of pit line protection has become somewhat standard with the use of Y-connected

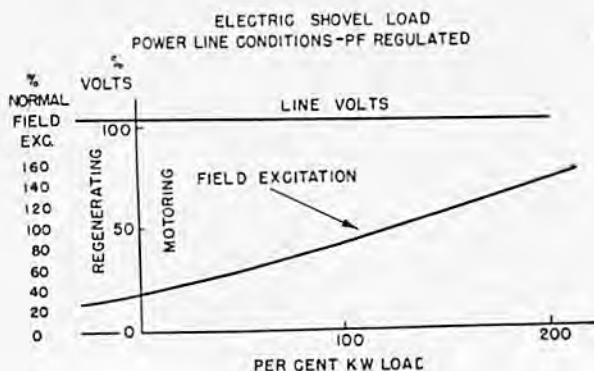


Fig. 5

secondary transformers, neutral ground resistor, and to a certain extent, identical tripping accessories. However, some of the items used in the pit distribution system, particularly the switch-houses, still remain largely the product of individual mines. It is true that for some years there were no factory assembled articles available for your use. That is not the case today. Even now the factory assembled articles do not include all of the features which you desire. This world would be Utopia if that were true. I urge you electricians and electrical engineers to get together and make the necessary compromises on detail so that it will be possible for all of you to purchase a standardized article. It is not now too late because we are barely on the threshold of expanding operations in this industry. This suggestion is offered to the end that you may have as near complete interchangeability of devices as possible among your several mines. Under the ideal condition of standardization the resale value of distribution system accessories would be increased and you could help each other out under varying conditions of operation and emergency just as you now do in the parts situation.

In these days each one of us is of necessity a specialist in his area of operation. You men are specializing in the mining of coal by the stripping process and it is the responsibility of you electricians to make your electrical distribution systems just as dependable and free from shut-downs as possible. You utilize the knowledge and services of specialists in all product lines. They are the men who can bring to you new ideas and suggestions for better use of their products in your field of operation. I have found your industry to be one of the most interesting to work with, because of the very fact of your open mindedness. I have seen the use of another kind of specialist in your industry—namely, the L. E. Meyers Company, whose services have been employed in the construction of permanent and semi-permanent pole lines and field sub stations. You have found that L. E. Meyers Company, a specialist in its field, can do this job more cheaply than you can with your own

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forces, or in any event they are able to perform a service for you which would be difficult of accomplishment with your normal forces. In concluding this paragraph on specialization I state my conviction that you have need for the services of qualified electrical contractors in other phases of your operation, particularly in connection with the modernization of electrical installations in coal washers and also to perform the installation of such a system in a new coal washer.

You men in the Coal industry should look forward to the future with considerable confidence for there is a bright future ahead of you. In the first place, your expanding operations produce a greater market for the commodity which you produce. I am told that on the average you use 9 kilowatt hours of electrical energy per ton of coal mined. Now this does not represent a large percentage of your production, slightly less than  $\frac{1}{2}$  of one per cent, but it is nevertheless a factor.

However, let's take a look at the rest of industry to analyze its increased demand for coal as represented in generation of electricity. Since V.J. Day there has been a tremendous increase in the use of electrical power and this accelerated trend will continue for several years, the average estimate being through 1955. I ask your indulgence while I quote several statements and figures that are of considerable interest to anyone in the electrical industry, and to you in the coal industry. Many of you will recall the statement by Mr. Price, president of Westinghouse Electric Corp. earlier this year, when he stated that within ten years America will be using 374 billion kilowatt hours of electricity per year, requiring an increase in power generating facilities to 95 million kilowatts. Mr. Price's forecast involves an 80% increase in generating capacity, and he told utility construction men that in the next ten years they may spend for new construction an amount equal to the present value of "your utility plant after 60 years of growth."

Now you may say that all of this electricity will not be produced from coal — and that is true at the present moment. However, I do know that the steam turbine-generator manufacturing capacity of our large manufacturers are overtaxed and that their combined output equals a large part of the expansion during the next few years.

The Edison Electric Institute has given the following figures on kilowatts of generating capacity installed and due to be installed through 1951:

First — 1947 — 2 million KW  
1948 appears to be 4,750,000 KW sure  
1949 — 6,700,000 KW  
1950 — 5,800,000 KW  
1951 — 6,060,000 KW

Gentlemen, those 18,560,000 KW to be installed during the next three years represents the requirement for a large amount of coal.

For some years I have been tremendously impressed with the future of the coal industry. I shall quote a few paragraphs from remarks by prominent engineers during a recent symposium, covering the use of



electric power in many industries. An engineer engaged in the application of power to the Coal industry stated: "It is generally conceded that the bituminous coal industry is on the threshold of events of great importance, arising from the necessity for amplifying and eventually entirely supplying the nations dwindling gas and petroleum reserves with similar products obtained from coal. Several full scale experimental projects are in various stages of operation or under construction. The extraction of gasoline, fuel oil, and other petroleum products from bituminous coal if carried to the point of completely replacing the present sources, will require some 65% more coal than is now being mined. This is expected to add some three to three and one-half billion kilowatt hours to the present energy demand for mining alone."

Now an engineer extremely interested in the coal industry might be expected to be enthusiastic about the prospects of his future work; well, lets turn to the remarks of a man whose primary interest is in the petroleum industry. I quote "Today more B.t.u. energy is extracted from petroleum and natural gas than from coal. This condition will not continue. Oil companies and geologists are shouting that oil is precious and that it must be conserved. More and more of the B.t.u. requirements must be based on coal and this means that more coal B.t.u.'s will be turned into electric power. Petroleum products and synthetic liquid fuels must more and more be conserved for automobiles, airplanes, Diesel electric locomotives and ships.

"As the value of petroleum products increases, whether or not the reserve is conscientiously conserved, economics will force the change; and this means more electric power based on coal, even in the petroleum industry. Recently it was remarked that one of the east coast refineries would save one million dollars a year if its fuel were coal instead of petroleum products. And if a refinery cannot afford to burn petroleum under its boilers and stills, who can?"

"Based on knowledge of synthetic fuel plants now being constructed, a synthetic liquid fuel program of two billion barrels a year would require about 700 billion h.p. hours per year to produce. A large amount of this would be mechanical drive turbine compressors, using heat from the process, but a large amount will also be electric power. This is almost twice as much power per year as is now generated by all the utility companies.

"As petroleum products become more valuable, more energy per barrel will be expended on them to more highly refine them. Even as the volume of natural crude goes down, the total electrical energy consumption will go up.

"As mentioned, truly staggering amounts of power will be required to make synthetic fuels. Even if research develops a synthetic liquid fuel process, based on coal, that requires only half as much energy as in present process and liquid fuels are rationed to a mere billion barrels a year, this will require power generation equipment about equal to all the central station plants now existing—

"Perhaps in 15 or 20 years it will become common practice to supply refineries with coal fired steam turbine driven electric plants because

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oil will be too valuable to burn there. Indeed this has already happened in some refineries."

And I could go on in the other industries such as paper, textile, steel, and so forth, and quote statement after statement indicating the ever increasing use of electric power to obtain more production, greater production per man hour, and a higher standard of living for all. As indicated heretofore, this increase in power must, for the most part, be based on coal. And so I say we can look forward with considerable confidence to the future of your industry, the coal industry.

#### ACKNOWLEDGMENTS:

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and

Mr. D. D. Wright  
Central Illinois Public Service Company  
Marion, Illinois

for information concerning their company's plans for increased capacity.

\* \* \*

Chairman Jenkins: Thank you, Mr. Groat.

If any of you gentlemen have any questions, I'm quite sure he'll be glad to answer them. If we have no questions, as soon as these gentlemen get themselves organized we'll go on to our next paper.

Our next paper is "Service Units for Trackless Mining," by Mr. E. M. Arentzen, better known to most of you as "The Chief."

## SERVICE UNITS FOR TRACKLESS MINING

By E. M. ARENTZEN

Lee-Norse Co., Charleroi, Penn.

Mr. Schonthal, Mr. Chairman, and Gentlemen: I believe this title, "Service Units for Trackless Mining," is a little off, but I think you gentlemen will bear with me. I picked that title because I thought it was a good thing to think about at the present time. You could call it "Service Units for Coal Mines," or a number of different things, depending on what we mean by "service."

In the automotive field, we all know what a "Service Station" means and modern auto service includes, gasoline, water, cleaning, greasing and lubrication, minor repairs and many others.

Now let us get back to the coal mines. What kind of service do they need? We recognize immediately a definite need for proper lubrication and maintenance of all the complicated machinery and equipment used in Modern Mechanized Coal Mining.

Not long ago I examined at one of the large captive mines in Western Penna. a very unusual and special "Service Car." This unit was built by the Coal Company for their own use and intended to serve one Loader Section Crew. The mine was equipped with track mounted loader, cutter and regular track transportation. The service car looked like a mine car with a special body into which was built all the necessary compartments to hold:

Shovels—picks and all hand tools for the section crew

Grease—oil in small quantity

Powder—and explosive supply

Drill augers—and bits

Cutting machine bits

Brattice cloth

Small supply of machine repair parts: bolts, nuts, screws, chain parts, etc.,

Every item of supply was worked out to meet the regular daily need of the Loader Section Crew. The Service Car was taken in to the section at the beginning of the shift with the man-trip car and at the end of the shift the service car was brought outside for "refilling" of items that had been used during the working shift also replacing any "miner's tools" that might have been lost or missing.

This special "Service Car" was fairly successful, but the system has not been adopted generally at this mine.

This car, of course, could not take care of the supply of timbers or rail material or any other major items of supply, but it was an attempt to concentrate all the miscellaneous *service needs* for a Loader Section and especially try to get some system of control of the handing out of *tools* to the miners.

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We all know that the supplies and service cost is quite a large portion of the total operating cost, therefore, any improvement in the handling of supply and services is welcome.

In this paper I want to tell you about some of the improvements in handling and applying lubricants in coal mines.

Lubrication of modern coal mining machinery is of vital importance to a smooth running and efficiently operated coal mine. The management must use every effort towards establishing a safe, efficient and economical system for handling and applying lubricants to the many expensive pieces of machinery and equipment now used in mechanized coal mines. In this case, like so many other places in modern industry, you can truthfully say that "A well oiled machine" gets results.

Recent Federal Coal Mine Inspections have revealed some good and some definitely hazardous practices and systems for storing, transporting, handling and distributing lubricants in and about coal mines. I am referring to circular No. 7244 issued by the Bureau of Mines in June 1943. In the earlier days of coal mining prior to mechanical loading when the so-called "mining machine," shortwall cutting machine and the electric locomotive were the main pieces of machinery in the coal mines, they could get along with simplified methods of lubrication using mostly hand oil cans. However, since mechanical loading was introduced and universal cutting machine together with self-propelled and electric driven drills and numerous other equipment, the amount of machinery operated in a working section has increased to such an extent that a modern system of lubrication becomes necessary. Furthermore, mechanical loading and multiple shift operation complicates the problem. The operation of mechanical equipment for two or three shifts daily requires an available supply of two to four different kinds of lubricants. These must be transported and applied safely and if stored near the working area, they present the constant threat to the safety of the mine and to continued operation of the equipment.

Quoting from Bureau of Mines Circular No. 7244 which describes some of the better systems now in use and which outlines recommended practices for storing, transporting, and handling lubricants in and about coal mines, I notice with particular interest what they say about lubrication trucks:

"Use of portable type lubrication cars is the safest and most efficient method of transporting, distributing and using of grease and oil inside coal mines. These cars are either of the special pressure pump lubricating type or of special cars used to transport containers of lubricant from place to place. The special pressure-pump type serves the dual purpose of transporting the lubricants and providing the medium and equipment for lubricating the machinery with minimum handling and eliminates inside storage and exposure of the lubricant to possible contamination. This method also provides a preferred lubrication job which can be done during the idle shift and be included with routine inspection of the equipment."

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Now I want to show you a few slides of various greasing trucks that have been used in coal mines showing Wheeling Township Coal Mining Company Grease Truck and showing the same Greasing Truck in outline drawing.

This company deserves a lot of credit for building the earlier type of lubricating cars and during May 1931, Mr. A. J. Ruffini presented a paper at the American Mining Congress in Cincinnati, and gave a full description of this particular greasing truck used by the Wheeling Township Coal Mining Company at Adena, Ohio. Mr. Ruffini called this arrangement "Semi-Automatic Lubrication of Mechanical Loaders".

The construction of the machine is as follows:

The bed consists of a standard bed for the mine car — three feet wide and twelve feet long, constructed of 2½" plank with steel re-inforcement. This is mounted on a 42" gauge, 28" center roller bearing truck. On one end is mounted a 75 pound capacity, electrically driven lubrication gun equipped with a braided, rubber-coating high pressure hose. The gun builds up a pressure of 3300 lbs. per square inch which makes it very easy to lubricate and flush out all bearings.

At the center of the machine is mounted two 78 gal. capacity tanks, one for oil and one for grease. This capacity was governed by the height of seam and the length of the truck bed.

On the other end of the truck is mounted an air compressor with a capacity sufficient to make a pressure of 80 lbs. per square inch which allows the compressor to run continuously while lubricating the loader.

The oil tank is equipped with 24 feet of rubber hose and is also equipped with a flow meter. The greasing tank is equipped with a hose and a flow meter. All piping consists of flexible hose to take care of shocks and vibrations.

In filling the truck the oil and grease drums are taken into a special oil house which we call a filling station. Here the drums are placed on racks and the compressor furnishes the air to transfer the oil and grease from the drums into tanks on the greasing truck.

The operation of greasing truck is done on the "Off Shift" and the greasing crew consists of 2 men having grease truck and locomotive to haul same to the various machinery in the mines.

A somewhat similar type greasing truck was made and operated by the Valier Coal Company, Valier, Illinois, and I believe that several other coal companies have used their own make of greasing truck for many years. One of these self-made lubricating cars was made by the Snow Hill Coal Corp., Terre Haute, Indiana, and the design was fully described by Mr. H. H. Lowry, Chief Engineer, in an article appearing in "MECHANIZATION", October 1944.

You will please notice that in the very early development of the grease cars, all lubricating trucks had been dependent upon a

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locomotive for locomotion around the mine. In other words, all these early types of grease cars were portable but *not self-propelled*.

The Lee-Norse Company started certain developments of the greasing truck in 1943 and came to the conclusion that the early type of greasing trucks needed to be improved upon from a standpoint of safety and convenience.

The use of a locomotive in connection with a greasing truck is more expensive. Therefore, we decided to make the new greasing truck *self-propelled* so as not to be dependent on a locomotive for transportation.

The MT6 Permissible Greasing Truck sometimes is called "The Mine Service Station on Wheels". It is self-propelled and powered from the mine trolley system by means of a trolley pole and cable reel, and driven by one traction motor which is geared to drive both axles.

The air compressor is driven by a separate motor and provides the air needed to operate the lubricant pumps, air brakes and air sanders.

A large oil and grease tank is built into the truck frame as part of the frame and body.

One round center tank for hydraulic oils and machine oils.....	3 barrel cap.
One side tank for transmission lubricants.....	2 barrel cap.
One side tank for chassis lubricants (pressure gun grease) .....	1 barrel cap.

Total Capacity.....6 barrel

All electrical equipment is of the permissible design and the MT6 Lee-Norse Greasing Truck is the first and probably the only one which has been given a *permissible plate* by the Bureau of Mines.

The total weight of the machine is.....	10,000 lbs. empty
With oil and grease.....	2,700 lbs.

Total Weight.....12,700 lbs.

It will travel approximately 8 to 10 miles per hour. The average time taken to grease a loading machine is 10 to 12 minutes.

We now have several of these greasing trucks operating in various parts of the country and every one of these installations has proved successful by:

- Reducing the amount and therefore the cost of lubricants.
- Getting proper and sufficient lubrication regularly.
- Reducing maintenance and increasing the running time of mining machinery.
- Better safety and considerably less contamination of lubricants going into machinery.

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There are several ways this greasing truck can be operated. The best method we have found is the "ONE MAN OPERATION". This means that only one man operates the greasing truck on the working shift. This operator, who is called the "Greaser", is an expert on lubrication (not a grease monkey). He should have the skill of a junior mechanic, thoroughly understanding the various machinery that he is to lubricate. When this one operator comes on to a working territory, he shuts down the cutter or the loader that is to be serviced and the operator and helper of the mining machine join with the greaser in giving the machine a through greasing job. By being three men on the job, they will grease the machine quicker and complete the job in 10 to 12 minutes.

Furthermore, the report that the greaser has to make out will be more complete and more correct because he has the advice of the machine operator who knows how the machine is acting and how the machine is performing. If there are any unusual leaks in the hydraulic system or in the transmissions or if there are any single bearings that heat up or do not function properly due to lack of lubrication, the machine operator and helper usually know and it takes less time to find the bad spots and correct them. The reporting system in connection with the greasing truck is very useful not only for the maintenance department but also for the operating officials.

The other method of operating the greasing truck is by "TWO MEN ON THE OFF SHIFT". They will travel to various sections of the mine greasing the cutting machine, loader machines and other mine equipment, but they will have no assistance from anyone, consequently, they will take a little more time at each machine, and in some cases it takes a little more time to get to the equipment, especially if there are mine cars in the road. It also takes a little more time to hook up the nips and run the machines when it is necessary to lubricate a portion of the machine that is running.

No matter what arrangement is decided on for operating the greasing truck, whether it is during the working shift with one man or during the off shift with two men, the results will be very beneficial to the mining machinery.

#### AUTOMATIC LUBRICATION

In the last few years considerable developments have been made to provide mining machinery with complete automatic lubrication. This some times is known as the "ONE SHOT" lubrication system. It is based on the fact that each Point to be lubricated on the machine is piped to a central point where it can be lubricated from. The greasing truck cannot be eliminated by automatic lubrication because you still have to furnish hydraulic oil, transmission lubricant and grease for filling the automatic system. But, of course, if all mine machinery were equipped with automatic lubrication, the greasing truck more or less would be transporting the lubricant to the machines and, of course, the same greasing truck could serve a much larger territory during the working shift.

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It is my experience, however that mining machinery cannot be equipped 100% with automatic lubrication and in many cases the frequent repairs of mining machinery makes it an additional burden on the maintenance crew to maintain an automatic system, therefore, it is still a long ways off when you can hope for 100% automatic lubrication on mining machinery.

#### GREASING TRUCKS FOR TRACKLESS MINING

The MT6 Greasing Truck is particularly suitable for track mounted operation, but can also be used in connection with a trackless mining system. At one mine in Illinois we have one of these greasing trucks in service where they grease the caterpillar type cutters and loaders by bringing them to the track where our greasing truck can reach them. In this case, we have found it necessary to use longer grease hoses. This arrangement works fairly well when the track is located close to the working face (max. 300 ft.). However, when the mine is layed out for a trackless system using shuttle cars and butt entry belt operation, it then becomes necessary to have a different kind of greasing truck, and to meet this situation, the Lee-Norse Company has developed the so-called RJ1 MINE SERVICE JEEP (For Trackless Mining).

The RJ1 Mine Service Jeep is a special designed rubber tired vehicle to serve trackless mining and particularly suitable for the following jobs and services:

*As a Utility Truck* — for handling supply and materials needed for operating and maintenance crews.

*As a Mine Tractor* — for pulling rubber tired trailers, with timber and other supply, also to pull miscellaneous equipment such as rock dusters, air compressor units, etc.,

*As a Grease and Service Unit* — fully equipped with air operated oil and grease guns for complete lubrication of mining machinery at the working face.

*As a Timbering Machine* — equipped with air operated timbering boom and power driven timber saw.

*As a Post Puller* — four speed transmission gives power and speed for pulling post. Can also be equipped with electric driven winch.

It can be built for battery power and the battery is made large enough so that it can operate two shifts before battery needs to be changed.

It can also be built for 250 or 500 Volt D. C. cable reel operation. Both these arrangements are permissible.

This special mine service Jeep is equipped with the various apparatus needed to do a complete job on a trackless section. That

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makes it possible to recommend this unit for one section only. In other words, in a small section where only one loader, one cutter, two shuttle cars and possibly a mounted drill is working, you can afford to add one mine service Jeep because it can do all these various things and will be kept busy.

I wish to bring to your attention that the maintenance crew can do many of their jobs in less time and with less effort when they have a service Jeep available, because the timber boom will act as a crane to lift heavy units.

The air system will furnish air for inflating tires at the face and the general utility of this vehicle makes it a very valuable piece of equipment for trackless mining.

All of you who have had experience with shuttle car transportation behind loaders know very well that the shuttle cars are also being used for taking timbers and supply from the track to the face, but somehow a better way must be found because the shuttle car was not designed to do this supply and service job.

The combination built into our Service Jeep, whereby all the various jobs, including timbering, can be done with one unit, is bound to make it fit into many new schemes of operating and the shuttle car will be kept hauling coal instead of doing the other jobs which they are less suited for.

In conclusion let me mention that other makes of rubber tired service units have been on the market and are available to the mining industry. Notably, THE BAKER TRACTOR and THE BAKER TIMBERING MACHINE.

And last, but not the least, I want to mention the very useful personnel transportation unit known as "THE TRIKE" Made by Baker for low coal. All these developments will eventually solve most of your problems in connection with trackless mining.

#### SERVICE UNITS FOR CONTINUOUS MINER

Before I close I want to bring to your attention that in connection with the so-called Continuous Miner, whether it is the "Joy" or the "Col Mol", or any other similar type, the *Service Unit* will play an important part in working out a continuous operation, because these continuous machines need extra service to eliminate shut downs. Also if and when shuttle cars are replaced by Sectional Conveyor Units.

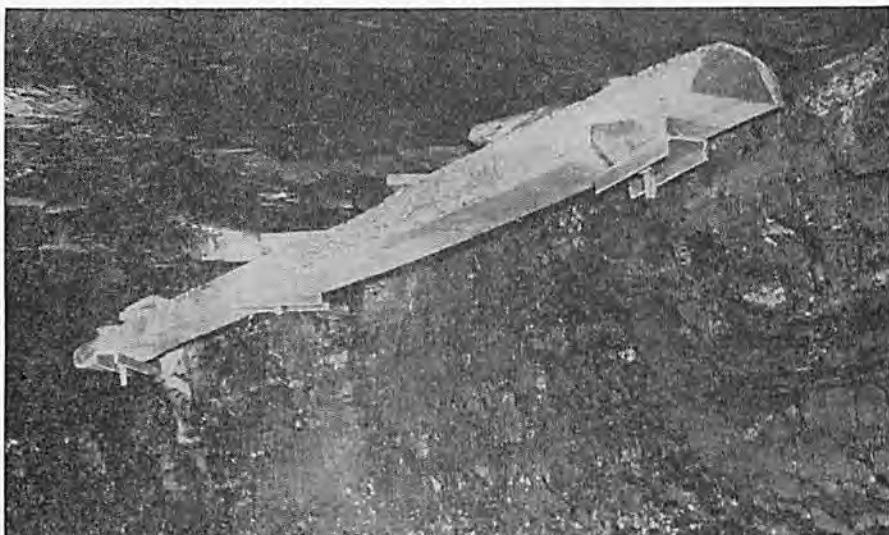
The burden of handling the Conveyor, Setting Timbers, bringing in supply and performing general service behind the continuous miner, will fall on the so-called "*Service Unit*" and I believe that we are heading for developments in this direction in the very near future.

\* \* \*

Chairman Jenkins: If any of you gentlemen have any comments or questions, I'm sure Mr. Arentzen will be glad to take care of them.

If there are no comments, we'll go to our final paper, which is "Roof Support with Suspension Rods," by Mr. C. C. Conway.

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Bolted crossbar eliminates posts at room neck

## ROOF SUPPORT WITH SUSPENSION RODS

By C. C. CONWAY

Chief Engineer, Consolidated Coal Company

Mr. Chairman, Members of the I.M.I., and Guests: I was a little concerned about being the last to appear on a long program, but I see there is a nice crowd here; now it remains to be seen whether I can talk interestingly enough so the crowd will be here when I finish.

National Safety Council statistics indicate that coal mining is among the most hazardous occupations and the Bureau of Mines reports that falls of coal and roof are the major causes of accidents. For that reason it seems advisable to discuss a different and possibly advantageous method of supporting roof by suspension rods anchored in a strong strata overlying the draw slate. I say "possibly advantageous" because it may not be so for all roof conditions encountered, although in our case, and under our conditions, we have found that not only is our safety greater, but that we can mine areas which might otherwise be uneconomical.

### ROOF CHARACTERISTICS

The Consolidated Coal Company's Mine No. 7 at Staunton, Ill., in the Central Illinois field, on the Wabash Railroad about 40 miles out of St. Louis, is in the Illinois No. 6 seam. Natural conditions are typical

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for that section of the state. The coal has about 375 ft of cover with the upper 50 to 150 ft composed of unconsolidated materials which are chiefly clay, gravel, and sand. The remainder of the overburden is shale, sandstone, and limestone, with the exception of several thin seams of coal and the further important exception of a slate, usually referred to as draw slate, which lies immediately above the coal.

Since the limestone over the slate is of exceptionally fine character and of thickness probably never less than 20 ft, our chief concern is with the slate which is a black material ranging from a laminated structure to a more blocky arrangement with cleavages usually horizontal. This physical difference represents different stages of metamorphism from shale to slate. Although the slate is usually well bedded, steeply pitched point planes are fairly common and the resulting slips are often the source of difficulty in supporting the mine roof. The slate at best has comparatively little structural strength, but conditions are particularly aggravated by pockets of extremely soft material which are locally referred to as "clod." The thickness of the slate varies from a few inches to 7 or 8 ft; when of moderate thickness it does not usually cause much roof difficulty, provided it is of such a nature that it does not fall with the shooting of the coal, but as its thickness increases, the difficulties are many. The labor and timbering involved in holding the slate safely in place is considerable, but the labor involved in cleaning rock from the top of new falls of coal is even greater. A cleaning plant with ample coal washing capacity can handle a certain amount of slate, but not to the extent of 5 ft of rock with  $6\frac{1}{2}$  ft of coal where the refuse would be approximately 62 per cent by weight.

#### THE THEORY OF ROOF BOLTING

The bolting procedure, and the reasoning behind it, can probably be best described with the help of diagrams and sketches. Fig. 1 is a longitudinal section of a room with dotted lines to show the advancement of the room cut by cut; that is, by falls of coal. If the room is timbered systematically and uniformly after each cut, then any section back from the face—as for example the crosshatched section—is the same as every other section, as far as support is concerned. The cross-

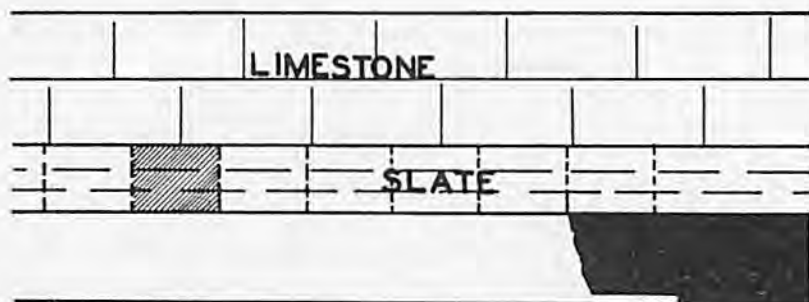


Fig. 1. Longitudinal section of a room.



hatched section, representing an 8 ft length with 5 ft of slate overhead, can obtain no support from adjacent sections because the adjacent sections are similarly supported. The problem then is to hold each section of roof, consisting of slate, 5 ft in thickness, 8 ft long (the depth of the cut), and the width of the room which we will consider in this case to be 24 ft.

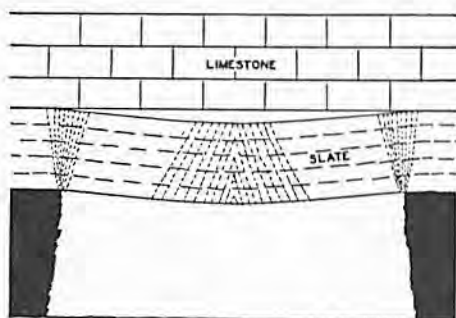


Fig. 2. Cross section of a room with slate unsupported.

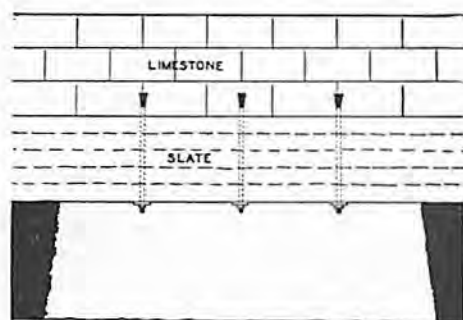


Fig. 3. Room with slate held by rods.

Fig. 2 represents a cross section of the 24-ft room and a side view of the 5 by 8 by 24-ft section of slate which must be supported. The slate has been sketched as a beam with fixed ends and with an exaggerated deflection. Such a beam — at 175 lb per cu ft — would have a weight of 7000 lb per foot of lineal length. If this beam were of steel and of the specified loading, the deflection might easily be calculated, but since the slate does not have uniform elasticity, and in fact is not uniform in any manner except possibly in size, it is impossible to predict its behavior. Regardless of whether or not the beam is uniform in its elasticity, and excepting the possible presence of slips, it is quite evident that the



stresses will be greatest at the points indicated by dotted lines. If the beam is allowed to deflect any appreciable distance, there will be failures at the ribs and at the center because slate has such poor tensile strength.

The same beam is shown in Fig. 3, with the slate bolted to the overlying strata so that deflection does not occur and consequently there is no failure at ribs or center. If this beam can be supported—as shown in this illustration—we have accomplished the prime purpose of roof bolting, as it is quite obvious that if the slate is held in place by the roof bolts until the face is sufficiently advanced, then conventional timbering is possible, and the beam will have all of its original strength. If the ribs are not broken, then they will carry the major portion of the load and the timbers and roof bolts will be supplementary, whereas, if the ribs are broken, then the entire beam is more or less dead weight on the supports. At this point it might be well to mention that there is no intention to completely eliminate timbering. It is likely that in many cases the amount of timbers will be somewhat reduced, but it seems desirable to maintain a systematic plan of timbering; that is, systematic under any given set of conditions.

#### EQUIPMENT AND BOLTING PROCEDURE

Fig. 4 illustrates a typical spacing of bolts and props and shows the most important feature of roof bolting—the placement of bolts as near to the face as possible. This should be done before the coal is

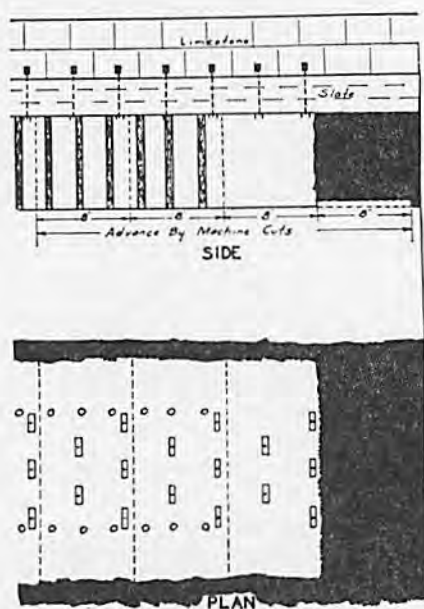


Fig. 4. Plan and section show typical bolt spacing.

undercut, as the roof then has its greatest support and the slate immediately adjacent to the face should not be under any abnormal stresses. Although the amount of roof normally unsupported, except by ribs and face, is usually not less than 16 ft, where the advancement is 8 ft per cut, the roof bolts support the roof within 9 ft of the face after the fall of coal is shot. It is this feature that makes it possible to support the roof until the face has advanced a sufficient distance to set props. The roof bolting at the face also provides greater safety for the face workers.



Fig. 5. Two types of anchors used.

Essential parts of the bolting equipment are shown in Fig. 5. The expansion shell is similar to that used to support trolley wire, the bolt is 1 in. diam and of such length as may be necessary for the particular thickness of slate encountered. A short section of channel iron is used as a washer, but for extremely poor slate it might be advisable to use a channel spanning two or more suspension bolts. The special nut is used to tighten the rod in the expansion shell and to facilitate the removal of the rod when necessary. It is used only as a tool to aid in placing the roof bolt. A photograph of another type of expansion device is also shown. This last type of bolt is similar to that ordinarily used in the metal mines and is the type used by the St. Joseph Lead Co. in their mines near Bonne Terre, Mo.

The actual operation of placing the roof bolts is shown in Fig. 6. The man on the left is operating a safety stoper, which is used to drill the hole through the slate and 12 to 16 in. into the limestone. This drill differs from the usual design and is called a safety stoper because it is supported on a column consisting of two telescoping tubes which are forced into the bottom and into the roof by air pressure. It is so equipped that in the event of a broken hose or other cause of air failure, it will continue to support itself for at least 30 sec. The stoper is rather long and it is necessary to use 18-in. changes of drill steel but, even so, it is possible to set the machine and drill through 5 ft of slate

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Fig. 6. Two men drill roof holes and set bolts.

and 18 in. of limestone in approximately 4 min. After the driller has completed the hole, he places the bolt, complete with expansion shell, into the drilled hole and as the last portion of the hole is the smallest, he sets his expansion shell to such gauge that it is necessary to drive the rod with his air hammer through that portion of the hole. To protect the threads during the driving, he uses the special nut previously mentioned and with the drill socket forcing against the nut, he further extends the expansion shell by using a wrench on the special nut, thereby turning the bolt and pulling the expander deeper into its shell.

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Then the driller's work—in connection with that particular roof bolt—is finished. While he drills the next hole, his helper, who is shown on the right—places the channel iron and other washers as may be required on the bolt and tightens the nut with the special wrench provided for that purpose. A bolt, complete with expansion shell, is shown leaning against the face and in the right foreground is shown a bolt placed into the roof but without washer or nut.

The truck whose end is seen at the left of Fig. 6 is shown in Fig. 7. This truck was built in our own shops, it is self-propelled by a 5-hp motor, equipped with a 145-cu ft, air-cooled compressor driven by a 40 hp d-c motor, and receives its power by means of a trailing cable. The truck has a bed of sufficient length to carry 8-ft props with little overhang.

Two men with a truck do the bolting operation. These men—their truck loaded with props—step into the cycle immediately behind the loading machine and precede all other face preparation. They bolt the roof where the fall of coal was just loaded out and then place timbers as necessary under the slate of the preceding cut. In the event that a crosscut or room neck is to be cut, they place roof bolts across the proposed opening or place a crossbar in a manner that will be shown in a later picture. The system requires that every face receive equal attention, as a failure to bolt will probably mean that the slate will fall with the shooting of the coal.

#### METHODS AND RESULTS OF BOLTING

Figs. 8 to 15 are photographs of bolted roof, with the exception of Fig. 8 which illustrates the general roof condition and indicates that considerable timber was required to support the 5 ft. of slate. Although the slate is supported over the crossbars, it is apparent by the falls between the prop line and the rib that excessive movement occurred



Fig. 7. Drill truck mounts compressor and carries supplies.



Fig. 8. A typical roof condition to be corrected by bolting

with the result that the rib was broken. Fig. 9 also shows 5 ft of slate with a roll in the limestone in the right foreground of the picture. This place, however, has been "caught up" by means of roof bolting and the remainder of the room, to the face, is standing well. The character of the slate is shown well in Fig. 10. This place was also "caught up" by means of roof bolting. Although roof bolts are visible under the crossbars, the three rods that made the catch are immediately behind the foremost crossbar and of course are not visible. A view of the bolting of this particular place is shown in Fig. 11. Note that several of the crossbars in the foreground do not have legs. The ends of the crossbars are bolted directly to the roof, eliminating legs which would otherwise be a handicap to the shuttle car haulage through this crosscut. The crossbar shown in its entirety

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Figs. 9 above, and 10 below, show combinations of roof holting and timbering

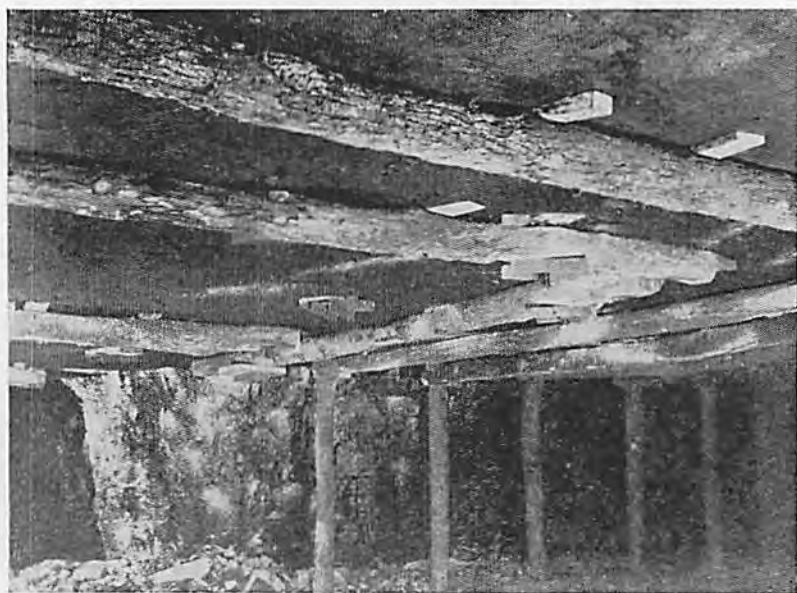


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Figs. 11 above, and 12 below, show combinations of roof bolting and timbering



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Fig. 14. Usual method of support of face with three suspension rods.

and without supporting props was placed before the crosscut was undercut or shot.

A shuttle car turnout is shown in Fig. 12. This combination of roof bolting and timbering, with only one leg placed in the entry, allows considerable freedom to turn the shuttle car in any desired direction. A number of roof bolts are shown in this photograph and the structure of the 5 ft of slate is also well indicated. A crossbar placed parallel to the room and in front of a proposed crosscut is shown in Fig. 13. (See opening illustration.) It is interesting to note that the method of placing this crossbar was to support the crossbar on a roof jack and drill the three holes through the crossbar, through the slate and into the limestone. The pneumatic hammer drills a surprisingly smooth hole through oak timber at about the same rate of advance as in limestone.

In the usual manner of timbering directly at the face of rooms three roof bolts are placed immediately adjacent to the face. A typical installation of these bolts is shown in Fig. 14. A washer, consisting of a 2 by 12 by 12-in. oak plate, was used under the channel irons on these particular bolts to obtain some cushioning as well as greater

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bearing area. Prior to the use of bolts, the slate in this particular room was all down, but it was "caught up" with the first application of roof bolts and held up continuously to the face which is visible in the background. This particular row has  $4\frac{1}{2}$  ft of slate.

The practicability of supporting slate from a bed of limestone has been demonstrated in more than a year of experimentation, during which hundreds of suspension rods were placed without a single failure. In every application the slate has been caught with the first round of bolting. It has gained the respect of workmen in the territories where it has been used and where it is indicated that it will be the answer in mining some coals that would otherwise be marginal.

#### LAMINATED SHALE MADE HOMOGENEOUS BY BOLTING

Many mines, however, do not have limestone into which expansion bolts may be attached and we have limestone available in only a small percentage of the total workings of all our mines. In Southern Illinois the limestone is not of comparable thickness with Central Illinois and there also exists 25 to 80 ft of shale between the coal and the limestone. Experiments with the bolting of shale roof are just getting under way in our Southern Illinois mines, where the problem of supporting a roof of 20 or 25 ft shale is of course entirely different than the support of slate to a bed of limestone as just described. If roof bolts are to be used, then the immediate roof shales must be bolted to other shales lying above.

The shales of Southern Illinois are usually described as grey, fine-grained, and well-bedded, but due to displacements and other ground movements, slips are quite common. Their number and severity vary widely from mine to mine and often in small areas, so any plan to support shale roof must take these slip planes into consideration and also consider joints vertical to the bed. The frequency of vertical joints varies widely over small areas and the number of joints in one direction may also far outnumber the joints in a direction at right angles. Where fault planes are pronounced, it is often found that places driven perpendicularly to the fault planes, stand better than those driven parallel because of the frequency of the joint planes and their effect on the beam strength of the roof.

The sketches in Fig. 15 are presented in connection with the discussion which is to follow. Again it is appreciated that shale—like slate—does not have a uniform modulus of elasticity and that due to slips and cleavages, it is unpredictable. But there seems to be some merit in considering the problem as a beam requiring support and then to add protection to accommodate for slips. The top sketch represents a number of thin beams of rectangular sections, arranged to form a composite beam supported at each end. The thin beams are intended as an analogy to the laminations of shale. Through a thickness of, for example, 4 ft of shale, there would be hundreds of laminations. Now assuming, which seems logical in most cases, that the shales above the beam are self-supporting, then the only load

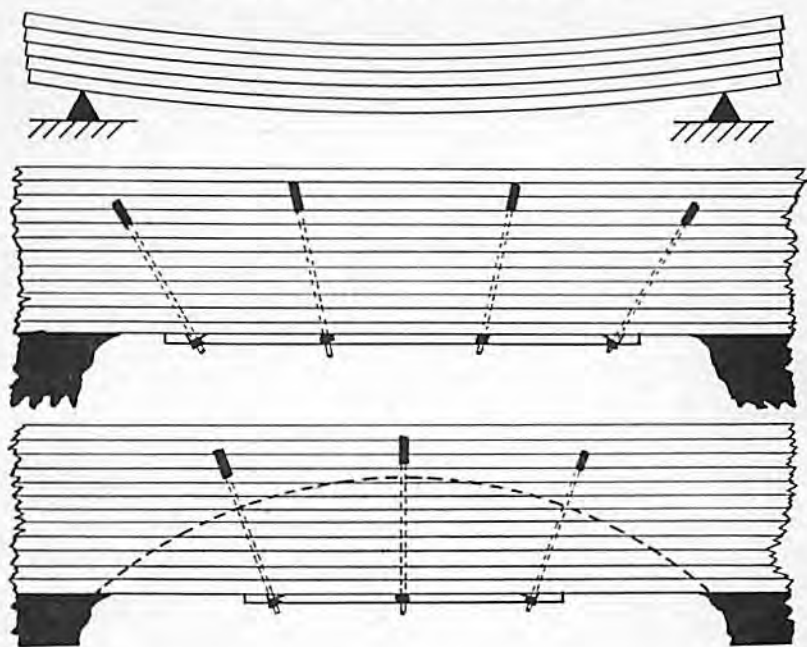


Fig. 15. Theoretical roof action and function of suspension rods.

carried would be the weight of the beam itself. Now if the separate laminations were free to slide on each other—as shown in the sketch—entirely without friction, then each thin beam would deflect a certain amount and every other beam of the same thickness would deflect an equal amount. The deflection would not change, regardless of how many thin beams were used. If, however, this beam is homogeneous and of the equivalent depth, then the deflection would be greatly reduced because the strength of rectangular beams of the same width varies as the square of the depth of section. For example, a beam of unit thickness would have a strength of  $(1)^2$  or 1, and eight such beams would have a capacity of 8, assuming that the adjacent surfaces were frictionless, whereas a solid beam of 8 units of thickness would have a relative strength of  $(8)^2$  or 64. Fortunately the laminations of shale are usually fairly well-bedded and they have considerable resistance to failure in horizontal shear so it would seem that if the roof were bolted as shown in the center illustration of Fig. 15, the effect would be to more nearly approach the condition of a homogeneous or single beam.

The lower sketch in Fig. 15 shows the shale roof supported into a theoretical arch. This is based on the fact that any room or entry will eventually arch itself to full support. Of course if the arching is allowed to proceed over long periods of time, the effects of weather-

ing, swelling, and temperature changes will be pronounced and the arch will be high. If, however, we consider the first falls and neglect the progressive effects, then the arch will usually be within the limits necessary for use as support. Discounting the progressive effects seems logical on the basis of preventing the original fall and thereby eliminating further deterioration.

To demonstrate that the theoretical arch is within range of bolting, the actual dimensions of roof falls in a number of room and entries of two mines — rather widely separated — have been plotted as shown in Figs. 16 and 17. The proposed method of bolting these places has been indicated on the sketches, and it will be noted that the theoretical arch is well within reach of the 6-ft rods. The placement of the bolts may be changed after trial, but they have been placed to correspond with the foregoing theories involving both truss action and support from an arch.

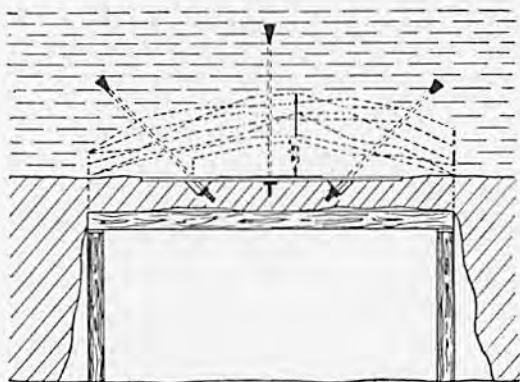


Fig. 16. Entry

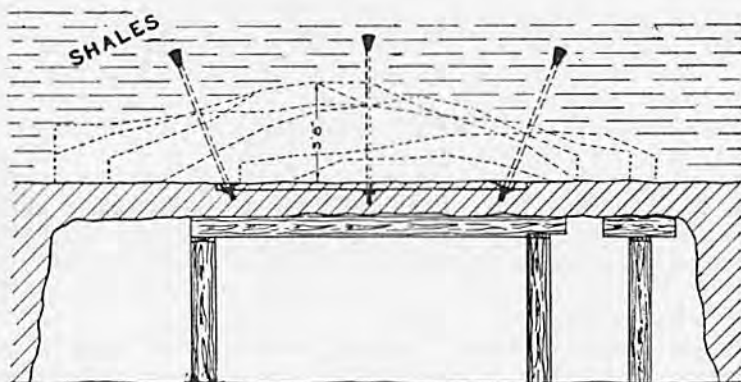


Fig. 17. Room.

Bolting to prevent arching roof falls.

Props and other timber are the miner's barometer or measuring stick as they are practically his sole means of judging the condition of his roof. Timbers should not be eliminated and roof bolting should be considered as supplemental support; the chief advantage being that it prevents loss of the roof's original beam strength before adequate timbering is possible.

\* \* \*

Chairman Jenkins: Thank you.

I'm sure if any of you have further questions on this, to help wind up this meeting, you can see Mr. Conway after the meeting.

I believe that just about winds up our responsibility for this session of the meeting, so I'll turn it over to our Secretary.

Secretary Schonthal: Thank you. That concludes this part of the meeting, and I want to remind you all to be here promptly at 6.30, because we're going to start promptly at that time.

I would like to ask one more favor of you gentlemen. If you are in the other room or out in the hall or anywhere within hearing, please let's have quiet tonight, because we're going to have a very good talker and we don't want to have anyone disturbed who wants to hear the speaker.

Thanks very much for your cooperation and your attendance. The meeting is now recessed.

[The meeting recessed at 4:15 o'clock.]





## EVENING SESSION

November 5, 1948

The meeting reconvened at 7:45 o'clock, President Moses presiding.

President Moses: We'll proceed now with our program.

When I came here I found sneaked down at the bottom of the program there was an address of welcome from your President. I'll give you that address of welcome in about four or five words — I'm awfully glad to see all of you here.

I want to advise you at this meeting of the Illinois Mining Institute that the Institute has grown by 134 new members, four of whom are new Life Members, making a total registration at this meeting of 653, the biggest meeting in the 56 years of our Institute.

I would be strangely remiss if I did not spend a minute or two telling you how proud I am of having had the honor of being your President during this past year. I would be even more remiss if I did not acknowledge my gratitude to the actual source of the Illinois Mining Institute, the person who devotes his time and his efforts to the running of it. I want to pay great tribute to him, and I think you should all be very appreciative of the efforts that our genial and worth while Secretary, B. E. Schonthal, spends in the operation of this Institute.

I want to express my sincere thanks to each of the gentlemen — and mostly young gentlemen — who participated in our technical program today. Their fine, inspiring, intelligent, capable papers will become part of the record of the mining industry of America, and most of them will prove very, very valuable. Thank you very much for that.

I think I would be strangely remiss again if I did not take this opportunity [if you will pardon me for personally assuming the right to do this] to thank each and every one of you in this industry for the fine treatment, for the great friendship, and for the great respect that you paid to me, my mother, my sister and my brother last February, when your good friend and mine, my father, left us. Thank you very much for that.

I have a job now that I propose to get through quickly, but I assure you that in doing it quickly I am only trying to save time. I could spend a lot of time telling you about the people who are here with us tonight at this table, but I propose only to introduce them briefly to you. I will save one or two of them as I go along, for future reference a few minutes later.

*Buyer meets Seller in the back of this book.*

I would like very much at this time to introduce on my left, Mr. A. P. Kubricht, Coal Editor of the Chicago Journal of Commerce.

Next, Editor of the Mining Congress Journal, Mr. Sheldon P. Wimpfen.

Next, from Coal Age, and known to most of you, Ralph R. Richart.

Next, from another trade journal, Mechanization, George C. Lindsay.

At this time, paying particular tribute to the young men who put on our technical program today, I'd like to introduce the chairman of the morning session, Mr. J. W. MacDonald.

And the third of three generations of contributors to the Illinois coal industry, and of one coal company, W. J. Jenkins, II.

And an old-timer, and a member of the Executive Board of the Institute, Fred S. Pfahler.

One of our few Honorary Members, and the oldest living member of of our Institute, Mr. Fred Weissenborn.

The senior member of that three-man firm, another Honary Member of our organization — past President of the organization, 1936 and '37 — Mr. W. J. Jenkins.

Then, beginning at the other end of the table, the head of the Mining and Metallurgical Department, University of Illinois, your good friend and mine, Professor Harold L. Walker.

Next, a vacant chair that I have been dared to mention. I refuse to mention it — Herb Taylor.

Next, the Secretary-Treasurer of the Illinois Coal Strippers Association, Mr. J. W. Bristow.

The gentleman who so inspiringly talked to us this morning as the chairman of the Advisory Committee of the Mining and Metallurgical Department of the University of Illinois, who talked to us about our problems and brought us a mesage of real, worthwhile interest, Mr. Henry C. Woods.

Next a very old friend of mine who has been hobbling around here on a cane, the President of the Illinois Coal Operators Association and new member of the Executive Board of the Illinois Mining Institute, George F. Campbell.

Because I want him to stand up now, to give me another chance to tell him how well he runs this Institute our Secretary, Mr. B. E. Schonthal.

At this time I going to present to you a gentleman who I am sure is a great executive, a fellow who is able to run — from long distances and by remote control — one of the finest parties we have had here in a long time. It started last night back there in the back room. Before I introduce him, I want to tell you of a definition I recently heard of a good executive: — a good executive is the fellow who runs around with a worried look on his assistant's face. I want to introduce to you your next President, the fellow who takes this job over for next year, the Vice President of the Illinois Coal Operators Association, your good friend and mine, Mr. J. Roy Browning. Roy, come on over.

*Our Advertisers, who make this volume possible, will appreciate your inquires.*

President-Elect Browning: Thank you, Harry, and thank you, gentlemen.

I just had a telegram a few minutes ago from my opponent, congratulating me on my victory — Charlie McCarthy. It was a tough fight, but we fought it, and I thank you.

Speaking of elections, I believe we did have an election this week. A Republican friend of mine called me up the other day and said, "Did you hear what happened?" I said, "Well, how do you feel?"

He said, "I feel awful. I feel like that little old hen dusting herself in the middle of the road one day when a big truck came along and ran over her. She got up and dusted herself off, shook herself a little bit and said, "Gosh what a rough old rooster."

President Moses: Now you have some idea of what you're going to have to put up with next year.

At this time I want to take a minute and depart from the regular program.

I was here this morning when Professor Walker came into the session of the Institute and brought with him twenty young men, many of whom are the recipients and beneficiaries of scholarships provided by the industry and this Institute at the University of Illinois in the Mining School. Some of them came because they wanted to come to the Illinois Mining Institute meeting, not because they were scholarship beneficiaries, and I'm happy to have all of them here. I have never seen a more inspiring thing happen in this industry than to have these twenty attractive young men walk in here this morning and serve notice to this industry that they expect to be a part of it some time in the very near future.

At this table immediately in front of me are those boys, and I'd like to have them stand up en masse, and without identification, to be recognized by all of you who are here tonight. Please, boys.

I have two more very pleasant jobs, and it's going to be hard to be brief with either of them, but I expect to do the best I can.

I am told that a toastmaster or a master of ceremonies at a dinner such as this, should be, first, witty, and I think I am half qualified. The other virtue is brevity, and I hope to be able to be as brief as I can in these two very pleasant jobs.

I was born in the State of Illinois in a little mining town south of Danville, known to most of you at least by name—Westville. In that community, just before the turn of the century, we had two levels of social distinction. One was composed of the coal miners, whom Mike Kelly exploited by bringing them in there to operate his coal mines. The other group comprised the farmers of our community—the old residents who had lived there when it was called Scott's Corner. Among that group was a farmer family of great distinction and large property, and in that family of three boys, one girl, the mother and father, the oldest boy was one of the really unusual fellows in our community. He had gone to college, and I think that perhaps he was the first fellow in our community to ever go to college, other than the few professional men we had in the community.

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He had gone to a self-help university over in Indiana called Valparaiso, and — even more important than that to a small boy in the community — he had played football at that particular college, which ranked him with Dick Merriwell and Ted Coy and the glamorous football players of that particular age.

I knew him then — or, rather, he knew me. I lost track of him for several years. In 1912 he happened to be one these fellows I thought were “the forgotten man” until last Tuesday. He was a Democrat. In 1912 Roosevelt the First was in the political picture, and caused a fellow named Dunne to be elected the Governor of Illinois for the first Democrat since John Altgeld, and all of a sudden this young man who had been away to college and had been working in the mines around our community turned up to be the Mine Inspector in the Fifth Inspection District of Illinois.

He held that job — as most politicians do — as long as his party stayed in power, which was until the next election, and he left our community and went to southern Illinois. He worked at various mines in southern Illinois.

At the beginning of the first World War in 1917, he left southern Illinois to come to Taylorville. He has been in Taylorville ever since. Under the wise guidance of the Peabody family, George Reed and those many other people who have contributed to Peabody's great success, he has carved a niche for himself in the mining industry of Illinois that is particularly outstanding.

He has made himself the grand old man of the mining industry in Illinois at a comparatively young age, and it is with great pleasure tonight that I am the instrument through which the Illinois Mining Institutes acknowledges the industry's obligation to this man, who was President of the Illinois Mining Institute in 1914-15 — the oldest living ex-President.

It is with great pleasure that I announce to you that your Board of Directors and your membership, by vote, have given him one of the few major acknowledgments of ability that this Institute has ever passed out — an Honorary Life Membership in the Illinois Mining Institute — to my good friend and to a distinguished contributor to the cause of the industry in this state, Mr. J. W. Starks.

Mr. J. W. Starks (Peabody Coal Co., Taylorville, Illinois): Harry, Secretary Schonthal of the Mining Institute, and Gentlemen: It is certainly with a great deal of pleasure that I accept this Honorary Membership.

They told me I had a minute to talk to you, and I will not exceed that minute, because that would be too long, maybe.

I remember the time when the organization meeting of the Illinois Mining Institute was held in Springfield, and at that time we had a membership of about 40. The membership at that time was composed of a very few superintendents, the state mine inspectors, ex-state mine inspectors, the Mining Board, and some from the University of Illinois.

Very much to the surprise, probably, of some of the later organizations we have had — which have suddenly found out that probably safety was a big thing in the mining industry — our ideal 40 years ago was safety, and that has grown all through the years.

You know, it gives me a pain that some agencies can come forth with a lot of literature and with a lot of ideas and believe that they are the originators of the idea of safety in the coal mining industry. Forty years ago that was our idea. Our idea was to advance the idea of safety.

Back at that time, a fellow who wanted to take an examination as mine inspector or mine manager figured out these problems from the correspondence schools with a lead pencil, and probably all he had was about a third-grade education, so far as formal education was concerned. He did that work on the kitchen table after his wife and kids got out of the way, so he could follow out and try to figure out these problems so he could pass the examination. Those are the fellows who have advanced safety. Those are the fellows who originated your present mining industry.

I did have the advantage of going to college, as Harry mentioned. I remember that just before it was time to leave for college, my father told me, "Now if the oats crop is going to be good, we're going to take you to college." Well, the rains came, and oats sold at 7 cents a bushel, and the prospect wasn't too hot, but we finally figured it out, and I went to college for a little bit. I wasn't studying mining; I was just trying to study to be something that would be worth while as far as the rest of the country was concerned.

I never lost faith in our country — Democratic or Republican — and I still think that you fellows are the ones who are going to keep this Ship of State on an even keel.

Now, going from the proposition of the old fellow who had to figure these problems out with a lead pencil on the kitchen table to the present generation, I would say that in my particular district I have about 4,000 men, and I'd say that about 60 per cent of them have had at least some high school education, and many of them are college graduates.

Now one gentleman has made this Institute a success. We struggled on, as I said, with about 40 members. Mr. Schonthal came along, with his business ability, his ambition, and at the cost of a lot of time and his own money, he has been one fellow who has made the Illinois Mining Institute the leading mining institute of the United States. Thank you.

President Moses: Thank you, Bill.

Bill's reference to college makes me think of the time in my own college career when I was having a little discussion of finances with my father. After he had laboriously drawn a check, and deliberately torn it out of the check book, and held on to it a little bit when I was reaching for it, he offered me the observation, "You know, son, there are a lot of damned good section bosses spoiled by sending them to college."

*Our Advertisers are selected leaders in their respective lines.*



I have one other job to do, and it is also a pleasant one, of the same nature.

Back when I was a young man in Illinois, we heard about a dapper little university professor who was going to straighten out the coal mining industry of Illinois. We heard about his developing a new coal mine down in southern Illinois, and believe me, he did give us a lot of new ideas about coal mines in Illinois, and he did contribute a great deal to the welfare of the mining industry in this state. In addition to that, he has contributed to the coal mining literature of the world today and to the coal mining research of the world today.

He went on from us to go to Pennsylvania, where he had a distinguished career as vice president of one of the big coal companies in that state. He left that particular job to go into a consulting engineering capacity in which, through the last ten years, he has demonstrated what he is—an international authority on coal mining, an international authority on taking the things we learn in this country to other countries, a national authority on disseminating that information from company to company in this country, and tonight we bring back from the wilds of Pennsylvania, along with me, the native son whom the Institute is delighted to honor with the presentation of one of those rare gifts, an Honorary Life Membership in the Illinois Mining Institute, Dr. L. E. Young.

Dr. L. E. Young (Mining Engineer, Pittsburgh, Pa.) : Mr. President, Mr. Secretary, Fellow Members of the Institute, and Guests :

It is a real pleasure to be among friends, some of whom I have known intimately for thirty-five years, and particularly on this happy occasion. I appreciate greatly the distinction of being made an Honorary Life Member of the Illinois Mining Institute. The Institute has played an important part in the development of the coal mining industry of Illinois and the attendance at the technical sessions this year indicates that the Institute has been prospering under vigorous and intelligent leadership.

The good fellowship that has prevailed in the organization is a definite indication of the splendid cooperation among the leaders in the industry, and the presence here tonight of a number of men who reside outside the State of Illinois is proof that the mining practice in Illinois has attracted the attention of progressive operators and engineers throughout the nation.

We are all happy to see these young men from the University and we welcome them into this fellowship. Nowhere is there a more hospitable group of mining men, and the mining fraternity throughout the world is known to be most friendly. Wherever you go throughout the mining world, you will meet royal good fellows.

You are starting work in a progressive field, where you will be expected to play a part because you have had the opportunity afforded by a technical education. There have been times and places when a technically trained man has been discredited, even though he showed a willingness to learn and did not presume to tell veterans of the industry how to run it.

*Our Advertisers are our friends and fellow members. Consult them frequently.*



Some years ago, while in London, I met a young mining engineer, a graduate of the Royal School of Mines, who told me of his experience in going to his first job. The Scotch mine superintendent said to him, "Laddie, did you come here to learn us or to be learned?" He very discreetly said that he was there "to be learned."

Any of you young men who go to a mine in Illinois to take your first job will find a more cordial welcome than the young British engineer, because the Illinois coal mining industry is progressive and open-minded. Moreover, many of you, I trust, will be going back to the communities where you were born and will be welcomed into the ranks by friends of long standing. The Illinois coal mining industry is to be congratulated on this splendid showing of confidence in the future by the interest of its younger citizens.

The mechanization of underground mines, which has been in progress in Illinois for more than twenty-five years, has had a large influence on coal mine mechanization throughout the United States. The practices started here have been adopted in many lands. The men here in this hall tonight are the "tops" in coal mine mechanization.

A number of leaders in the Illinois mechanization movement have passed on. With my good friend, Mr. W. J. Jenkins, we have just been calling the roll of these dear friends who have been an honor to this Institute and to the coal mining industry; they made many contributions to the progress that has made Illinois a leader in mechanization and their record should be an inspiration to all of you.

In accepting this Honorary Life Membership, which I prize most highly, I want you all to know how happy it makes me to come back home among friends and to be greeted so cordially. I wish to thank the officers and members for this mark of esteem and for the great honor conferred on me.

President Moses: Thank you, Lou.

Hearing Bill Starks talk about the push-button age reminds me of a story. This occurred during the construction of the Alcan Highway. A couple of very brilliant young engineers were hustling the job through, and they were setting up their power lines and doing this job and that, and one of the jobs was to transport a tremendously big transformer across a river on a ferry.

Late at night it suddenly dawned on them that the equipment was due, and they hadn't figured this problem out, so they rushed up to the ferry boat man's shanty and measured his boat. They were all over the place, and they began calculating with their slide rules about how many pontoons they would have to put on each side of the ferry and how they would have to put new rope on it, and strengthen it with steel cables and do things like that.

The old ferry boat man was paying very little attention to them, sitting there with his feet up to the fire. Finally they got a little aggravated with him and said, "Jim this is your job, too; you should pay some attention to it." He said, "Yeah, I did. I hauled it over last night."

*Mentioning this publication when writing Advertisers puts friendship into business.*

I have one more final thing to do as your President, I am going to do it quickly. I would like to say something in praise of the gentleman we have asked to come here tonight, with his homely philosophy and his wonderful understanding of human life and human nature. I have been fortunate enough to have heard him a time or two. When he finishes, you introduce him to me. I shall only tell you, "Here is Strickland Gillilan, the 'Sage of the Shoreham Hotel,' as I have christened him, and one of America's outstanding after-dinner speakers."

\* \* \*

[Mr. Gillilan gave his remarks.]

[Reprint omitted at Mr. Gillilan's request.]

\* \* \*

President Moses: I thought you'd be assured that he was as good as I said he was.

This closes the 56th Annual Meeting of the Illinois Mining Institute. I want to give a last word of appreciation to all of you for inviting me to come back home after sixteen years of being away, and spending this time with you and having the distinguished honor of being President of your Institute. I thank you very much, and God bless you!

Gentlemen, now having completed my duties and term of office as your President, it is with great pleasure that I again introduce to you your President for the ensuing year, and will ask him at this time to come forward and conclude this meeting, Mr. J. Roy Browning.

President Browning: Gentlemen of the Illinois Mining Institute and guests, I greatly appreciate the honor that you have bestowed upon me today in electing me to the Presidency of this Institute. I appreciate that my experience and knowledge of the coal industry is not comparable with that of my immediate predecessor, Mr. Moses, and those who have preceded him as President of this Institute. However, I shall do my utmost to carry on the high standards of this Institute for the edification and benefit of our mining industry in Illinois and those who are engaged in it. If our genial and competent Secretary, Mr. Schonthal, will keep "that worried look on his face" throughout the ensuing year, I am sure that my administration will be successful.

Before closing, I want especially to say to these young men from the College of Mining Engineering of our university that we have

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enjoyed having you as our guests today, and we will welcome you and your professors at all of our meetings during the coming year and especially at our annual meeting next November.

Again thanking you for the honor you have bestowed upon me, and with best wishes to all of you in your endeavors, and looking forward to seeing all of you at our future meetings, I now declare this meeting adjourned.

(The meeting adjourned at 9:15 o'clock)



## ACTION TAKEN ON RESOLUTION ADOPTED NOVEMBER 5, 1948

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November 29, 1948

TO THE MINING ADVISORY COMMITTEE:

A copy of the resolution adopted at the annual meeting on November 5, together with the following letter, has been sent to all those listed below, and on the page following:

\* \* \*

November 16, 1948

Dear Sir:

The Illinois Mining Institute has a total membership of over 1200, comprised of men connected with the coal mining industry of this State.

At the 56th annual meeting, held at Springfield, Illinois, on November 5, 1948, with a registered attendance of 653, the attached resolution was unanimously adopted.

The mining industry of this State—especially in employment and dollar volume production—and its possible contributions to mining and metallurgical research make it important to attract more students to take courses in mining and metallurgy.

The Department of Mining and Metallurgical Engineering at the University of Illinois at the present time is housed in several buildings and is, in our opinion, inadequately equipped to meet the needs of the day.

We urge serious and immediate consideration of this resolution. Any assistance you give will be mutually helpful.

Respectfully yours,  
B. E. SCHONTHAL  
Secretary-Treasurer

\* \* \*

Governor Dwight H. Green.

Governor-Elect Adlai E. Stevenson.

President George Dinsmore Stoddard, University of Illinois, Urbana,  
Ill.

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- Pres. of the Board of Trustees, University of Illinois, John R. Fornof.  
Hugh White, President, United Mine Workers of America, Springfield, Ill.  
John Mc Cann, Pres., Progressive Miners Union, Springfield, Ill.  
American Chemical Society, F. Leo Kauffman, Sec.  
American Foundrymen's Society, Victor Roell.  
American Institute of Chemical Engrs., Carl W. Peters, Sec.  
American Inst. of Electrical Engrs., H. E. Nason, Sec.  
American Inst. of Mining & Metallurgical Engrs., T. S. Washburn, Sec.  
Society for Non-Destructive Testing, Inc., Phil Johnson, Sec.  
American Society for Metals, Chgo. Chapter, A. A. Engelhardt, Sec.  
American Society of Mechanical Engineers, J. D. Pierce, Sec.  
American Society of Tool Engineers, Wm. R. Shrode, Sec.  
American Welding Society, T. B. Jefferson, Sec.  
Electrochemical Society, P. L. Howard, Sec.  
Western Society of Engineers, Donald V. Steger, Exec. Sec.  
American Institute of Chemists, Mary Alexander, Sec.  
American Society of Civil Engineers, Howard F. Peckworth, Sec.  
American Society for Testing Materials, G. E. Stryker, Sec.  
Illinois Society of Professional Engineers, Frank Spiedel, Sec.  
American Ceramic Society, J. L. Wilkinson, Sec.  
American Electroplaters' Society, J. M. Andrus.  
Illinois-Indiana Strip Mine Electricians Association.  
Illinois Society of Coal Preparation Engineers.  
Illinois Mining Electricians & Mechanics.  
Illinois Coal Operators Assn., F. S. Wilkey, Sec.  
Illinois Coal Producers Assn., Walter C. Gill, Pres.  
Illinois Coal Strippers Assn., James W. Bristow, Sec.  
Mining Electrical Group, Ernest Green.  
Belleville Fuels, Inc., Richard F. Wood.  
Illinois Society of Coal Preparation Engineers & Chemists, Laning Dress, Pres.

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MINING ADVISORY COMMITTEE MESSAGE  
TO ILLINOIS MINING INSTITUTE

Mr. B. E. Schonthal  
Secretary-Treasurer  
Illinois Mining Institute  
28 East Jackson Boulevard  
Chicago, Illinois

December 8, 1948

Dear Mr. Schonthal:

The University of Illinois has recently appointed a group of leaders of the Illinois coal industry to constitute a Mining Advisory Committee to the Department of Mining and Metallurgical Engineering at the University. The personnel of this committee is as follows:

J. Roy Browning  
George F. Campbell  
D. H. Devonald  
Miles Haman  
B. E. Schonthal

H. H. Taylor  
H. A. Treadwell  
Paul Weir  
Henry C. Woods, Chairman  
Harold L. Walker, Secretary

The Mining Advisory Committee has been meeting with personnel of the Department of Mining and Metallurgical Engineering for the purpose of establishing policies and procedures with respect to education in the mining industry.

At a meeting of the Mining Advisory Committee on December 1 at the Union League Club in Chicago the committee instructed me as secretary to transmit to you, as secretary of the Illinois Mining Institute, the following action taken by the Mining Advisory Committee:

"The Mining Advisory Committee commends the Illinois Mining Institute and all of its officers for the very fine reception given to the holders of mining engineering scholarships and other mining engineering students at the annual meeting of the Illinois Mining Institute in Springfield, Illinois, on November 5, 1948. The reception received by the students not only tended to increase the interest of students in the mining industry but it also enlivened the meeting of the Institute and increased the Institute's interest in the students. Furthermore, the Mining Advisory Committee believes the reception given the students by the mining industry will do much toward furthering the interest of University students in the Illinois coal mining industry in the future."

The Mining Advisory Committee requests that this letter of commendation be published in the 1948 transactions of the Illinois Mining Institute. Best personal regards.

Very truly yours,

H. L. WALKER

Head of the Department of Mining & Metallurgical Engineering, University of Illinois; Secretary, Mining Advisory Committee

*Play ball with the Advertisers who play ball with us.*



LETTER FROM MARION B. WALLS  
FORMER SCHOLARSHIP STUDENT

Box 151  
Oro Grande, Calif.  
Dec. 31, 1948

Illinois Mining Institute  
B. E. Schonthal, Sec'y-Treas.  
Chicago, Illinois

Dear Mr. Schonthal:

For some time I've been planning to write to you, so now while sending my dues under separate cover I'll take time to review my progress for you.

Enclosed is a money order for one-hundred dollars to complete the return of the monetary value of the scholarship given me. I hope it is of as much help to someone else as it was to me.

I have now been with the Riverside Cement Co., at their Oro Grande plant for a year and a half, most of which I was their mining engineer. This plant is just in the process of modernization and enlargement and most of my time was spent in prospecting and exploration of deposits. Also I spent a while on taxation maps and reports.

Several months ago I was given a promotion and am now transferred to production as night mill foreman. I have enjoyed my association with this company and the work has been interesting. Also I've enjoyed this desert climate and have felt better than I have for years.

Again I'd like to thank the Institute for the scholarship's help to me, and I wish all of you the best. I have been to mining meetings since I've been in the west, but may I say that the programs do not match the caliber of your meetings? And I say that honestly. The papers presented in your yearbook are generally very interesting and informative.

May 1949 be your best year!

Yours truly,  
MARION B. WALLS

REPLY TO LETTER FROM  
MARION B. WALLS

January 7, 1949

Mr. Marion B. Walls  
Box 151  
Oro Grande, California

Dear Marion :

Your letter of December 31 was delayed in the mails, as it just reached us today. It was most welcome, and your gesture in paying back in full the value of the scholarship is more than appreciated.

We are taking the liberty of printing your letter in the 1948 Proceedings, which is now at the printer's. It should serve as an example of what can be done by a person who has the will to do, after getting a good foundation for his career.

We are proud of your accomplishments and want to wish you continued success for a very long time. We hope you will let us hear from you again from time to time and will continue to keep us posted on your progress.

When you receive the 1948 Proceedings you will be interested to note that the scholarship program has grown very nicely, as a number of the coal companies are now sponsoring scholarships, as well as one of the individuals who is an active Institute supporter.

Thank you again for your letter—and all good wishes to you for a bright future.

Cordially,

B. E. SCHONTHAL

Secretary-Treasurer

*Reprinted from June, 1948 issue of "Mining Congress Journal" by permission of the author and the American Mining Congress.*

## COAL CONSERVATION

By JAMES BOYD

Director, United States Bureau of Mines

In our resource development and extractive industries we have far too long neglected the conservation phase of our responsibilities to the public and the coal industry particularly has definite responsibilities in preserving, through conservation, a continuing source of energy for future generations. By conservation I do not mean that we should keep our coal buried in the ground, as is another great resource at Fort Knox, Ky., but I do mean that we should get it out of the ground as we need it, as completely and efficiently as possible, and use it in the wisest way that we know how or can devise.

In most instances, our wasteful coal-mining methods are based on the traditional assumption that our coal reserves are so ample as to be virtually inexhaustible. Although past practices of leaving large blocks of coal unmined are understandable, certainly in the light of current knowledge such procedures can no longer be condoned. We cannot continue to shy at attempts to get out the last practicable bit of coal. It is to the interest of both the producer and the Nation to see that maximum extraction is attained.

We hear more and more comments regarding the difficulties that certain companies are now having in locating new accessible beds of the right type of coal to continue their operations. Well known is the present-day struggle of some coke producers to find coal supplies with a sulphur content within the limits necessary for good steel-making practice. The most responsible quarters of the coal industry have long recognized that practical conservation measures pertaining to safety and accident prevention usually lower costs and improve operations. It takes comparatively little study of conservation measures to show clearly that the same principle applies to the development of mining methods that will extract a greater proportion of our coal beds as they are being mined.

### AIM AT MAXIMUM EXTRACTION

The past practices of "skimming the cream" in the mining and use of our coal have arisen from many temporary considerations. These include: (1) Concentrating on highest quality of coal—purest in the sense of being lowest in ash and sulphur and of which the supply is relatively scarce; (2) concentrating on deposits in fields which are nearest markets, regardless of the rank and special properties of coal; (3) concentrating on lowest coal cost beds—this is entirely justifiable economically but again the principle of wisest and most suitable use must be given more consideration.

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Because of competitive conditions in the United States, American coal mining engineers are striving to reduce operating costs rather than to increase maximum recovery from the bed. The principle of maximum economic return has ruled, and this is primarily influenced by wage rates and the competitive price of coal. In the United States, where wage rates are high and coal-in-the-ground costs are usually low, engineers have found little incentive to save coal and to seek maximum recovery. Mining laws set standards of safety but there are none governing the degree of extraction. Although the incentive to maximum recovery obviously exists, competition requires the greatest emphasis on daily output at lowest cost.

With the improved outlook for coal, the time has come for universal thought and action on research and the application of practices for maximum recovery. In the mining of coal, we should strive to eliminate the staggering and no-longer-defensible losses. A good cooperative start has been made by the Bureau and industry in the anthracite field. Conservation demands that like measures be followed in the bituminous field.

#### RECOVER BOUNDARY COAL

The case against the losses of valuable coal in mining practices can be built up to a much greater degree, but the conclusions and the need for action are clear. One further source of avoidable losses is somewhat indeterminate, but it is certainly large in the aggregate; losses through premature abandonment of both irregular areas near the end of beds or near boundaries. Theoretically, these pieces of virgin coal—often of highest quality—could be later reopened and mined. Actually, however, because of irregularity, size, isolation, disrepair and collapse of workings, the new opening facilities are uneconomic; yet, during the active life of the original mine, the additional cost of recovery would have been relatively small. Naturally, many instances of these losses by abandonment have resulted from mine financial conditions following the period of high-price (for coal) that prevailed from 1916 to 1922. It was reported that 4802 such cases of shut-down mines occurred in the period of 1923 to 1932. Only a few had been worked out, and few, if any, can be rehabilitated. From the standpoint of public good, this, we see most clearly, is not conservation.

An anthracite laboratory is being constructed at Schuylkill Haven, and it is hoped it will be in use within the next 18 months; pending construction of the building, a number of investigations are continuing. In addition a bill is now pending before Congress for the appropriation of approximately \$560,000 for an engineering study into the water problems in the anthracite region.

#### RESEARCH PROMOTES INCREASED RECOVERY

Mechanical mining research has gained favor with the industry and the Bureau is making every effort to meet the demands upon it for services. The objective in mechanical mining research is to improve mine operation by introducing machinery and methods especially suited for

anthracite conditions. New equipment has been designed, and certain European machines, modified for local use, have been introduced. It has been found, for example, that mechanical chain-cutting of gangways in steeply-pitching beds will double the rate of advance over hand-mining methods, reduce the amount of roof-trimming for the miner by providing a more secure top, and, through the use of conveyors, eliminate the blasting of wall rock for clearance. Lightweight German shearing machines, imported by the Bureau of Mines in 1946, have been fully tested and are now under-going slight changes in design to make them even more suited to anthracite pitching-bed conditions.

The loading machine for thin, steeply-pitching beds was designed, constructed and tested by the Bureau. Its use eliminates transportation delays in driving gangways, and tests show that several times the best day rates of advance are possible with this machine. One of the principal developments in the German coal industry was the coal planer. Although this machine was used in friable soft-coal mines, it is expected that a vibrating blade can make the machine adaptable to anthracite operations; the Bureau is developing such a machine at the present time.

Fundamentally, low percentage of coal extraction may be due to (1) relatively thick beds, (2) excessively thin beds, and (3) properties of roof and bottom. In the past, the planning of a coal mine for maximum extraction has been inhibited by the factor of high costs. Does this factor apply today? If the total tonnage extracted from a mine is increased, the total fixed charges per ton would be reduced. The industry is faced with the necessity of opening new mines, usually in areas less favorably located with respect to transportation, topography and other essential features. However, if increased recovery can be obtained from mines in existing fields, the life of these present fields can be prolonged.

Increased mechanization of mines has presented problems, especially the extraction of coals with mechanical equipment. The investment necessary to equip a mechanized mine is great, and in order to reduce the fixed charges per ton, the working area should be so planned that maximum recovery can be obtained for a given territory. The type of equipment used for mechanized mining, including equipment for pillar extraction, can be determined only after extensive studies of the physical conditions in and surrounding the coal beds.

#### CONSERVATION THROUGH BETTER PREPARATION

Another approach to the general objective of fuel conservation may be obtained through the application of preparation technology which may be directed to two broad channels of development.

First, and most obvious, there is the application of efficient coal preparation practices to recover the maximum fuel value from raw material now being mined. Conservation is affected by eliminating the losses of coal in gob material, mine rock dumps, and picking plant and washery rejects.

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Second, there is the more difficult but much broader phase of upgrading mediocre or substandard coals to make them more valuable. Typical of such problems and of major importance are (1) improvement of coal from the high-sulphur areas of the Pittsburgh and western Pennsylvania seams to adapt it to metallurgical use—an accomplishment that would enormously increase the reserve of metallurgical coal in the area; (2) treatment of the western lignites to obtain a satisfactory domestic and industrial fuel—a preparation and processing project; (3) preparation and treatment of the high-ash rider coals associated with the Pittsburg seam so that the entire coal bed may be mined and used.

There are many local situations where the solution of the preparation problems would greatly increase our supply of fuel. In many localities such developments would not only conserve the national fuel supply but would also furnish a more dispersed and dependable source of energy for general industrial use.

All phases of coal-preparation are being studied by the Bureau of Mines. In work with a cyclone and with a kerosene flotation process the Bureau has shown how to recover usable coal from washery waste. Studies of operation of these processes for commercial preparation has led to fruitful suggestions for their improvement. Also, fundamental studies have been conducted to provide data essential to the development of new preparation techniques.

One of the greatest contributions to conservation is through improved coal utilization. These contributions of the Bureau through combustion research are many and of classic nature. They include fundamental studies on burning coal most efficiently in hand-fired as well as in different types of stoker-fired and pulverized-coal-fired furnaces. Likewise, the published coal carbonization studies made by the Bureau are a valuable source of information on the carbonizing properties of American coals, the only difficulty now being that it has not been possible to conduct test work as rapidly as the needs for new sources of coking coals have developed. We have proposed to expand these carbonization studies to include work on upgrading and blending poor coal with high-quality coking coals as a means of conserving and extending the use of the remaining scarce, high-quality coking coals.

Although this country has made and still is making mistakes in the use of coal, as our new horizon of knowledge now tells us, the record in this respect is far more satisfactory than our record concerning mining losses.

#### MANPOWER CONSERVATION

No discussion on conservation measures is complete without reference to the conservation of manpower through safety measures. It has long been recognized by responsible units of this and other industries that safety pays. There are numerous examples of the fact that the costs resulting from unsafe practices vary inversely to the number of dollars and amount of constructive effort spent on

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safety measures. For many years the Bureau has advocated the application of rock dust in bituminous-coal mines to prevent the propagation of explosions, and this approach has been widely recognized by the industry. Nevertheless, too many mines continue to be inadequately rockdusted. In some mines rockdusting has been applied to entries and other easily accessible openings, but little, if any, has been applied to the less accessible places such as back entries, air courses and rooms. Partial rockdusting provides a false sense of security because if an explosion of gas or dust occurs in a bituminous-coal mine it will follow the path of least resistance and propagate through mine openings where dust is lacking or is inadequate.

The efficacy of rock dust in preventing the propagation of an explosion has been proved in numerous instances. Recently an explosion occurred in the section of a bituminous-coal mine that had been vacated only a short time previously by workmen who were in a man-trip en route to the surface. The haulage road and open parallel entries were well rockdusted; unquestionably the rock dust quenched the explosion and prevented it from reaching the workmen, but extensive damage was done to the mine in the areas in which the explosion was propagated. Centraila No. 5 mine explosion in which 111 men were killed is an outstanding example of the high loss of life resulting from the propagation of an explosion through passageways not rockdusted. Although this example was spectacular and widely publicized, there still remain far too many mines that have not recognized the dangers of inadequate protection from this menace. Federal inspection reports continue to indicate that far too many mining companies are continuously ignoring this principle.

Although the Federal inspection reports are posted at the mine and transmitted to management and labor and reported to the press, in some areas this procedure has not seemed to have been completely effective. Consequently we are now inaugurating a more comprehensive system of following through. We are reporting to the State Mine Inspectors directly all those mines which continually fail to comply with the fundamental violations of safe practices in regard to explosion hazards. At the same time we are picking out the worst hazards reported in Federal inspection reports and drawing them to the attention of the presidents of the companies, many of whom may not themselves recognize the dangers in the mines from reading the inspection report itself. We are also establishing other methods of following through the reports from the Federal inspectors.

There are other causes of explosions and preventive measures besides rockdusting that should be undertaken; these are included in the reports now being made. The prevention of disasters in mines rests chiefly on the shoulders of management. Failure to recognize and correct flagrant violations of safety provisions approaches irresponsibility. It is essential to the growth and well-being of the industry that responsible members of it assist the Federal and state authorities in insisting that all operations conform to fundamental safety measures in the prevention of accidents in coal mines.

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## EDUCATION IS SAFETY

Innumerable accidents also result from day-to-day activities of the individuals working in the mines. Although management must provide the tools and supervision and discipline to maintain safe conditions in the mines, nevertheless much can be done in this direction through the individual workers themselves. To accomplish this, the Health and Safety Division is carrying on numerous educational activities devoted primarily to the prevention of accidents. This type of work has been done since the Bureau was brought into being in 1910. To intensify the Bureau's efforts in this direction the Coal Mine Inspection Branch has assigned some of the Federal inspectors to conduct classes for mine safety committeemen and other interested persons for the purpose of explaining and discussing the inspection codes and demonstrating mine hazards through visual aids to the end that fatal and nonfatal injuries in coal mines will be reduced. These activities have had definite support of both management and labor, and the classes have been well attended; approximately 2500 mine safety committeemen have completed the course of training and more than 1000 are enrolled in training classes at the present time.

Additional activities are conducted by a small group of selected mining engineers who conduct courses in coal-mine accidents prevention for operating officials and others who aspire to become officials. The coal-mine accident-prevention course for officials includes considerably more detail than the course for mine safety committeemen because it covers virtually all accident-prevention aspects for coal-mine operations. It involves discussion of the studies and recommendations of the Bureau throughout its years of experience to the end that coal mines will be safer and healthier places in which to work.

The time for increased interest and practical demonstration of conservation is *now*—in mining methods, utilization and accident prevention. Conserve your assets and you will be well repaid both economically and in the realization that you have accomplished something worth while for yourself, your industry and for the nation.



*Presented at The American Mining Congress, Cincinnati, Ohio, April 26-28, 1948.  
Reprinted from 1948 Yearbook "Coal Mine Modernization"  
through courtesy of The American Mining Congress.*

## DRILLING AND BREAKING DOWN COAL WITH AIRDOX

By R. L. ADAMS

General Superintendent, Old Ben Coal Corp.  
West Frankfort, Illinois

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Airdox is the only permissible means of breaking down coal at the face on-shift that is at present available to underground mines in Illinois and Indiana, where its use is being rapidly adopted partly because of the many advantages of its use on-shift. Such advantages are too obvious to require enumeration and in addition, certain hazards attending the use of explosives are greatly reduced or eliminated entirely.

The equipment consists essentially of one or more air compressors capable of developing slightly more than 10,000 pounds per square inch; steel tubing tested to 20,000 pounds psi. to convey the compressed air from the compressors to within 150 to 300 feet of the working face; flexible copper tubing of equal strength to lead from the end of the steel tubing to the face and to which is attached the Airdox tube; line valves at all branches and at not to exceed 1000 ft. intervals in all steel lines as well as at or near the end of all lines, either steel or copper; pressure gages and blow-down valves in the flexible copper tubing at a point of safety such as in the open cross cut nearest the face, preferably not closer than 40 ft. to the face.

Face preparation for the breaking down operation does not materially differ from that used for explosives. The face may be cut horizontally at any point or sheared but it is questionable if both horizontal cutting and shearing is ever necessary or desirable. Undercutting only is the most common practice. Drill holes must be of approximately 3½ in. diameter to admit the Airdox tube or shell and the number of holes required is dependent upon the character of the coal and how and where the cutting is done. Since the expansive force of Airdox is far less than that of explosives, it is obvious that more drill holes are required. The type of drill used is governed entirely by the character of the coal seam and the necessity for a slightly larger hole than that required for explosives.

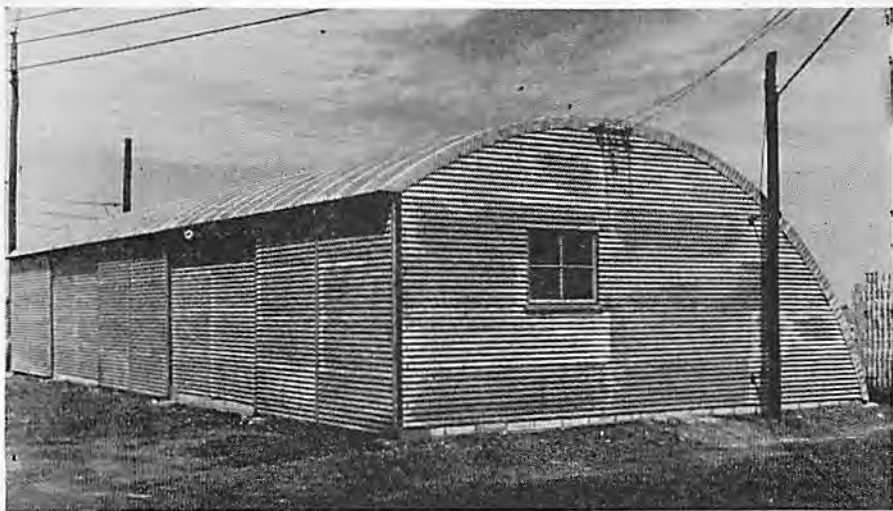
### COMPRESSOR INSTALLATION ON SURFACE

The purpose of this paper is to give an overall description of the installation and operation of Airdox rather than a detailed description

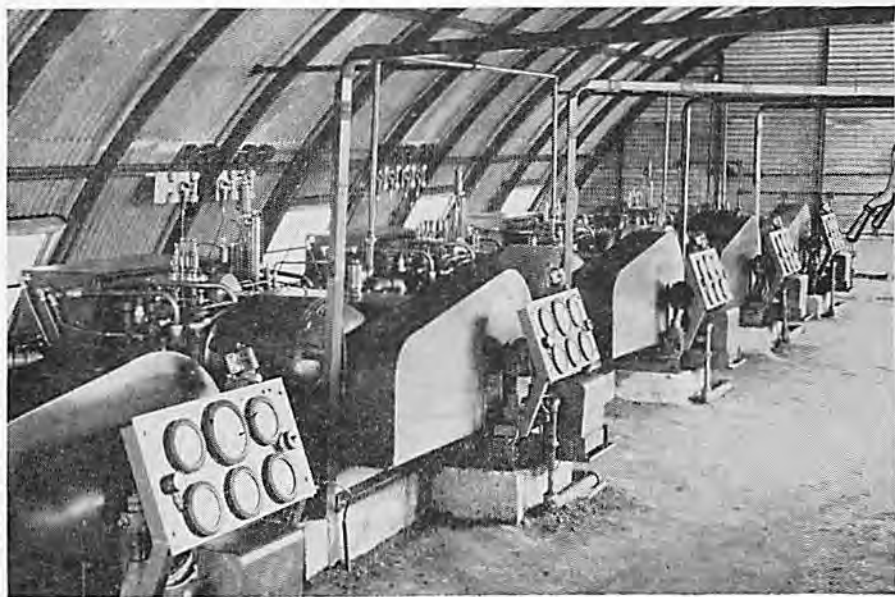
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of the equipment and general specifications of the installation are first submitted.

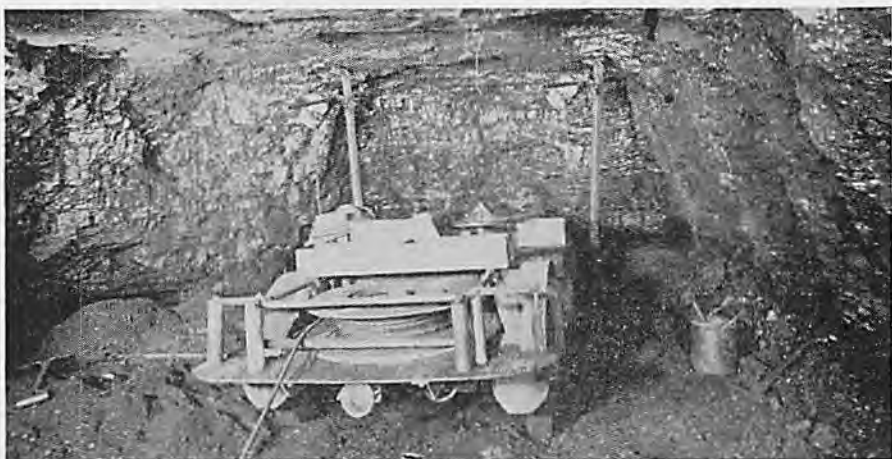
Beginning with the compressors: They should have an adequate concrete foundation if the installation is permanent. Little anchorage is necessary but some is preferable. There should be about 3 ft. of clearance between units and the controls should be mounted in such a



*Exterior and interior views of compressor station*



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*Drillmobile with two post drills*

position that they need not be disturbed when a compressor is moved in or out. The compressor station should be outside the mine in a substantial building with adequate openings for admitting the fully assembled compressors and for thorough ventilation at all times when the plant is running, particularly in hot weather. All doors and windows should be closed when the plant is idle especially in cold weather and the temperature inside the building should not be allowed to get low enough to be uncomfortable because of the adverse effect on the lubrication of the machines in starting after having stood idle over night.

Air compressors developing 10,000 psi. through six stages are from necessity built with close tolerances and proper lubrication is essential. The compressors do not require constant attention, they operate automatically, cutting in when the pressure drops 500 to 700 lbs. and cutting out when the pressure builds up to 10,000 lbs. or slightly more accordingly as the pressure microcontrol switch may be set.

#### PIPE LINE TO UNDERGROUND WORKINGS

One line of steel tubing,  $\frac{5}{8}$  in. inside diameter, from the compressor station into the mine is all that is required. It should be protected from freezing temperatures and the common practice is to put the line down the return air shaft and along the return air passages to the working sections. Good installation is important. The line should be securely supported from rib or roof every 10 to 15 ft., well grounded and well insulated at all points in close proximity to trolley wires or feeder cables. Line valves should be installed at intervals of not less than 1,000 feet and at all branch line take-offs. Oil and moisture traps are essential and should be located near the compressors.

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*Charging the hole with an Airdox shell*

If the mine openings are a long distance from the working sections, the compressor station may be located on the surface above the workings and the air line suspended in a drill hole penetrating a return airway. This may save a quantity of steel tubing, all of which has to be maintained and protected against falls and accidental damage from other causes. However, it must not be overlooked that at least 3,000 feet of line for each compressor should be in the system between the compressor station and face to serve as an air receiver. The nearer the steel line is carried to the working faces the less flexible copper tubing will be required.

This copper tubing is subjected to rough usage causing considerable waste in cutting



*Pressure gage and blowdown valve*

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out the kinks and sections otherwise damaged. When it is to be moved it is advisable to drag or carry it, if possible, without attempting to coil it. The superintendent of mechanical maintenance of an Illinois operation has devised and built a machine for reconditioning the tubing by pulling it through a die and winding it into coils about in the same manner as it is received from the manufacturer. When a bad kink shows up it is cut out, the reconditioned tubing on the reel is removed and a new start is made; no tubing has been reconditioned the second time. It is easy to determine the approximate length in any coil without uncoiling.

There should be two or three Airdox tubes or "shells" in the working section for each tube in actual use. There should be a tube repair station conveniently located and properly equipped with tools for dismantling the shells and replacing broken or damaged parts. This station should be located on the main haulage road leading to all working sections. The repair man in this station will not be required to spend all his time on Airdox repairs but can be kept profitably employed at other repair work.

#### FACE OPERATION

The Airdox operator, or "shooter" if you please, works alone. After the face has been cut and drilled, then the final preparation before the breaking down work begins is to put a small amount of water in each drill hole. This can be done with an ordinary grease gun of the simplest type although it is advisable that it be of brass with water-resistant plunger leathers. Less than a quart of water in each drill hole is enough to effectively prevent dust from rising in the air following discharge of the Airdox.

The first act of the operator is to "block off" with appropriate signs, the working place that he is preparing to break down so as to prevent anyone else from entering the possible danger zone. He then at-



*A typical drill pattern for Airdox*



*Coal completely broken down for mechanical loading*

taches the pressure gage and blow-down valve to the flexible copper tubing that has previously been semi-permanently installed and which terminates in a cross-cut or other place of safety near the face. Next, he opens the line valve to bring the compressed air up to his blow-down valve. The shell is then attached to the flexible copper tubing leading from the blow-down valve to the face and inserted in the first drill hole. The tube is pushed all the way to the back of the hole and then withdrawn about 6 inches to give a small air cushion to the discharge.

The operator then returns to the blow-down valve and gage. He opens the floating plunger valve admitting compressed air to the tube in the drill hole at the face until the gage shows the desired pressure, say 9,500 lbs., where-upon he gives a vocal warning of the impending discharge, closes the air supply and opens the blow-down valve. Immediately the "shell" is discharged, the sudden release of highly compressed air breaking down the coal. The tube is then inserted in the next drill hole to be used and the operation repeated until the whole face is broken down. Quite often some of the drill holes are not used because the drillers do not always judge conditions properly, and for the same reason, it is sometimes necessary to drill another hole or two to square up the rib or face properly.

#### GENERAL RESULTS

In a 7 ft. coal seam that is undercut 8 feet, one operator will break down about 450 tons per shift in a very acceptable manner for any type of mechanical loading. "Tight coal" is almost invariably an error in judgment by either the driller or the Airdox operator.

Five compressors are sufficient for a mine producing 4,000 tons per shift. If one should be off the line temporarily the other four will

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carry the load. Most operating men prefer as much capacity as  $1\frac{1}{2}$  compressors for each 1,000 tons per shift production. One operation in Illinois has twelve compressors housed in a single building, sufficient capacity for a production of 8,000 to 10,000 tons per shift.

At present, twenty-two mines in Illinois and seventeen mines in Indiana are using Airdox. They represent a daily production of about 80,000 tons. Thirty-two of the thirty-nine mines are double shifting. In these mines the second shift can follow the first with a much shorter interval than is possible when using explosives and off-shift shooting. In New Mexico, where on-shift shooting is also prohibited by law, at least two operations are using Airdox successfully for mechanical loading.



*Presented at The American Mining Congress, Cincinnati, Ohio, April 26-28, 1948.  
Reprinted from 1948 Yearbook "Coal Mine Modernization"  
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## HAULAGE SYSTEM FOR TRACK-MOUNTED EQUIPMENT

By JOE BOSE and JOSEPH ANSTEAD

Joe Bose, Superintendent, and Joseph Anstead, Chief Engineer  
Templeton Coal Company, Sullivan, Indiana

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When the Linton-Summit Coal Company decided early in the year 1945 to sink a new mine in Sullivan County, Indiana, one of the first important decisions that had to be made was what mining system and type of mechanical equipment would be employed in order to obtain the most satisfactory results. As a result of this study, high capacity, track-mounted loading and cutting equipment was chosen for the face workings with mine car haulage underground and a belt conveyor slope from the coal to the surface.

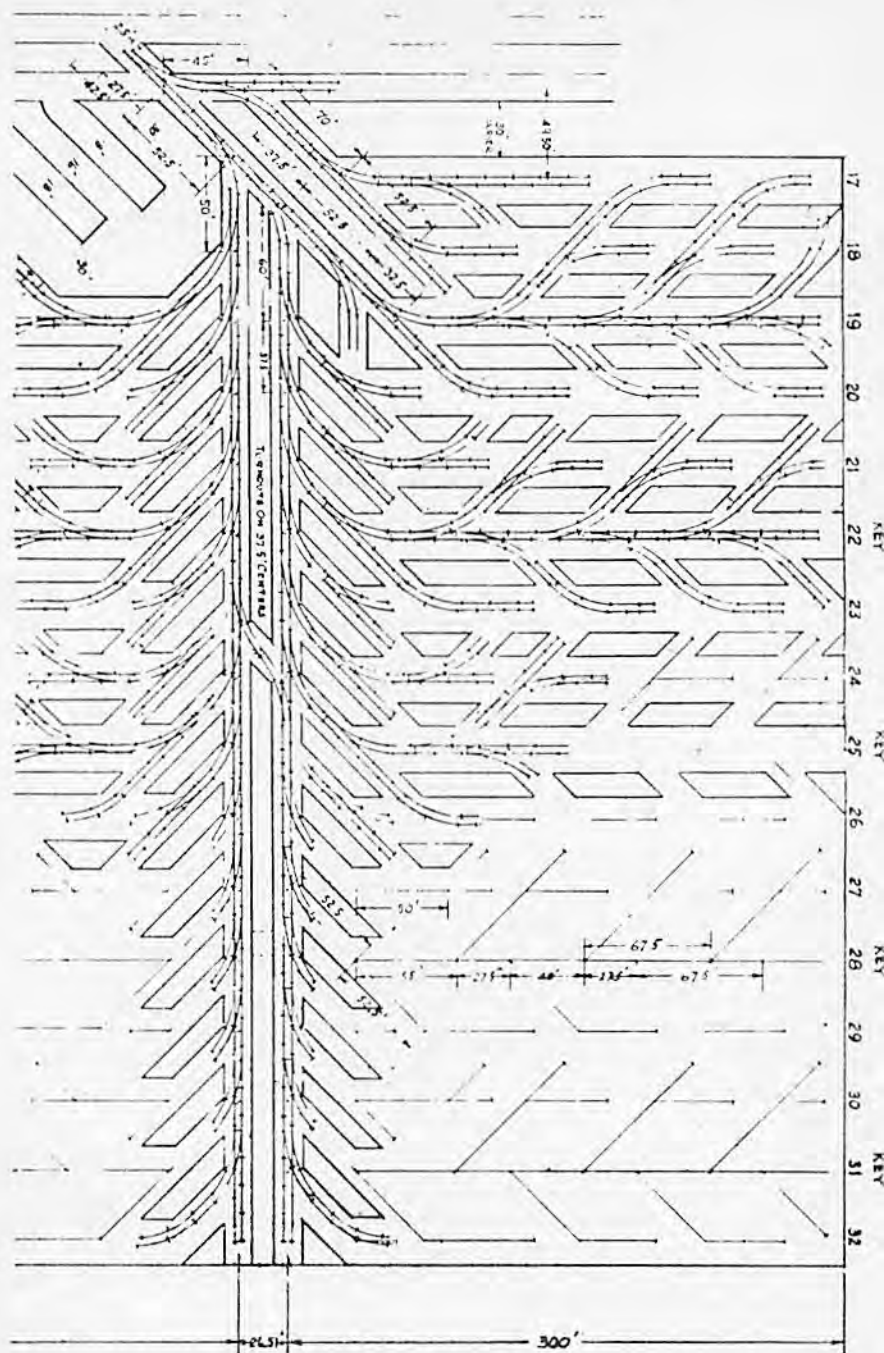
The seam mined is the No. 6, which averages 5 ft. 4 in. thick and is underlaid with fireclay, topped with a 5-in. band of slate that provides a hard bottom. The roof is composed of gray slate which provides a good top except in the presence of rolls where slips require cross-barring. Grades up to approximately 7% may be found in rooms.

### SLOPE SINKING

The slope was driven by a track-mounted loader; it is on a 17-degree pitch and is 18 ft. wide, 7 ft. high and 535 ft. long from the surface to the No. 6 seam. It was driven a total distance of 650 ft. to provide a dump bin under the main haulageway. When sinking operations were started, the first 50 ft. of overburden was removed with a dragline; the remaining distance of 485 ft. was driven by using a track loader, a cable hoist and 90 cu. ft. steel car. A set-off switch was placed at approximately 150 ft. intervals to allow the track loader to be parked in the slope, so that it was not brought to the surface during the preparation phase of the face cycle. After a round of rock was shot, the loader was attached to the front of the steel mine car which in turn was fastened to the hoist rope and lowered to the face where the fall of rock was loaded. The sinking operation moved along with such success that the 2nd and 3rd shifts were started with the result that three shifts per day, with a 6-day week, averaged 75 ft. of lineal advance per week.

Permanent roof support and permanent track was installed as the slope advanced. The roof is supported by steel cross bars placed

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*Plan of prefabricated track for room panel*



on 2 ft. centers; these rest on 10-ft. stringers set parallel to the rib and supported by steel pins anchored 4 ft. into the ribs on  $2\frac{1}{2}$  ft. centers. All pins, stringers and rails were immediately spot welded as soon as installed so that blasting at the face would not dislodge them. In the slope 60-lb. rail was laid on 5 x 7 in. wood creosote ties; 40-lb. rail on steel ties in 5 ft. and 10 ft. lengths was used at the face as the advance was made. When advanced a sufficient distance, a 30-ft. 60-lb. rail was laid to replace the 40-lb. rail. The track loader in slope development at the Regent mine was so efficient and successful that the Linton-Summit Coal Company later used this same method of sinking at their new Jonay mine near Sullivan, Indiana.

#### MINING SYSTEMS AND OPERATING CYCLE

A room and pillar system of mining is used at Regent mine. The main entries are four in number, each 14 ft. wide on 30 ft. centers; double cross and room entries are driven 13 ft. wide on 30 ft. centers in all working sections, except when rooms are turned at 45 degrees from the room entry. In that case, they are driven 24 ft. wide on 34 ft. centers to a depth of 500 ft. The one exception is in a territory where pre-fabricated track is being used. When these panel rooms, which turn at 45 degrees are driven 52.5 ft., they are turned on a second 45 degree angle and are thus driven to their ultimate depth perpendicular to the room entry. The room break-throughs are developed on 50 ft. centers and a 50 ft. barrier pillar is maintained on each side of the main entries as well as a 50 ft. barrier between panels.

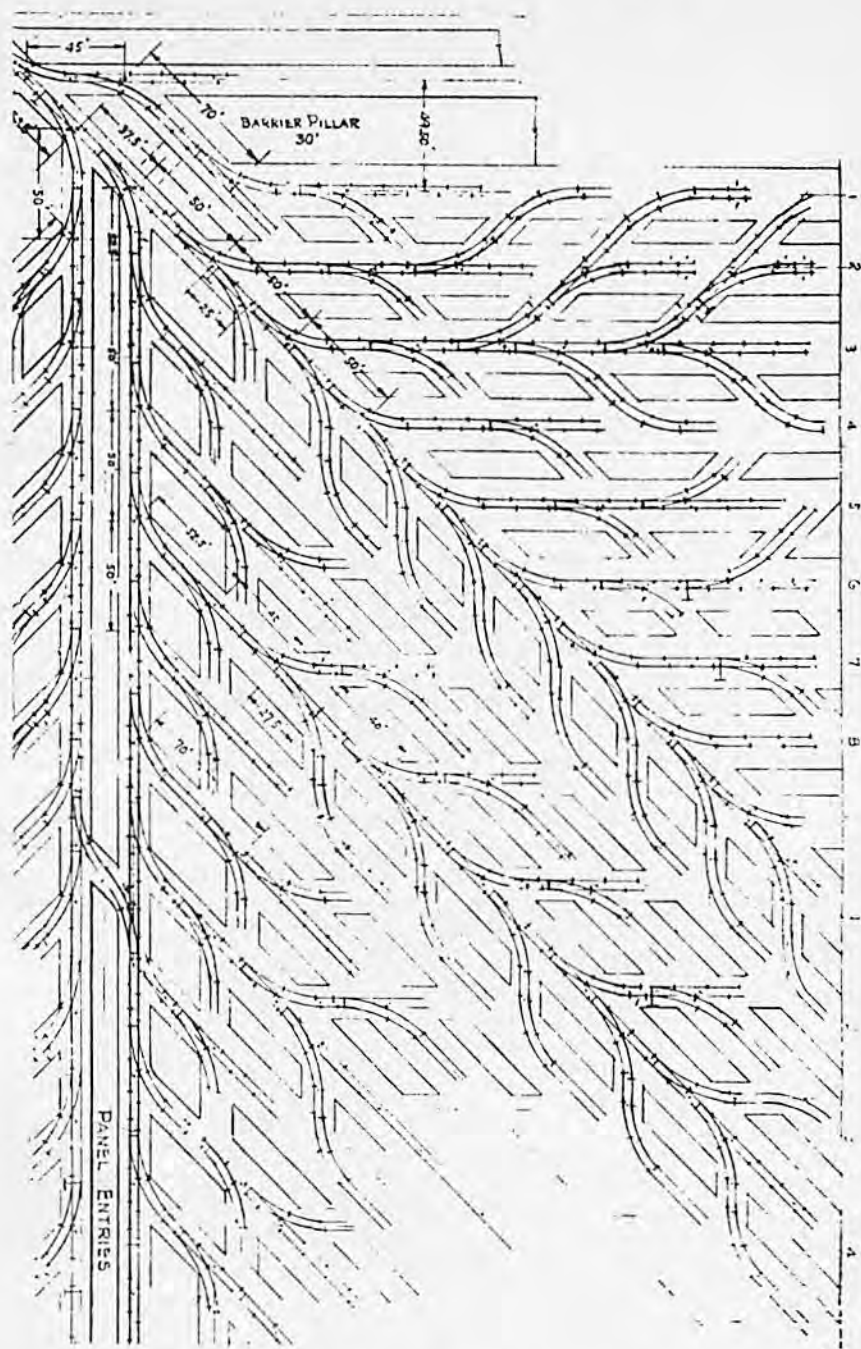
Face preparation is by a track-mounted cutting machine, post-mounted drills with the coal broken down by Airdox. The cutting machine is equipped with a 9-ft. bar which gives an average depth of undercut of 8 ft. and a  $5\frac{1}{2}$  in. kerf. This machine in a normal section will cut from 15 to 18 places per shift. A mucker follows the cutting and bugdusts the kerf with a long-handled shovel.

After cutting, the electrically driven post-mounted drills put in eight  $4\frac{1}{2}$  in. holes, using three set-ups. One is made along the right rib. The top rib hole is started 9 in. from the roof and is driven parallel to the rib but angled upward. A second right rib hole is driven horizontally at a height of 32 in. from the bottom. The top and bottom holes on the left side of the face are similarly spotted and drilled. Rib holes are drilled to a depth of  $7\frac{1}{2}$  ft. When drilling the center holes the drill is set on the center line of the room or entry. The top right hole is spotted  $1\frac{1}{2}$  ft. to the right of the center line and 10 inches from the top and is angled upward and to the right so that the end of the hole is 3 feet to the right of the center at the roof. The top left center hole is spotted and drilled in a similar manner to the left of the center line. The two bottom center holes are each spotted and drilled horizontally directly below the top holes and directly above the slate band. The center holes are 8 ft. deep.

The coal is broken down "on shift" by Airdox. The lower center holes are broken first, followed by the lower rib holes, top center holes

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*Prefabricated track for rooms at 45-degree angles*

Table 1—TIME STUDY OF LOADING MACHINES  
(Time shown in Minutes and Seconds)

Operation	Unit 1		Unit 2		Unit 3	
	Total Time	Percent of Shift	Total Time	Percent of Shift	Total Time	Percent of Shift
Loading.....	256'-30"	51.2%	225'-30"	45.0%	239'- 0"	47.9%
Car Change.....	98'-30"	19.7	98'-30"	19.6	88'-30"	17.8
Trip Change.....	87'-30"	17.3	78'-30"	15.7	81'-30"	16.4
Moving.....	45'- 0"	9.0	42'-30"	8.5	37'-30"	7.5
Delay.....	14'- 0"	2.8	56'- 0"	11.2	52'- 0"	10.4
Total Face Time..	501'- 0"	100.0%	50'- 0"	100.0%	498'-30"	100.0%
Operation	Unit 4		Unit 5		Composite	
	Total Time	Percent of Shift	Total Time	Percent of Shift	Total Time	Percent of Shift
Loading.....	273'-30"	55.6%	284'- 0"	57.6%	255'-42"	51.5%
Car Change.....	79'-30"	16.2	70'- 0"	14.2	87'- 0"	17.5
Trip Change.....	72'-30"	14.7	59'-30"	12.1	75'-48"	15.2
Moving.....	43'- 0"	8.8	43'- 0"	8.7	42'-12"	8.5
Delay.....	23'-30"	4.7	36'-30"	7.4	36'-24"	7.3
Total Face Time..	492'- 0"	100.0%	493'- 0"	100.0%	497'- 6"	100.0%

and finally the top rib holes. Compressed air carried at a pressure of 10,000 lbs. per sq. in., is brought from surface compressors into the mine and up to the room neck by  $\frac{3}{4}$  in. steel seamless pipe. Three-eighths in. copper tubing carries the air up to the face.

The coal is loaded by high capacity, track-mounted loading machines, served by 5-ton steel drop bottom cars. The cars are placed at the loader in 4-car trips by 6-ton cable reel locomotives. Following the loading machine, a slate man and timber man scale down loose roof and set the necessary props. Completing the cycle, the track crew extend the rail to within 7 ft. of the face, making it ready for the cutting crew to enter. This continuous cycle is followed in each working place.

#### TRACK AND TIMBERING

The main line haulage track is laid with 60 lb. rail with treated wood ties, which are 5 in. x 7 in. x 6 ft. In the cross or room entries 40 lb. rail is laid on treated wood ties 3 in. x 5 in. x  $5\frac{1}{2}$  ft. With one exception, all room sections use 30 lb. rail on No. 3 steel ties; the one exception is in that section where pre-fabricated track is being used. The pre-fabricated track is 40 lb. rail on No. 5 steel ties. The pre-fabricated track section has a No. 3 frog but in all other sections a No.  $2\frac{1}{2}$  frog is used.

Standard timbering plans are in effect throughout the entire mine. The main haulage entry is crossbarred with 80-lb. steel rails set on

Table 2—LOADING MACHINE PERFORMANCE  
(One Shift)

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Composite
Cars loaded . . . . .	133	112	119	124	109	119.4
Tons per car . . . . .	4.75	4.75	4.75	4.25	4.75	4.75
Total tons . . . . .	632	532	565	589	518	568
Average loading rate (tons per minute) . . .	2.47	2.36	2.36	2.15	1.82	2.23
Total car changes . . .	99	84	89	90	82	89
Average time per car change . . . . .	1'-0"	1'-10"	1'-0"	0'-53"	0'-51"	0'-59"
Total trip changes . . .	33	28	29	29	27	29
Average time per trip change . . . . .	2'-33"	2'-48"	2'-48"	2'-30"	2'-12"	2'-34"
Average time per over- all car change . . . . .	1'-24"	1'-35"	1'-26"	1'-16"	1'-11"	1'-22"
Average distance per car change . . . . .	83 ft.	61 ft.	67 ft.	69 ft.	55 ft.	67 ft.
Number loader moves . .	15	15	15	14	14	14.6
Total time of moves . .	45'- 0"	42'-30"	37'-30"	42'-56"	42'-56"	42'-10"
Average time per move .	3'- 0"	2'-50"	2'-30"	3'- 4"	3'- 4"	2'-54"
Total tramping dis- tance . . . . .	4350 ft.	2080 ft.	2805 ft.	3145 ft.	2815 ft.	2039 ft.
Total time loader idle during trip changes . .	39'-30"	41'- 0"	38'-30"	39'-30"	33'- 0"	38'-18"
Total number of places loaded . . . . .	16	14	14½	13	14½	14.6
Men in section . . . . .	19	17	19	18	19	18.4
Tons per man . . . . .	33.3	31.3	29.7	32.7	27.3	30.8

Note: Coal height, 64 inches; room width, 24 feet.  
Entry width, 14 feet; four cars per trip serving loader.  
All times expressed in minutes and seconds.

4 ft. centers. These rails are supported by a set of stringers that parallel the rib and are carried on steel pins which are set 42 in. into the rib. The two main intake entries and the other room entries are crossbarred with 5 in. x 5 in. x 12 ft. timbers on 4 ft. centers. Two rows of posts are set adjacent to each rib in the rooms, the first row being set 4 ft. and the second 8 ft. from each rib. The posts are set 3 ft. apart. Crossbars are used where needed.

Drop-bottom mine cars of 5-ton capacity transport the coal from the loader to an 80-ton underground bin at the slope bottom. Coal is fed from the hopper onto a 48-in. belt conveyor 50 ft. long by reciprocating cross feeders; this conveyor deposits the coal onto a 42-in. belt laid up the slope to the surface and discharging directly into 40-ton railroad cars. The slope belt measures 715 ft. from center to center and travels at a speed of 350 ft. per minute. It is powered by 150 HP, 2300 volt A.C. motors.

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## PERFORMANCE RECORDS AND TIME STUDIES

Five track-mounted loading machines are used in this mine; all are in operation on the day shift and two machines work on the night shift. These seven machine shifts are producing an average of 3,850 tons of raw coal per day. A typical action crew is as follows:

Loading machine operator .....	1
Loading machine operator's helper .....	1
Cutting machine operator .....	1
Cutting machine operator's helper .....	1
Drillers .....	2½
Shotfirer .....	1
Timberman .....	1
Slateman .....	1
Trackmen .....	4
Bugduster .....	1
Locomotive operator .....	1
Locomotive operator's helper .....	2
Mechanic .....	1
Section foreman .....	1
Total men .....	19½

Forty drop bottom cars of 5-ton capacity handle all of the tonnage produced from the five working sections on the day shift and the two on the night shift. This means that on the day shift with a tonnage of 2,750 tons, each car is loaded 13.8 times during the shift. Fourteen 6-ton cable reel locomotives are used in the mine. Each mechanical loader is served by two 6-ton locomotives and eight mine cars, one locomotive acting as a relay motor. Each day shift relay locomotive makes an average of 27½ round trips per 7½ hour shift. The average round trip haul is 4,600 ft.

Table 1 shows a tabulation of time studies made of loading machines in each of the five working sections in the mine. It will be noted that the composite average of 51.5% of the total shift is utilized in loading; this average is, I believe, well above the general average in the mining industry. A total of 32.7% of the total face time is charged to car change and trip change.

Table 2 shows a composite average per shift of 119.4 cars loaded with 89 car changes and 29 trip changes. The average time of 59 seconds per car change for an average overall of car change of 1 minute and 22 seconds indicates the speed and efficiency of the transportation system. Moving and delay time are held to a minimum.

Table 2 also shows a total average tramming distance of 2,039 feet for 14.6 moves, with an average of 2 minutes and 54 seconds per loader move. Thus, from Table 2, we find an average of 568 tons for the first five loader units was loaded per machine shift with an average crew of 18.4 men. This gives 30.8 tons per man at the face.

## DISCUSSION

BY J. B. HASKELL

West Virginia Steel &amp; Mfg. Co., Huntington, West Va.

In selecting this subject, I am sure the program committee had in mind an efficient haulage system; the one you have just heard described is in that class and makes us realize some of the advantages gained by the advances in the design of track work. In my brief discussion, I will speak more of the haulage than some other phases of the mine system which were well covered in his paper.

The rail sizes that Mr. Anstead mentions are the sizes that are generally accepted as being correct for track-mounted equipment and the use of a No. 3 frog, which promotes easy, rapid turnouts, fits very well with a 45 degree room layout. There is something to mention in this connection that is very well known but it is so often ignored that repetition at this time might not be amiss. There are certain characteristics that make good track and too much emphasis cannot be placed on the determination of the correct rail size. Figured vertical strength alone, for carrying the load, usually indicates a rail too light for the work and actual practice has shown that modern cutting and loading machines demand a 40-lb. rail for rooms. This size with heavy steel ties, properly spaced, will provide a stable, stress-resistant foundation for the work that modern machinery must perform. There are quite a few instances of modern cutting and loading machines working on 30-lb. rail, but it is generally agreed that their full capabilities cannot be reached when so mounted. Of course, with the room track of 40-lb. rail, the entry track could well be made of 60-lb. and the main haulage track of 60-, 70-, or 80-lb. rail.

Granting that the proper size rail has been selected, the track that must be moved from place to place as the development and mine workings proceed, must be so designed as to be laid with the least possible labor. Recovery and moving costs should be low. To show what can be accomplished in this direction, a figure of fourteen labor hours has been accepted as quite common for laying a 40-lb. No. 2½ turnout on wood ties but now, by using all preformed parts and steel switch ties, many mines are doing this work in two labor hours. The No. 3 turnout would take slightly longer in time.

The paper gives a very good idea of what a quick turnover can produce in tonnage; each car is loaded approximately 14 times per shift so it is evident that there is very little time loss anywhere along the line. A cycle of 59 seconds per car is reflected in the profit. The length or distance per car change was kept to the low distance of 67 feet and the total tonnages averaged 30.8 tons per man; these figures

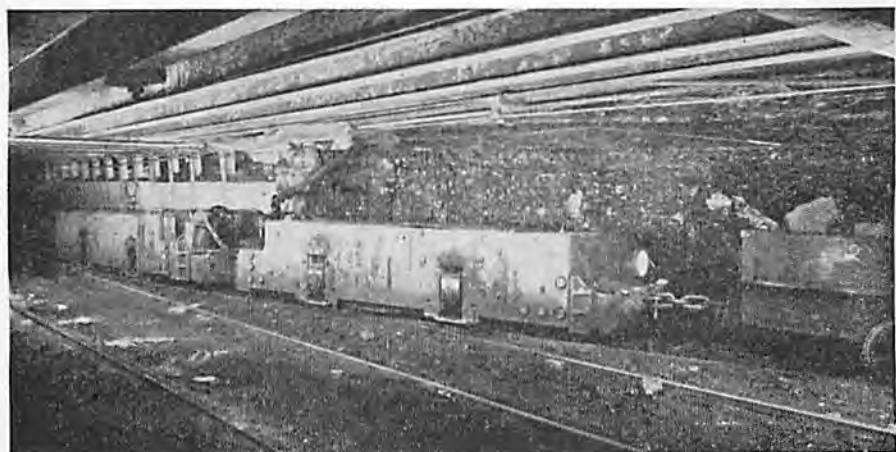
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indicate what careful planning and modern track equipment can do in the way of mining and moving coal.

Without adequate car supply, top production is impossible, so it follows that the haulage system should be so laid out that car supply tracks are now available at a minimum distance from the loading machine. Prefabricated track helps make this easier to realize, for with the time and expense of laying a turnout lessened, the turnout is more certain to be laid and not passed up because of lack of track layer's time.

Even if the track be well designed and properly manufactured, much of the coal moving efficiency that this track would possess could be lost because of improper installation. Properly installed trackwork permits good haulage speeds, lessens derailments, and lowers tramping time. Properly designed track-work recognizes and meets the needs of the rolling stock and mining machinery that is to pass over it. Nearly all of the elements that make for economical operation of track-mounted mining equipment are known to those who have the responsibility of that operation. Many elements are so small in themselves that they are often neglected, but it is quite possible, with modern design and with good attention given to each element of the trackwork system, to mine coal and move it quickly and economically on steel track.



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*Presented at The American Mining Congress, Cincinnati, Ohio, April 26-28, 1948.  
Reprinted from 1948 Yearbook "Coal Mine Modernization"  
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## BELT CARE AND MAINTENANCE

By J. A. BOTTOMLEY

Assistant Mine Supt., Sahara Coal Co., Harrisburg, Illinois

"Safeguarding Conveyor Belts" would probably be a more nearly correct title to this paper because that is actually our prime consideration. The belt, as it is received from the factory, is capable of doing the work for which it was intended, and with proper initial care its life will be as expected. As one belt engineer has said, in using a well-known slogan, "save the surface and you save all." Of course the amount of care in installation and the amount of money spent on an installation can only be determined after a careful study of the economics involved.

First, I will cover a few points on initial installation and handling of conveyor belts with some of the items to watch for and the resultant damage that may ensue. While many of these are well known to all of us, it will do no harm to refresh our memories.

### IMPORTANCE OF PROPER ALIGNMENT AND LEVELING

A permanent belt installation such as the main slope belt and some main haulage belts underground usually receive better initial care in installation than the secondary belts and room entry belts. Such permanent installations generally are favored with expert attention by the manufacturers of both the conveyor and the belt itself. Close attention is paid to loading and discharge points with reference to chutes and guards. Proper alignment and support of the structure is also taken care of which results in a good installation. Such is not the case with narrow underground belts which are being lengthened and changed at intervals. As they are only temporary as to their location, they are handled in such a way that they receive considerable abuse. Spillage from poor loading is usually the rule rather than the exception. Initial training is not carefully considered and as belts become worn and stretched, this becomes more difficult. Side guide idlers are often used to assist in initial training of a belt but caution should be exercised in their use as permanent injury to the edges of the belt may result.

The subject of training the belt is one of the most important to be discussed as poor alignment usually causes the first damage. As in the case of a new automobile, the hazardous period in the life of a belt is immediately after installation. If one portion of the belt runs off center at any point the belt is not cut squarely. If all portions run

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off center at a given point the equipment is at fault. Good practice underground dictates setting your conveyor on transit lines. Lining up by eye or getting an approximate location with reference to the rib is not good enough. The conveyor must be level laterally, that is, at right angle to the run of the belt in order to obtain proper training. It is a well known fact that the belt will travel to the high side, but it is surprising how little attention is paid to the proper leveling of the supports. Here again, because of a so-called temporary installation, too little attention is paid to the proper support of the conveyor. A permanent installation on wood blocks should be checked for level at intervals to guard against deterioration of the blocking and subsequent settling of the conveyor frame.

Self-aligning troughing rollers and return idlers are good when used for the purpose intended but I do not believe any manufacturer intended such a device to overcome poor installation or design of a conveyor. The self-aligning rollers and idlers do exceptional service when dirt collected on rollers causes the belt to move laterally. Off center loading which often occurs, will cause a belt to run to one side and here again the self-aligning devices are of great help.

The edge wear and damage to a belt due to improper training is very often the start of the destruction of a good piece of equipment. One company I know of insists that no installation or extension be attempted without an engineer's transit spads being placed on line from 25 to 50 feet apart. As the conveyor is extended two men follow along aligning and leveling the conveyor frame. As a result, when the last section is bolted in place, the entire extension is properly leveled and in line. With this procedure this company has been able to have a new installation of 42-in. belt conveyor operating perfectly under full load within an hour after completion. They state that only minor



*Excellent construction and maintenance characterize this belt installation*

adjustments of troughing rollers are necessary after the load comes on to obtain satisfactory training of the belt. Troughing rollers and return idlers are set from accurately measured 50-foot marks on the conveyor frame; these marks are located with a steel tape to insure the rollers being at right angles to the run of the belt.

#### PROTECTION AGAINST ROOF FALLS

Breaks and cuts in the belt are usually caused from falls of roof or large lumps of coal but if the loading chutes are properly arranged, little damage from lumps of coal will occur at that place. A common practice at loading points is to have a straight discharge on to the belt from right angles, with an attempt to control spillage with high sideboards. With such an arrangement the belt receives considerable impact from large lumps and center loading is almost impossible. A proper chute should turn the coal so it will fall parallel with the belt and thereby provide center loading and reduce the impact of the lumps. A good arrangement uses a counterweight so that the chute discharge may be kept close to the belt, but at the same time a large lump will raise the chute as it passes under. The counterweight should be a fixed arm with adjustable weights rather than weights hung on a rope over a pulley. If the rope breaks, the weight of the chute will be too much to raise and damage to the belt from a pile up of coal may ensue.

As a general rule, control wires are hung so as to be protected from damage with subsequent power interruption. One company does just the reverse in that they have their control wires running directly over the center of the belt so that the circuit may be easily broken. Their experience with falls of roof, which at times, has resulted in very serious damage to the belt, caused them to install the control wires where they would be easily broken. The two small wires are hung about eight inches apart so that any roof fall of importance breaks them and the belt stops immediately. In addition, they have knife switches in the circuit every 200 feet so that a conveyor may be stopped promptly if necessary.

#### REPAIR AND INSPECTION

The manner in which repair of cuts and breaks is handled varies considerably throughout the industry. Some companies prefer to do their vulcanizing on the surface in a shop designed for that purpose. Probably the most common procedure is to repair all but very serious damage underground. As a rule, panel belts receive scant attention and have few vulcanized repairs. Common practice is to repair with metal splice plates or as often happens, the bad spot is removed by cutting the belt and making a complete splice. The rubber manufacturers recommend the use of temporary patch material to exclude grit and moisture until permanent repairs can be made. This practice is followed by some companies but with such a repair the tendency is to let the temporary patch become permanent.

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One operator has a man to patrol all belt conveyors in the mine at least once each day. The inside belts receive additional attention and any adjustments necessary are made immediately. Breaks and cuts are vulcanized by their own crew as soon as possible after they are found. If a major damage occurs, such as a long cut where several day's work is involved, the repair may be made in their shop on the surface; otherwise, the repairs are made underground with the belt in place. In this way all repair work is kept up and no temporary patching is necessary. Some operators bring in one of the rubber company's expert repairmen at intervals to vulcanize cuts and breaks; with this arrangement, however, there is a tendency to put off work that should be done promptly due to the difficulty in making an immediate appointment with the repairmen.

#### SAFEGUARDS TO PREVENT DAMAGE

There is always considerable hazard at a loading point or transfer point that is unattended. Usually, some mechanical safeguard is installed to interrupt the control current and stop the belt, if a pile-up of coal, due to some obstruction, occurs. While the men may be cautioned not to load extremely large lumps, they are nevertheless loaded at times and the chute at a transfer point may be blocked; with a safeguard, however, when the coal builds up to a predetermined point it will trip a paddle or lever which breaks the control circuit. There are a number of ways that this may be worked out depending on local conditions but with numerous loading points on a main belt conveyor, some device to prevent overloading should be installed. One company has a switch under the belt which is actuated by the weight of the coal; if the load becomes excessive the switch shuts off the power to the belt delivering at that point. As soon as the load diminishes the circuit is closed permitting the side belt to resume operation. Another company has had considerable trouble with tail shafts and bearings breaking and in such a case if the belt is not stopped immediately, serious damage may result. They solved this difficulty by installing simple knife switches in the control circuit at the tail pulley, actuated by a wire fastened to the switch lever and the tail bearings. In the event a shaft or bearing breaks, the wire pulls the switch lever which breaks the control circuit and stops the conveyor immediately. Most companies interlock all belt circuits with a standard roller switch.

An unusual amount of wear on the carrying side of the belt may be caused by dragging the belt through coal at the loading points, at the tail pulley, or underneath on the return side. Belt speeds and chutes should be adjusted so that the coal runs smoothly on to the belt to prevent such excessive wear. Unusual wear on the pulley side of the belt is usually caused by slippage on the drive pulley or poor adjustment of troughing rollers and return idlers. Attempting to run a belt conveyor on extremely long centers with a single drive pulley or without enough tension, usually accounts for slippage. There are a number of factors which influence the selection of belt centers

and no attempt will be made to discuss them here. The practice of moving rollers from their correct right angle to the belt position to properly train the belt will account for considerable wear on the pulley side. This is a common practice and is much easier done than properly leveling and aligning the frame. Then, too, in handling, conveyor frames are bent and twisted so that leveling may be difficult.

In conclusion, I wish to repeat that maintenance of conveyor belts in a coal mine is essentially a job of safeguarding them. The nature of the work is such that they are subjected to all manner of hazards and for that reason "preventive maintenance is paramount."



*Presented at The American Mining Congress, Cincinnati, Ohio, April 26-28, 1948.  
Reprinted from 1948 Yearbook "Coal Mine Modernization"  
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## WHAT'S NEW IN COAL PREPARATION

By HENRY O. ERB

Preparation Consultant, Terre Haute, Indiana

The days of loading ROM or lump, egg, nut and slack are over. Markets are demanding many sizes and definite qualities of coal that must be prepared in plants of the best engineering design. Coal preparation has become an art and the progress made in the past 25 years has really been amazing. Mechanical loading has made it necessary to clean coal mechanically and today we are mining seams that, without keenly engineered plans, could not be marketed profitably.

Higher quality and *consistent* quality are now most essential; a variation in quality in a steam plant or home causes no end of trouble. The ever-increasing demand of stoker coals has also added greatly to preparation processes. Elaborate crushing and screening facilities have had to be built. Flow sheets have become quite complicated. A tippie or cleaning plant is now a "factory" making "tailormade" coals.

Coals for metallurgical purposes are becoming more scarce, and preparation plants, to prepare coals for this demand are being constructed. Efficiencies have improved, maintenance costs and loss of operating time reduced with improved designs and experience.

More knowledge of the limitations of equipment has been helpful and constant improvements in equipment are being made.

### BAUM TYPE JIG

The Jeffery Manufacturing Company, which markets a Baum Type Jig, has recently published a description prepared by Byron M. Bird of its new heavy-medium jiggling process, together with operation data. The new jiggling method involves two essential features:

(1) The circulation of a bone medium about  $\frac{1}{8}$  in. x 0 which fills the voids in the jig bed, in this way converting the jig into, in effect, a float-and-sink machine.

(2) The use of a type of jig stroke such that the entire separation takes place on the back, or suction, stroke. This type of stroke holds the medium in the bed and prevents washing it over with the coal.

The fundamentals involved in "back-stroke" jiggling, show that in theory it is a perfect gravity process, one that will effect a sharp

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separation over a great range of sizes. The jig must be operated with a minimum of water, just enough to transport the coal over successive compartments. After the operating details of using a "backstroke" separation were worked out, so that a heavy medium could be recovered and reused, fine bone of about 1.8 to 2.0 specific gravity was recycled back to the jig feed to form a circulating load. As most coals contain some laminated coal and refuse, this is commonly crushed and recycled with the bone medium. Some observations on the artificial heavy medium may be briefly summarized as follows:

(1) The jig medium acts over a size range from 8 in. to 100 mesh. For instance, the cleaning of the 48-mesh x 100-mesh sizes is greatly improved by its use.

(2) All sizes of the coal tend to be washed at one specific gravity. This observation conforms to theory, showing that backstroke jiggling has no sizing action.

(3) The crushing circuit used in conjunction with the medium is of great importance in liberating and recovering coal from laminated pieces.

(4) Seemingly, any difficulty of separation can be handled. Some data are given in the paper showing some difficult separations and Mr. Bird has reported by private communication that one plant is effecting an even more difficult separation than any shown in the paper. This is an example of effort to obtain greater efficiency.

#### BELKNAP WASHER

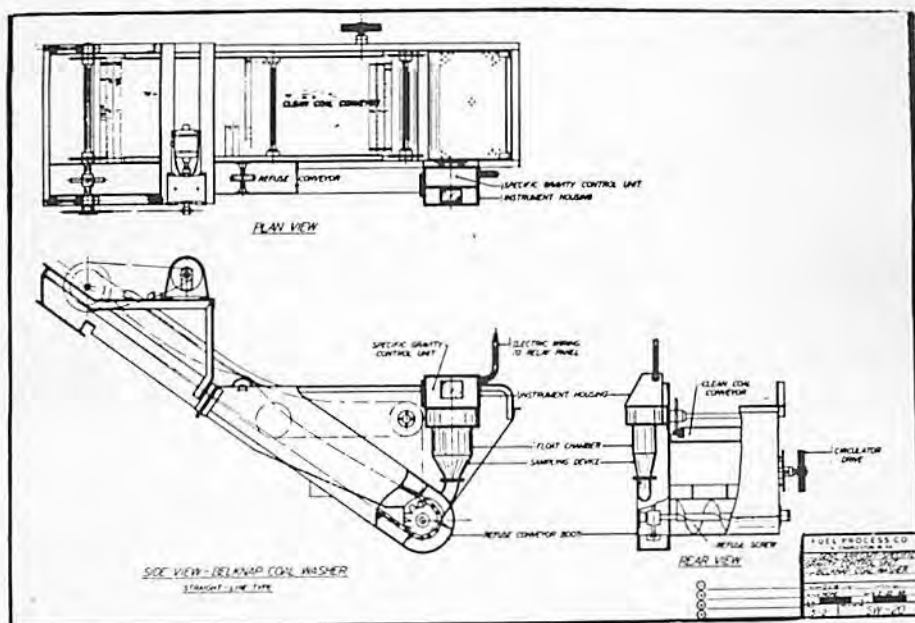
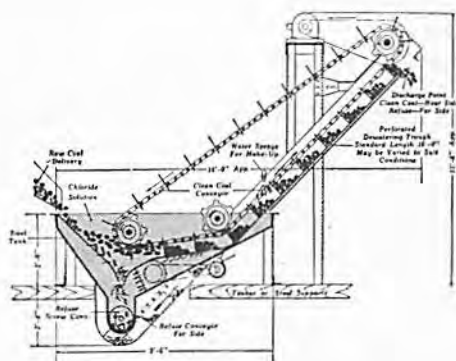
The principle of operation of the Belknap Coal Washer is a familiar subject to most coal preparation men. The process is generally grouped with the heavy medium systems. Separation of the coal to be recovered and the materials to be rejected is effected by circulating a solution of calcium chloride at a predetermined specific gravity within a self-contained washer unit. The coal is passed over a slot or "throat" and is collected and removed from the liquid by an inclined conveyor. The trough of this conveyor acts as a drainboard and excess solution is drained back into the washer tub. The heavier materials to be rejected fall through the slot or "throat" and are collected and removed by a second conveyor system, which also has a drainboard section to recover solution from the refuse being removed.

The effective specific gravity of separation within this washer is obtained by (1) maintaining the determined actual specific gravity of calcium chloride solution, and (2) adjusting the circulation flow so as to provide for the differential between the actual specific gravity of the calcium chloride solution and the *effective separating specific gravity* of the washer. The latter operation is comparatively simple since the valves, distributing vanes and speed of circulators are all adjustable and can be varied to suit the particular requirements of a given washing job.

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The actual specific gravity of the tub solution is maintained by adding water and calcium chloride in the proper proportions to correct for the loss of solution which is carried out by the coal washed.

Probably the most important of the recent improvements to the Belknap washer is a device to automatically proportion the addition of water and calcium chloride to the washer so as to maintain the pre-determined *actual specific gravity* and *level* of tub solution, and thereby increase the efficiency of the washer by eliminating the



Section and plan of Belknap Washer

errors which are apt to occur where the maintenance of these important factors are left to an operator with several other duties calling for his attention.

This control unit consists of a combined float chamber, instrument housing, and sampling device, located near the rear of the washer tub and directly above the refuse conveyor boot section. The float chamber is open into the refuse boot section at the bottom so as to allow the solution to flow upward through the float chamber and into the washer tub proper. This provides sampling of the tub solution at the same time allows the level in the float chamber to vary directly with the level of the tub solution.

The float chamber is provided with a dual float which is directly connected by linkages to a level control unit which, through a series of adjustable toggle switches, provides for the proper tub level by controlling the (1) normal water supply, (2) the auxiliary water supply provided in case of unusually heavy demand for solution, and (3) the level warning light.

A specially designed hydrometer floating between the cylinders of the dual float is adjusted so that the upper end of the stem, which is provided with a target, interrupts a beam of light within an especially designed electric eye unit when the pre-determined specific gravity of the tub solution has been reached. When this beam is interrupted a relay deactivates a solenoid valve in the calcium chloride supply line and stops the flow of calcium chloride to the washer tub. Flow of calcium chloride is resumed when the specific gravity of the tub solution lowers to allow the hydrometer stem to fall below the light apertures in the electric eye unit. Since the eye electric unit is mounted on the float, specific gravity readings of the special hydrometer are not affected by the level of the tub solution. The specific gravity of the tub solution is maintained with a maximum variation of less than .004 for these units in actual field operations.

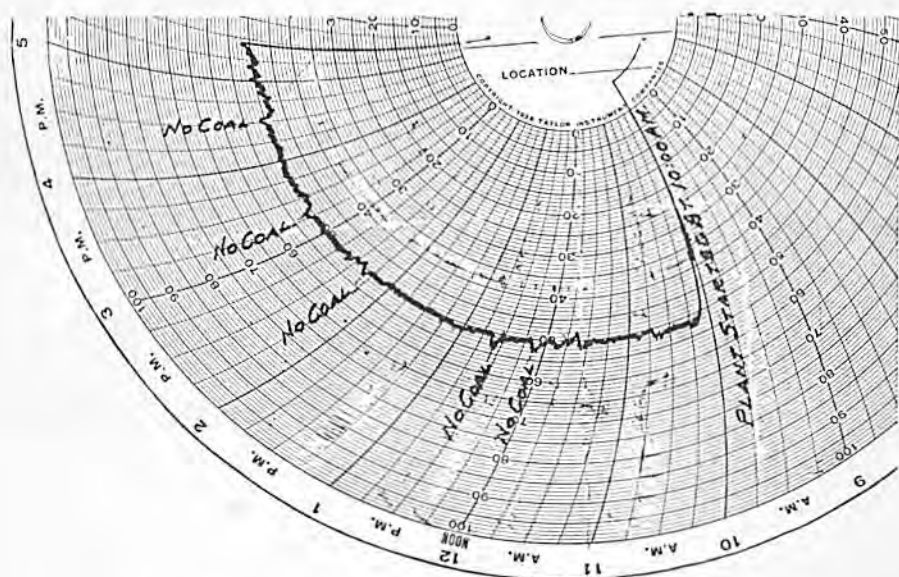
A relay type or a mechanically-operated type power cut-off switch (depending upon the installation requirements), is provided to cut off both water and chloride when there is no coal being delivered to the washer. This action eliminates the effect on the tub level of the washer being completely emptied of coal during shut-downs or intermittent operation.

The Automatic Control Unit eliminates the necessity of having an operator take a specific gravity reading at close time intervals, insures uniform separation, and provides fully automatic operation of the washer.

#### CHANCE CONE

In the case of the Chance cone, a recent development is a specific gravity control which automatically maintains a pre-determined specific gravity of the fluid mass at all times. This automatic control of the specific gravity is maintained by electrical controls which add additional sand as required for the purpose of maintaining a uniform gravity.

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*Chart shows one shift operation of Chance Cone*

This chart is a record of one day's operation.

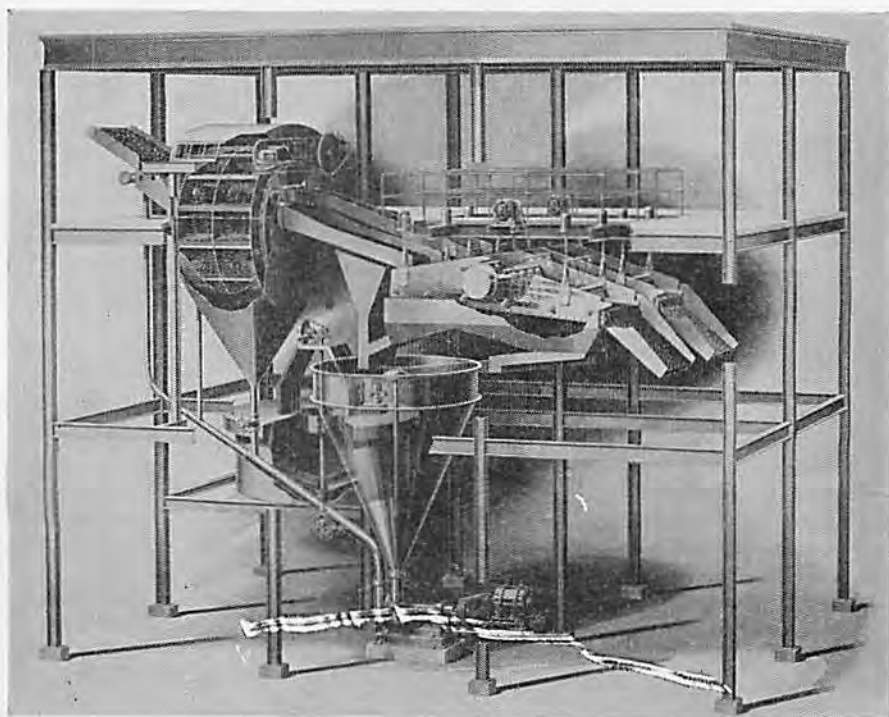
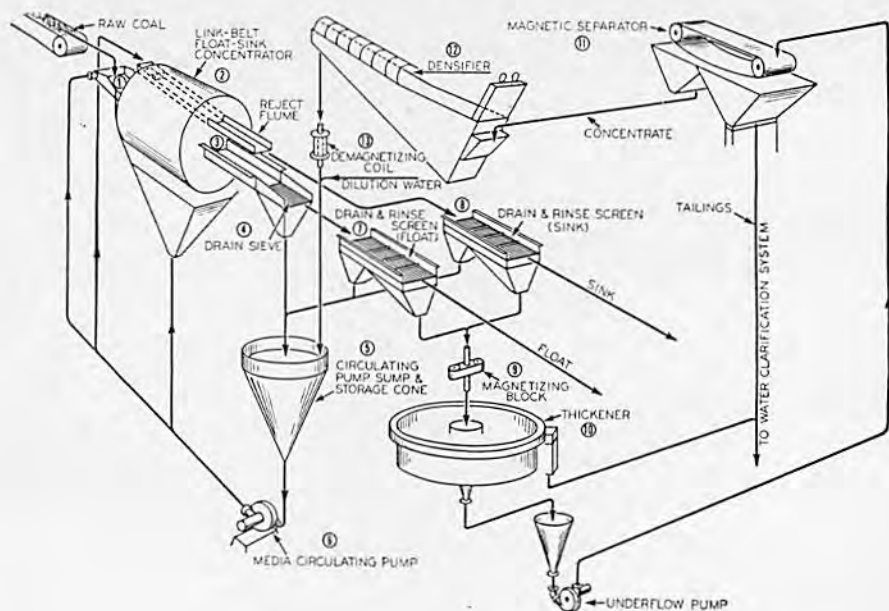
I am advised by the United Engineers and Constructors, Inc., that a three-product Chance cone has been developed, producing two coals of different qualities and a reject. There are several of these units in operation in England and South Africa and there are two plants now under construction in this country so designed that three products can be produced if desired. The plants now in operation are reported to be making excellent separation at gravities of 1.40, 1.40-S x 1.55-F, and plus 1.55.

#### HEAVY MEDIA SEPARATION

A comparative newcomer in the Heavy Media Separation field for coal are the processes licensed by the American Zinc, Lead & Smelting Company. The American Cyanamid Company is sole Technical and Sales Representative. These processes use magnetic ore ground to proper fineness as media. So far these processes are applied to sized coals with fines removed. Tests have been run using the heavy media in the Dutch State Mines Cyclone on fine coal with good results.

A pilot plant has been in operation at the Champion No. 1 Mine of the Pittsburgh Coal Company which was designed by the Link Belt Company. It is reported this pilot plant has been handling 200 tons per hour, capacity, being limited by equipment feeding the plant and refuse disposal.

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*Diagram and view of Link-Belt heavy media process*



Link Belt is now constructing a plant to wash  $4\frac{3}{8} \times \frac{3}{16}$  in anthracite for the Rhoads Contracting Company. The H. C. Frick Coke Company will also use this process at Robena using Deister Concentrator Company tables on the fines. The Nelson L. Davis Company of Chicago is designing a plant for the Jones and Laughlin Steel Corporation, also using the heavy media process and Concentrator tables on the fines. The following is a description of this plant that I believe is most interesting. Metallurgical coal and steam coal will be prepared; this means three products.

#### NEW J. AND L. PREPARATION PLANT

The new plant is located approximately forty miles south of Pittsburgh on the Monongahela River, not far from Brownsville, Pa. It will handle the combined output of Mines Nos. 4 and 5 which are being consolidated underground and equipped for 100% mechanical mining with total seam extraction. The mine's output to the cleaning plant will average 2,000 tons per hour over two 7-hour shifts per day, all of which will be mechanically cleaned after being crushed to a top size of approximately five inches, following which, the raw coal will be pre-sized over vibrating screens having  $\frac{1}{4}$  in. clear openings.

The  $\frac{1}{4}$  in. x 0 fraction will be cleaned by free discharge launders, the middlings from which will be re-treated over concentrating tables. The clean coal from the concentrating tables will be combined with the clean coal from the free discharge launders and the rejects from both launders and concentrating tables will be final rejects. Thus, a two-product separation of the  $\frac{1}{4}$  in. x 0 coal fraction is gained, the cleaned coal from which will be combined with the  $5 \times \frac{1}{4}$  in. metallurgical coal recovery by Heavy Media Float-and-Sink Process after the manner described as follows:

The  $5 \times \frac{1}{4}$  in. raw coal fraction will be treated by two stages of Heavy Media separation. The first stage results in separating coal from a final reject, which reject is comprised of sink material at 1.55 specific gravity. In this manner, all manual picking of the coarse coal sizes is eliminated since the first separation is accomplished by float-and-sink method in a highly efficient manner and down to the  $\frac{1}{4}$  in. size. Since the sink material only remains in the liquid medium less than one minute of time, contamination of the water system by colloidal clay material resulting from rock which rapidly disintegrates in water, is avoided. Meanwhile, the 1.55 specific gravity float coal is conveyed to a 7,000-ton capacity blending bin, from which the blended coal is withdrawn for the secondary stage of mechanical cleaning. Here the separation occurs at approximately 1.35 specific gravity, yielding a  $5 \times \frac{1}{4}$  in. metallurgical float coal, and a  $5 \times \frac{1}{4}$  in. middling. The metallurgical coal is then combined with the  $\frac{1}{4}$  in. x 0 clean coal fraction to form  $5 \text{ in.} \times 0$  final metallurgical coal product which is then conveyed to clean coal blending bin storage of 4,000 tons capacity preparatory to being loaded into river barges at the rate of 2,000 tons per hour.

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which make a separation at approximately 48-mesh size. The 48-mesh x 0 coal and process water goes to Dorr thickeners where the water is clarified and where the thickener underflow sludge is collected and pumped to vacuum filters, thus producing a clean coal filter cake at approximately 22% surface moisture.

Meanwhile, the  $\frac{1}{4}$  in x 48-mesh fraction is delivered to a battery of Carpenter driers which produce dried coal product containing approximately 6% surface moisture. The effluent from the Carpenter driers, along with the fine coal solids is filtered by a battery of Bird centrifuges which produce a filter cake containing approximately 23% surface moisture and a filtrate containing less than 6% solids of fine micron size. Thus, recirculation of the Carpenter drier effluent is avoided and this step of the process is considered essential to a closed water system which has been designed in such a manner that no effluent from it will be required.

The  $\frac{1}{4}$  in x 0 rejects, along with their processing water, are passed to a drag tank which has been designed to overflow minus 48-mesh solids. The  $\frac{1}{4}$  in. x 48-mesh rejects are recovered as underflow from the drag tank and are further dewatered by an inclined drag conveyor prior to joining the 5 x  $\frac{1}{4}$  in. rejects from the Heavy Media primary separation. The overflow water and minus 48-mesh solids are flumed to a Dorr thickener for the purpose of water clarification and the recovery of minus 48-mesh reject sludge which is filtered in Bird centrifuges prior to joining the rest of the plant rejects are then conveyed to a pair of 1,200-ton capacity reject bins for final disposal.

There are many other features embodied in this new plant, among which are the following:

1. The main washery building is only 45 feet above yard grade level and there are only two work floors, one two feet above yard grade and the other seventeen feet above yard grade. Thus, the plant is easily accessible and will be economical to maintain.

2. The three principle bays of the main washery building each have overhead bridge cranes which travel above the equipment and clearance is provided beneath the crane hook for the bodily removal of any single piece of equipment.

3. Blending bin storage is provided between primary and secondary Heavy Media separation and between the presizing screens and the fine coal cleaning plant. Thus, surges resulting from variation in the sizes either side of the  $\frac{1}{4}$  in. separation are leveled and averaged in the blending bins, so that a constant uniform feed of 5 x  $\frac{1}{4}$  in. coal is delivered to the secondary plant and similarly a constant uniform feed of  $\frac{1}{4}$  in. x 0 coal is delivered to the fine coal plant. This is a highly desirable feature because it results in economies for the processing equipment which can be provided to handle a uniform feed instead of widely variable peak surges. Furthermore, this arrangement of blending bin storage promotes means for continuous output from the mine in event of delays in the cleaning plant and, conversely, continuous output of the cleaning plant in event of delays in the mine.

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4. Automatic sampling is being provided for all products before and after cleaning and weightometers are installed with belt conveyors handling the raw coal feed, final rejects; 1.55 specific gravity float coal; 1.35 specific gravity float coal from the Heavy Media plant; 1.35 x 1.55 specific gravity sink coal from the Heavy Media plant;  $\frac{1}{4}$  in. x 0 raw coal to the fine coal plant, and  $\frac{1}{4}$  in. x 0 clean coal from the fine coal plant. Thus, a complete check of the performance for the plant and its operating efficiency, as well as the quality of the end products is gained.

5. The entire plant capacity is served by a series of individual, completely integrated, operating units, each one of which can be operated alone. There are eight of such units. Thus, the plant may be operated anywhere from one-eighth capacity to full capacity and any portion of the plant which is not in use, is therefore, not consuming power. This is highly important to a design for a plant of the magnitude of this one because in this manner it can be efficiently geared to current production demands.

You will note that this is a closed circuit plant, that is no water with solids leaving the plant. There is now pending in Congress a Stream Pollution Bill. Many of the states have also become stream pollution conscious. Future washers will have to be built to eliminate the discharge of any solids. Strip mines, of course, frequently use old pits.

If all the coal is wet washed as in the plant described, driers, thickeners and filters must be used.

#### NEW PLANT OF ISLAND CREEK

Another plant now being constructed for Island Creek Coal Co. by Roberts & Schaefer, merits description. This company operates numerous combination coal cleaning plants in which Stump boxes are used for the dry-cleaning part. Recently, in response to the insistence of their Sales Department, they decided to install a complete wet-washing plant in anticipation of lower ash clean coal and better recoveries. The fine coal cleaning plant chosen for their No. 24 Mine consists of the Hydrotator and Hydrotator Classifier combination with centrifugal drying in combination with heat drying for preparing the final dry low ash clean coal and maintaining a closed circuit water washing system.

The coal is screened dry in the existing preparation plant where the  $5 \times \frac{1}{4}$  in. size is washed in Link-Belt Launder Type Baum Jig. The  $\frac{1}{4}$  in. x 0 from the raw coal screens is delivered by sluice to the Hydrotator unit. This unit is of standard design with a 7 ft. diameter tank, a double deck  $5 \times 12$  ft. process screen and the usual pump and automatic refuse discharge equipment. The two decks of the process screen are fitted with  $\frac{1}{8}$  in. and 10-mesh screen wire cloth. The  $\frac{1}{4} \times \frac{1}{8}$  in. clean coal, in order to minimize degradation, by-passes the Bird continuous centrifugal filter and is delivered directly to the Raymond Flash Drier. The  $\frac{1}{8}$  in. x 10-mesh size from the Hydrotator is delivered

to the Bird Filter along with the Classifier cleaned coal. The minus 10-mesh material which recirculates as medium in the Hydrotator process is withdrawn in sufficient quantity to maintain uniformity of medium and is delivered to the Hydrotator Classifier. The Hydrotator Classifier is the standard unit with 14 ft. diameter tank and also having the usual auxiliary units consisting of pump, and the automatic refuse control mechanism along with the elevator but excepting the process screen. The clean coal from the Classifier side discharges with the accompanying water and the overflow, if any, from the Classifier are delivered to the Bird Filter along with the  $\frac{1}{8}$  in. x 10-mesh size previously mentioned. The Bird machine delivers dried coal to a conveyor which joins the  $\frac{1}{4}$  x  $\frac{1}{8}$  in. coal from the Hydrotator for delivery to the Flash Drier.

Refuse from both the Hydrotator and the Hydrotator Classifier is delivered to a conveyor which returns this material to the coarse coal washing plant for combination with the coarse coal refuse. The clarified water from the Bird Filter is returned to the circuit through a sump pump which pumps it to the coarse coal washing plant and an equivalent amount of water from the coarse coal washing circuit is returned to the Hydrotator plant so that systems are kept in closed circuit and in balance.

The cleaned and partially dried coal from the filters and screens is delivered to a Flash Drier which consists of an evaporating column combined with a cyclone dust collector. The heat for drying the coal is obtained from an ordinary combustion furnace fitted with a Pirite Stoker and burning dried coal for fuel. The dried coal from the cyclone collector is returned to a storage bin for combining with the various washed sizes from the coarse coal plant or to be loaded out as pulverizer fuel. The vented air and steam from the cyclone collector is, in turn, passed through an Air Tumbler. This Air Tumbler, manufactured by the Dust Suppression and Engineering Company, acts to remove the very fine dust particles from the air stream by water action and the resulting sludge is returned to the water circuit where the coal is recovered subsequently in the Bird Filter. The exhaust air from the Tumbler carrying steam and the very fine dust particles is vented to the atmosphere.

This plant, when in operation, is designed to deliver the lowest possible washed coal ash consistent with economic recoveries with the coal sufficiently dry to be handled in any of the modern types of combustion equipment. The regulation of the Flash Drier may be arranged to deliver the coal as low as 2% moisture or any increased percentage consistent with the handling characteristics of dried coal.

The Hydrotator process is effective in its washing to approximately 48-mesh bottom size and the cleaned  $\frac{1}{4}$  in. x 48-mesh combined with the recovered 48-mesh x 0 will result in a premium pulverizer fuel for the various markets served from this West Virginia zone.

One way to eliminate the wet fine coal problem is to clean the fines. Wet fines cause trouble in an air cleaning plant. One company is planning to eliminate the excess moisture by drying before air

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cleaning. In this manner drying costs should be reduced but there still must be dust collection.

Water clarification is a boon in coal washing and is expensive. Many have not made much attempt to prevent fines from leaving with overflow water because of the cost of recovery and quality of these fines. Some have made an effort to recover and clean these fines, but I believe more can be done and markets developed to use them.

Bituminous might well take a lesson from anthracite. In years past anthracite produced only coarse sizes. Most have seen the huge column banks. Legislation, development of burning equipment and shortage of fuel have changed the picture. I have a report prepared by Mr. H. R. Middleton of Wilmot Engineering Company that is most interesting. He states that the shipments of sizes smaller than "buckwheat,"  $\frac{3}{16}$  in. have increased from .8% in 1875 to 41.2% in 1947. In fact, the demand has exceeded the supply even though larger sizes are being crushed.

#### CYCLONE THICKENER

In connection with water clarification, the Bureau of Mines has been doing some fine work that shows great promise with the Dutch Cyclone as a coal slurry thickener or even as a fine coal dewatering device. The results of the work under the direction of Messrs. Yancey and Geer of the Bureau of Mines has been published in reports of the A. I. M. E. and give complete data.

The use of the Cyclone offers a low cost solution to the problems of (1) elimination of solids from process water, (2) concentration of solids from sludge tanks or cone underflows so they can be handled mechanically, and (3) as a preliminary dewatering device for fine coal. The second item would certainly be of tremendous value where settling ponds are used and have to be cleaned out frequently. Mr. Donald A. Dahlstrom, Instructor at Northwestern University, has also done some splendid work on this. His efforts have been mainly to eliminate solids from the process water, eliminating the silt and clay in the water which give the washed coal a poor appearance as well as affecting the rate of ignition of the coal.

#### BAUGHMAN VERTI-VANE COAL DRYER

Something new in the coal drying field is a revolving type coal dryer invented by R. G. Baughman and built by Robert Holmes & Bros. of Danville, Illinois. This dryer is a vertical type unit making use of a series of inner and outer conical shaped shelves opposing each other and capable of supporting a cylinder column of coal from the feed hopper at the top to the discharge opening at the bottom. The outside series of shelves being stationary are supported by eight pipe columns on foundation base, while the inner shelves are supported by six pipe columns mounted on a revolving table which moves at approximately one revolution per minute. By revolving the inside shelves they serve to feed the coal down from the hopper and give the wet mass of coal a gentle stirring during the drying process.

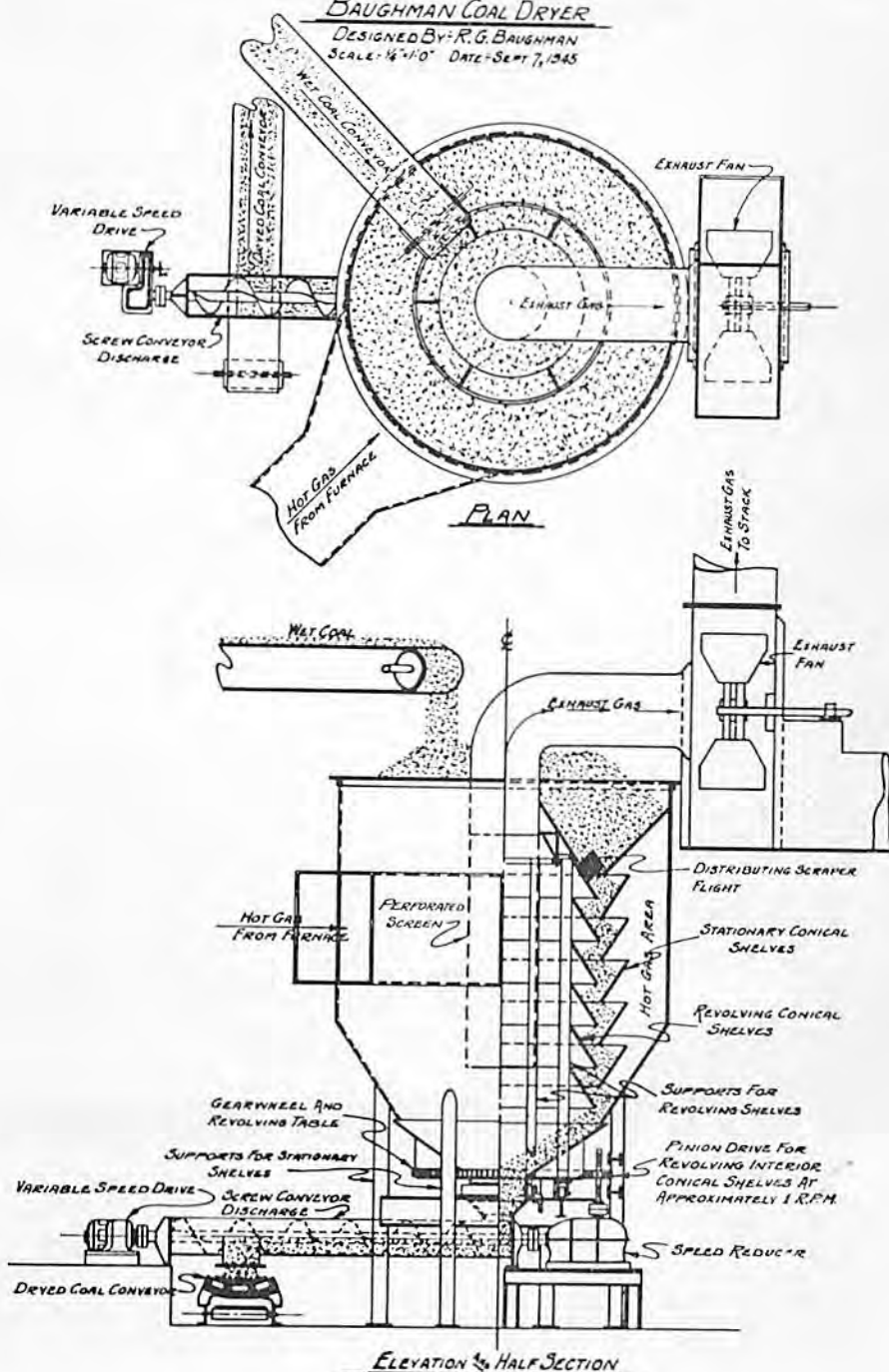
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BAUGHMAN COAL DRYER

DESIGNED BY: R. G. BAUGHMAN

SCALE: 1/4" = 1'-0" DATE: SEPT 7, 1945

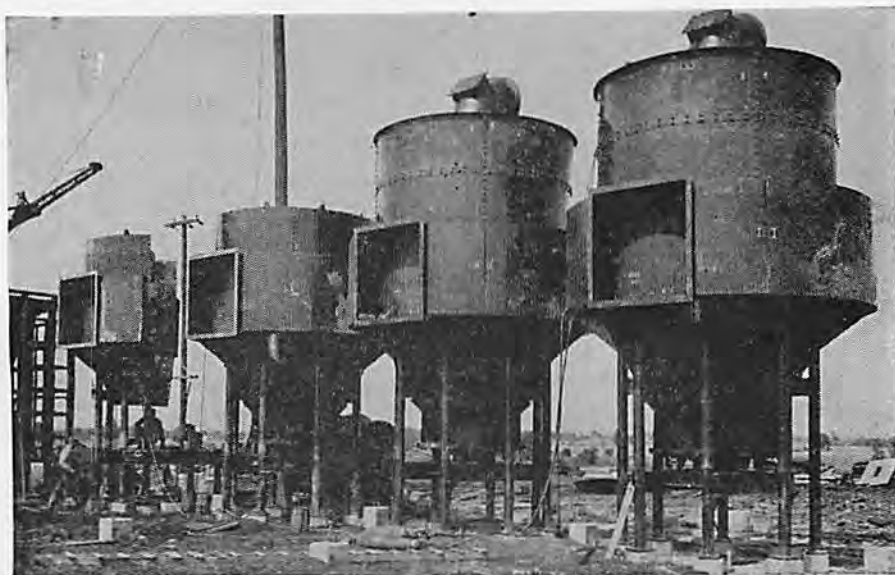




The hot gases are admitted on the side of the unit through a wide duct giving a manifold effect around the outside lowering shelves. Gases are pulled through the continually lowering mass of coal retained between the inner and outer shelves by the large exhaust fan located on top of the unit. The moisture-laden gases are exhausted directly through to the atmosphere. The dried product passes by gravity down through the center opening of the revolving table into a screw conveyor from which it is discharged into any type of conveyance desired to carry it to a point of loading.

This particular unit has many advantages not found in other dryers. It is claimed:

1. Degradation of the product is reduced to a minimum.
2. The slow movement of coal through the unit makes possible the use of low temperature gases, thus preventing the possibility of overheating the product.
3. The lower section of the dryer acts as a cooling chamber giving a cooler discharged product.
4. Vertical construction requires a minimum of floor space. For example a battery of these units may be set in line on 16 ft. 4 in. centers. The overall height is approximately 26 ft.
5. Uniform drying due to the smooth continuous flow of coal.
6. Fines may be left in product to be dried without need of dust collecting equipment.
7. High thermal efficiency.



*Baughman verti-rane dryers being installed in Indiana*

8. Extremely low installation and operating costs.

9. Low maintenance cost. (One unit has been in operation for 11 months at the Allendale Mine of the Central Indiana Coal Company near Linton, Indiana, and has required no maintenance whatsoever.)

Four of these units are under construction at the new "Maid Marion" Mine of the Central Indiana Coal Company at Odon, Indiana. Three of these will dry  $\frac{3}{4}$  in. x 1 MM and the fourth will dry  $1\frac{1}{2}$  in. or  $1\frac{1}{4}$  x  $\frac{3}{4}$  in.; each unit will handle 50 tons per hour. One furnace equipped with "Firite" stokers will supply heat to all four units; each having an exhaust fan driven by a 50 HP. motor. Each dryer drive is a 5 HP. Gear motor and the discharge screw conveyor has a variable speed drive with a 3 HP. motor.

In connection with dryers, I would like to call attention to a recent report presented by Orville R. Lyons and A. C. Richardson of Battelle Memorial Institute on "The Thermal Drying of Fine Coal" at the February meeting of A. I. M. E. This work was sponsored by Bituminous Coal Research, Incorporated, and the report is well worth your study if you have drying problems.

#### ACCESSORY EQUIPMENT

Sales forces are demanding up-to-date information on the qualities of the coals they have for sale. A producer must know what this product is. This means constant checking of products. Through the A. S. T. M. we have a set of standards for running all coal analyses. Some of these seem unwieldy for prompt results as well as expensive. One item for instance, is moisture determination. A committee has now been appointed to report on the use of the "Brabender" in which a number of moistures can be determined in about 15 or 20 minutes. This equipment has been used by some companies for several years and found reliable by their chemists. I believe A. S. T. M., in co-operation with the Bureau of Mines, should work up a standard of test procedures for rapid checking of washing results, something that will be uniform and not too complicated.

I understand a committee is now working to develop standard laboratory procedures for float-and-sink testing.

In connection with oil treatment of coal, the Viking Machinery Sales Corporation announces something new where high viscosity oils are required. This consists of a unit to keep the oil warm in the storage tanks and is also used for heating the oil in the tank cars for unloading. This arrangement heats and circulates hot oil and is completely automatic in operation. It eliminates the need for steam.

There have been many improvements in accessory equipment for coal preparation plants such as pumps, vibrating screens, etc., that are too numerous to discuss at this time.

In closing, I would like to state I believe the industry is fortunate in having progressive equipment manufacturers who are always striving to develop something new, with the cooperation of the industry, to improve the quality of our products in the face of keen competition of other fuels.

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*Presented at The American Mining Congress, Cincinnati, Ohio, April 26-28, 1948.  
Reprinted from 1948 Yearbook "Coal Mine Modernization"  
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## THE NATIONAL SCOPE OF RECLAMATION

By THOMAS C. CHEASLEY

Sinclair Coal Company, Kansas City, Missouri

I would like to review briefly the work of a number of organizations that have been mentioned here this afternoon, all interested in reclamation, and with their working representatives forming the Land Use Advisory Committee. Starting with Pennsylvania and the Mineral Producers Association represented by Bob Laing, moving into Ohio with the Ohio Reclamation Association represented by Larry Cook, then swinging into Indiana with the Department of Forestry and Reclamation with L. E. Sawyer we come to the Illinois Coal Strippers Association with J. W. Bristow and Lou Weber taking care of their interests. In Missouri we have the Missouri Coal Operators Association, of which I am secretary, and also the Reclamation Development Company, represented by Orel John. Kansas and Oklahoma have the Southwestern Interstate Coal Operators Association, and, the baby of the reclamation group, the Kentucky Reclamation Association. This has been organized since the first of the year, and is now functioning with Jim Moore as Field Director. They were fortunate in getting about 100,000 seedlings planted this spring. However, due to the lateness of the season, we are not too sure what the result will be.

I mention all of this to show you how the groups composed of your strip mining companies function as a unit through the Land Use Committee and the Land Use Advisory Committee, to get the job done on a national basis. The committees were formed with the object of helping one another, and I am speaking now of the help we can give each other in the matter of actual reclamation in the field; I know that all the groups in the organization can and will give assistance as and when needed. The trips made by the members of the Committee in the different reclamation areas have been the source of a lot of information on areas many of us knew nothing about.

Most of us are opposed to the word "leveling" in connection with the reclamation of strip banks. We feel it is the worst thing that can be done; that the porous bed thrown up by the shovel or dragline gives rain and snow a chance to penetrate instead of rushing away to the creeks; it gives the air a chance to penetrate to the roots and gives the roots a chance to spread rapidly. The porosity of the root bed or seed bed is probably the chief reason why we have the growth

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of so many species that are not expected to survive in contiguous so-called agricultural land.

The other reason, perhaps, is that the "deep plowing" brings up the minerals, the chemicals, the nutritional elements that are missing in the top soil; and with the combination of the moisture in the porous bed and these chemicals and minerals, we are perhaps, more fortunate than we know. Perhaps we can develop, as we go along, some information that will surprise Dr. Chapman and many others who are interested in this program.

Dr. Chapman and his field organization in the Central States Forest Experiment Station of U. S. Forest Service, have done a remarkable job and given wholehearted cooperation to us. Men like these give us new hope in the belief that Governmental agencies can spend tax money wisely.

To prove one point, with one slide, here is a case where Barberry thunbergi hedge was planted around the office building of a strip mine in Alabama, as you can see. The hedge was planted several years ago surrounding the office space. In one location, where a "dead man" had been buried at the time when the derrick was used for erecting the shovel for the operation, the hole which was dug for the "dead man" was filled with the excavated material before the planting of the hedge took place, and that was the only spot which had a porous root bed, enough to plant five or six plants. You will notice the difference in the growth in the picture, in the few years that that hedge has been planted, three to four times as great in the porous bed, and, I think you will agree that if we had planted on this type of soil, compacted by leveling, we wouldn't have had the results to show in our reclamation work.



*Many lakes are formed in strip pits*

*Presented at The American Mining Congress, Cincinnati, Ohio, April 26-28, 1948.  
Reprinted from 1948 Yearbook "Coal Mine Modernization"  
through courtesy of The American Mining Congress.*

## PROGRESS IN COAL HAULAGE

By LESTER E. BRISCOE

Electrical Engineer, Ayrshire Collieries Corp.  
Indianapolis, Indiana

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In 1946 the total bituminous coal and lignite mined by open-cut methods in the United States exceeded 109,000,000 tons. It has been fairly conservatively estimated that at least 90 per cent of this tonnage was hauled by trucks, either entirely or in part, from coal face to preparation plant, to transfer point or to conveyor, or direct to consumer. With this predominance of truck haulage some of the facts and conclusions developed from experience in actual operations with which I have been associated, are worthy of presentation.

### VARIED HAULAGE EQUIPMENT MEETS SPECIAL CONDITIONS

Six strip mines are in operation by the Ayrshire Collieries Corp. and another mine is now under construction. All of these mines are now using or will use trucks to haul the coal, in part or entirely, from the pit to the preparation plant. At each mine the coal is transported from the pits by trucks, first over the coal berm and then over company owned roads to a common transfer point or directly to the hopper preparation plant. At the Ayrshire and Patoka mines, the coal is loaded from the trucks into railroad cars, thence by rail to the preparation plant.

A total of 60 trucks with a combined capacity of 1,461 tons are in operation at these six mines. At the Harmattan mine, now under construction, it is proposed to use seven 20-ton trucks. This decision was made for two reasons: first, because part of the coal will be loaded into trucks on the fire clay; second, due to the short distance from the coal face to the preparation plant hopper..

A tabulation of the number of coal hauling units in use at the mines of the Ayrshire Collieries Corp. are shown in Table 1. At the Ayrshire mine, coal from the pits is hauled on contract. All of the mines, except the Ayrshire and Patoka mines, use trucks powered by Diesel engines. At these two mines, gasoline engines are still in use. The Autocars at the Patoka mine were originally at the Delta mine and have been converted from Butane to gasoline. The reason for the conversion was to eliminate the necessity of moving the Butane storage equipment for the short anticipated life of the trucks

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at the Patoka mine. The haulage equipment at this mine was purchased in 1934 to 1937 and plans call for replacing this equipment in the near future with Diesel-powered coal haulers. The Flamingo mine Dart trucks were originally powered by gasoline but were converted to Diesel engines during 1947. This is also true of the Autocar trucks now in use at the Clinton and Flamingo mines.

TABLE 1—COAL HAULAGE EQUIPMENT OF AYRSHIRE COLLIERIES CORPORATION

Mine	No. Units	Tractor	Trailer	Tons Capacity
Ayrshire .....	9	International .....	United Iron Works .....	20
Chinook .....	8	Euclid .....	Euclid .....	32
Clinton .....	1	Autocar .....	Austin-Western .....	20
	6	Euclid .....	Euclid .....	20
Delta .....	5	Euclid .....	Euclid .....	32
Flamingo .....	2	Autocar .....	Austin-Western .....	20
	6	Dart .....	Austin-Western .....	25
	2	Dart .....	Austin-Western .....	30
	5	Euclid .....	Euclid .....	20
Patoka .....	9	International .....	Sanford-Day .....	30
	7	Autocar .....	Sanford-Day .....	15
Harmattan .....	7	Euclid .....	Euclid .....	20

All Diesel trucks have Cummins engines. The Cummins 200-hp engine is used in trucks having a capacity of 25 tons or more and the Cummins 150-hp engine is used in 20-ton capacity trucks. The first Diesel-powered trucks were purchased during World War II and, being inventory-minded, the company has requested Cummins Diesel engines on all trucks that have been ordered since 1945. Now the company has, including one spare of each size, 44 Diesel engines. Five of these Diesel engines are in trucks used to haul refuse from the preparation plant.

Experience has shown a considerable saving in truck operation by converting from gasoline to Diesel power, because less fuel and cheaper fuel is consumed. In no case has it been found necessary to employ special Diesel mechanics to replace garage mechanics formerly used to make adjustments and repairs on gasoline or Butane powered trucks.

Details of actual operations of Euclid 20-ton and 32-ton coal haulers are shown in Table 2. In order to get a true comparison of



the two units, it is necessary to correct the truck cycle time due to the size of the loading shovel used. If this is not done, the time to load the truck is considerably more when using a two-cubic yard loading shovel than when using a  $7\frac{1}{2}$ -cu.-yd. loading shovel. This comparison is made on the assumption that a  $7\frac{1}{2}$ -cu.-yd. shovel is used for both sizes of coal haulers.

Each mine has its own problem in haulage-road cost and maintenance. For example, at one mine it is possible to use refuse from the preparation plant for maintaining the haulage roads, although at another it is necessary to purchase crushed stone or gravel. There are many such variables and for that reason, truck roads are left out of this cost-per-ton-mile calculation.

#### PERMANENT HAULAGE ROAD INSURES TROUBLE-FREE OPERATION

A description of the construction of a permanent haulage road from the edge of the coal to the preparation plant hopper might be of interest due to its importance to cycle time. Various conditions in the pit haulage road change from day to day, therefore pit road is omitted. The major portion of the haulage road at the Chinook mine is a well-maintained, permanent road constructed through spoil banks made several years ago. The subgrade was made during the winter season with a three-cu.-yd. dragline and bulldozer. The drainage ditches alongside the grade were made with the bucket of the dragline



*Loading a 32-ton Euclid coal hauler*

and are usually as wide as the bucket. All slopes of the cuts through the spoil banks vary as to the material encountered. The base material for this road was refuse from the coal washing plant, usually placed in two lifts. Crushed stone of 2 by  $\frac{3}{4}$  in. size was then applied  $4\frac{1}{2}$  to 6 in. thick, and bound to the base material by truck traffic. Final surface material was then applied, consisting of minus  $\frac{3}{4}$ -in. crushed stone  $1\frac{1}{2}$  in. thick. The road is maintained daily, especially on hoist day, by a Caterpillar No. 12 motor grader.

Maximum plus grade of 5.15 per cent is encountered by the loaded truck, but the average plus grade is 2.45 per cent for No. 1 pit and 3.42 per cent for No. 2 pit. The plus grade is encountered by the trucks on leaving the coal edge as they go up the incline to go through the spoil banks. Approximately 50 per cent of the total haulage road, a distance of one mile, for pits No. 1 and No. 2, respectively, is a minus 1.25 per cent grade from the highest point on the road on the spoil banks to the preparation plant hopper. Trucks from No. 1 and No. 2 pit use the same road for approximately the last 2,500 ft.

High speed operation of the Euclid 32-ton trucks is obtained even under adverse weather conditions because of an excellent road maintenance program, good visibility, and a road width ample for two-way travel throughout.

#### STUDY OF OPERATIONS PROVIDES COMPARATIVE DATA

In referring to Table 2, actual cost per day's operation for both Euclid 32-ton and 20-ton coal-haulage truck, for given distances, is shown. Information for this tabulation has been obtained by actual time study of truck operation. The only correction necessary is the loading time of the truck. It is assumed that a  $7\frac{1}{2}$  cu. yd. coal-loading shovel is used to load both sizes of trucks. It might be well to point out in detail how the costs in this tabulation were determined.

*Number of Units Required*—A mine requiring output where seven 20-ton units or five 32-ton units are necessary to give desired tonnage is assumed.

*Cycle Time*—From actual time study.

*Tons Per Unit Per Day*—It is assumed the truck will operate  $7\frac{1}{4}$  hrs. per day and to haul rated capacity.

*Truck Costs Per Unit*—The Euclid Road Machinery Corp., Cleveland, Ohio, quotes vehicle price as of February 15, 1948. The price is reduced five per cent for cash ten days.

*Garage and Tool Cost*—The truck garage at the Chinook mine is considered to be the latest word in storage and repair shops of its size for coal haulers. This garage is equipped to handle practically all repair work on the eight 32-ton trucks used at this mine. This garage is a steel fabricated building with concrete floor and overhead doors to permit the trucks to drive through. It is equipped with steam unit

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TABLE 2—EUCLID COAL HAULERS

Truck Operating Cost—7¼-Hr. Day, 220-Day Year		
Units required .....	7	5
Model of unit .....	27FDT-72W	39FDT-95W
Capacity .....	20 ton	32 ton
Haulage distance (round trip) .....	6	4
Cycle time—90 per cent efficient .....	25.95	21.50
Number of trips, 7¼ hr. ....	16.80	20.30
Total tons, 7¼ hr. ....	336.00	650.00
Miles, 7¼ hr. ....	100.80	81.20
Truck unit cost .....	\$18,667.50	\$25,935.00
Garage and shop tools (5-7 unit) .....	\$15,500.00	\$15,500.00
Diesel fuel .....	\$4.96	\$4.31
Motor oil .....	\$4.44	\$4.49
Transmission, differential, and general lubrication .....	\$1.17	\$1.17
Replacement parts .....	\$3.06	\$4.43
Tires and tubes .....	\$9.58	\$12.18
Garage labor .....	\$5.43	\$7.60
Truck Operators .....	\$15.34	\$15.34
Depreciation:		
Truck unit .....	\$17.00	\$23.60
Garage and shop tools .....	\$67	\$94
Interest, taxes, and insurance—Truck units, garage, tools, and truck inventory .....	\$3.37	\$4.62
Fixed charges .....	\$1.13	\$1.58
Total .....	\$61.15	\$75.26
Cost per ton .....	\$1.825	\$1.155
Cost per ton mile .....	\$0.0304	\$0.0289

heaters and automatic temperature control. The steam for the unit heaters is obtained from the boilers in the preparation heating plant.

*Fuel Oil*—Records show the 32-ton truck to operate on a fuel consumption of approximately 2.8 miles per gal. and the 20-ton truck to operate on three miles per gal. These amounts are the averages for several months' operation.

*Motor Oil*—Each of the Diesel engines is equipped with a No. 750 Lubri-Finer. The changing of the oil in the crankcase has been standardized to take place at the end of twelve 7¼ hr. shifts and the changing of the oil filter element after 36 shifts. A normal amount

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*A fleet of six International tractors with United Iron 20-ton trailers*



*A 20-ton coal hauler at Clinton Mine powered with a 150-hp Diesel*

of oil required to be added between changes is taken into consideration in determining the daily cost of motor oil.

*Transmission, Differential, and General Chassis Lubrication—*This information is based on changing the oil in the transmission and differential twice a year and a general lubrication of truck chassis twice a week.

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*Replacement Parts*— The use of Euclid coal haulers and Cummins Diesel engines has been most successful. Past experience shows that it is best to base unit repairs and anticipated repairs on 6,500 hr. for the HB-600 engine before a complete motor overhaul. Four years represent 6,390 hr., assuming a normal 220-day operating year. Average hourly repair cost on this type of equipment, not including labor, is 34 per cent of the purchase price of the unit divided by 15,000.

The first fleet of Euclid 32-ton coal haulers for Ayrshire Collieries was placed in operation during December 1945. Although it has not been necessary to completely overhaul the engine on this size unit, it is believed that the larger engine will require an overhaul at more frequent intervals than the smaller size. For this reason, an overhaul every two operating years is assumed. Average hourly repair cost, not including labor, for this size of equipment, is approximately 34.7 per cent of the purchase price of the unit divided by 15,000. Thus, the



*A 40-ton Euclid coal hauler with a 275-hp Diesel*



*Two 32-ton capacity trucks equipped with 200-hp Diesel engines*

average hourly repair cost on the tractor and trailer units is 60c for the 32-ton unit and 42.4c for the 20-ton unit.

*Tires and Tubes*—In order to obtain tire and tube cost per day, it is necessary to assume the normal average life of the tire and that the tube would be replaced when a new tire was installed. For practical purposes, it is assumed that 25,000 miles is the average life for all tires 16.00 by 24 in. and smaller and 35,000 miles is the average life for tires over 16.00 by 24 in.

*Shop Labor*—Two truck mechanics are employed for a fleet of five to eight trucks. One mechanic is employed on the day shift, which is the first shift, and the other on the second shift. The second-shift mechanic is on duty when the trucks are not in operation. In order to figure the correct shoplabor cost, the mechanic's vacation pay of \$100.00 per year is added to his normal earnings. Earnings include some overtime at  $1\frac{1}{2}$  times the hourly rate. The garage mechanics work on other mine equipment as well, and it may be estimated that the time spent on such equipment more than compensates for additional labor that might otherwise be required from time to time to assist them on repairing coal-haulage equipment.

*Truck Operator*—A normal day of  $7\frac{1}{2}$  hrs. has been assumed. To this a daily portion or  $1/220$  of his vacation pay of \$100.00 has been added.

*Truck Unit Depreciation*—The truck unit is depreciated on the basis of 20 per cent per annum.



*An International tractor—200 hp—used at Blackfoot Coal and Land Corp.*



*Garage and Tools Depreciation*—In this connection, garage and tools are depreciated over a 15-year period.

*Interest, Taxes, and Insurance*—Each mining company probably uses a different method of determining the charges due to interest, taxes, and insurance. In order to establish this daily cost, consideration was given to the total initial investment of each truck, including garage and tools, and the average truck inventory per unit.

*Fixed Charges*—Without a doubt, the truck operation should be charged with a portion of the fixed overhead charge of the operating company. The portion of the daily fixed overhead charge which is chargeable against the truck operation used in this tabulation is determined by taking that percentage value of the coal haulage equipment of the total value of capital equipment as the ratio.

From this information it is a simple matter to calculate cost per ton and cost per ton mile. Note that for the 32-ton unit the cost per ton mile is 2.89c for hauling coal a distance of four miles round trip, and, for the 20-ton coal hauler, the cost per ton mile is 3.04c for hauling coal a distance of six miles round trip.

#### LARGE TRUCKS GIVE LOWER COST PER TON

From this data, it is then possible to arrive at a cost per ton mile for Euclid coal haulage units of 32- and 20-ton capacity for various distances. Actually, from these particular operations one may obtain

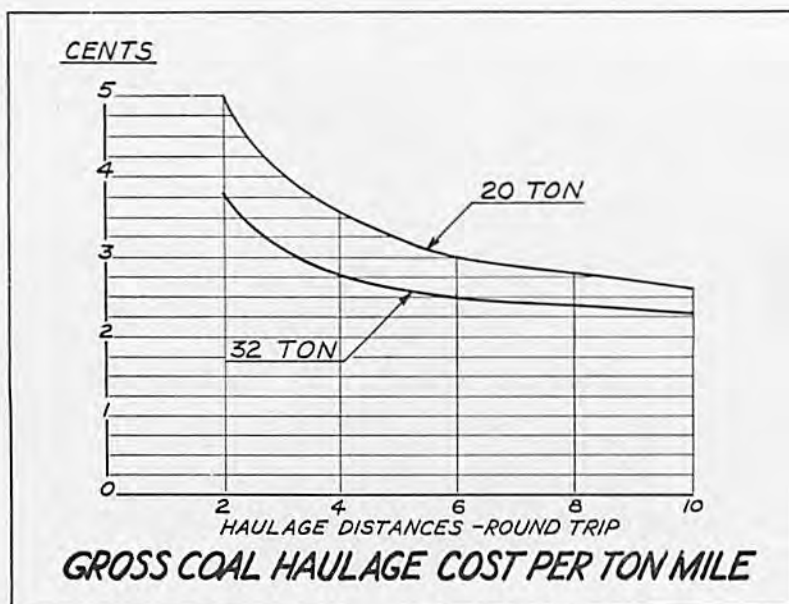


Fig. 1.

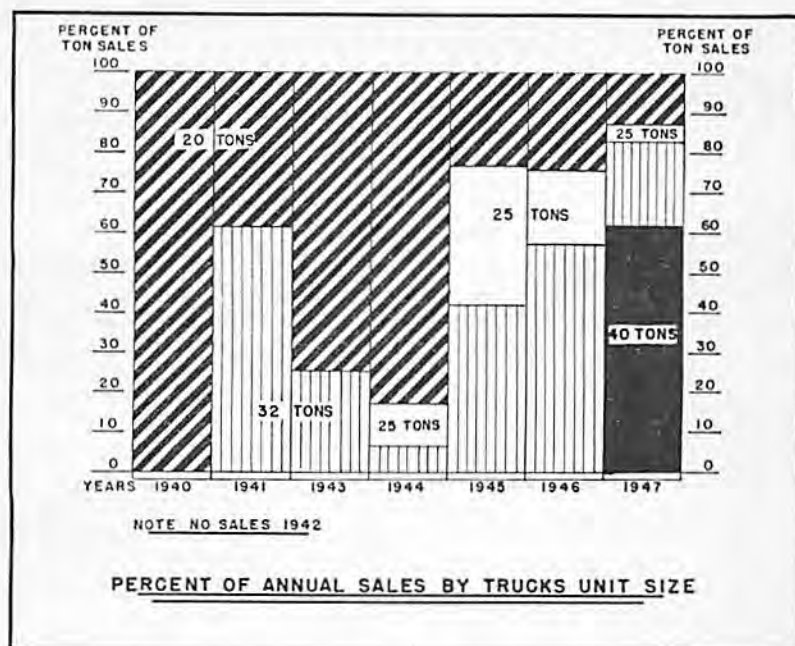


Fig. 2.

two values on each curve as shown by Fig. 1. Additional points on the curves are obtained by correcting haulage cycle time for loaded and empty trucks at a constant rate of speed, assuming this part of the haulage road to be a fairly level road. Actual maximum truck speed, loaded and empty, is not used but is reduced 20 per cent. The results thus obtained definitely show the 32-ton unit will haul coal more profitably than the 20-ton coal hauler for any distance where conditions are similar to those outlined.

Haulage-road construction and maintenance costs have been eliminated from the above operating cost per ton mile. Both of the coal hauling units referred to require well-constructed, well-maintained roads for satisfactory performance. Any coal hauling unit depends to a great extent on the condition of the haulage road for the time required to make a complete cycle. The larger unit, without doubt, requires somewhat better constructed roads and slightly higher road maintenance costs. The initial cost of the road construction should be proportioned to the life of the mine and probably road maintenance should be proportioned to an annual or daily charge. Experience has shown the 32-ton unit to require only a slightly higher road-maintenance-cost per ton mined in comparison to the 20-ton unit. At the various mines of Ayrshire Collieries, even though hauling coal with the same capacity unit, the haulage-road maintenance cost may vary from a

minimum of 2c to a maximum of 5c per ton of raw coal hauled. Haulage-road construction and maintenance costs for the 32-ton truck would never be great enough to overcome the cost spread by which coal may be hauled in comparison with the 20-ton unit. The smaller unit has its place in the strip coal industry and will continue to be used for many years.

Haulage equipment trends, especially through Ohio, Indiana, Illinois, Kentucky, and Missouri, have been towards larger-capacity coal haulers, anticipating increased tons per unit at lower cost per ton mined. This statement may well be expressed by a composite graph, Fig. 2, showing annual sales of coal-haulage equipment to the coal stripping industry of one truck manufacturer from 1940 through 1947. During World War II, probably all coal mining companies, in their purchases of equipment, were forced to sacrifice design and size due to government restrictions even though the coal mining industry had a high priority rating.

Strip operators since 1945 have shown a definite preference towards the 30- to 40-ton coal-hauling units. This applies to mines using off-the-highway truck trailer units.

The strip mining industry welcomes competition of new manufacturers of coal-hauling vehicles. It is necessary to have equipment to transport additional coal more profitably due to shorter work days and increased labor costs. The truck manufacturers have always been capable of meeting our demands. Looking somewhat into the future, truck manufacturers may be expected to continue meeting requirements.



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Reprinted from 1948 Yearbook "Coal Mine Modernization"  
through courtesy of The American Mining Congress.*

## LAND RECLAMATION BY ILLINOIS COAL STRIPPERS

By J. W. BRISTOW

Secretary-Treasurer, Illinois Coal Strippers Association  
Chicago, Illinois

The reclamation of land overturned by stripping shovels is now a general practice of Illinois coal strippers. There was little concerted effort along this line in Illinois prior to 1937, largely because the attention of our operators was directed toward the development of more economical mining methods, the perfection of preparation processes, the development of permanent markets for their product, and the acquisition of coal reserves with which to supply them.

As these problems were solved and the mined out areas increased in size, it became apparent that some profitable use would have to be found for these residuals of mining operations. Their unproductive status was not only a waste in the public economy, but tax accruals on an increasing large acreage, depleted of value, and a combined operator and public concern for the long range tax obligations of such holdings, served to make the restoration of productivity to these lands one of the important objectives of the industry.

A large scale attack on the problem was launched in 1938. At that time foresters and agronomists could supply no information whatsoever on the subject of plant species that might be successfully grown on recently exposed soils that had lain far below land surfaces through geologic ages. There were no sign posts pointing the way to profitable uses for such soils except large areas naturally revegetated by wind borne seeds of trees and grasses and two small forestry projects not sufficiently advanced to throw a great deal of light on the subject. However, starting with these indicators, a rehabilitation program was inaugurated, under which as of April, 1947, forestry, stock range and horticultural projects had been initiated on 23,437 acres of mined over land.

### FORESTRY

Up to this time 11,400,000 forest tree seedlings of some 35 different species have been planted on 10,725 acres of spoil banks in Illinois. A majority of these plantings have been successful, and where the species of trees selected were adaptable to the soil composition of the planting sites, survival and growth rates have outstripped that of similar species planted on undisturbed lands.

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One plantation of 40,000 black locust seedlings in southern Illinois established in 1938 is now producing fence posts six inches in diameter at shoulder height, and over the past three years has produced about 2,500 posts used for fencing a 600-acre stock range on the owner's property. Many species of pines have made phenomenal growth. In some instances plantings made in 1938 range from 14 to 16 feet in



*Locust posts — 8 years' growth*

height and are extending their growth at the rate of 18 to 20 inches each year. Walnut, ash, cottonwood, sweet gum, and other hardwoods have also shown prolific growth and there is every indication that these species will produce valuable lumber or pulp wood crops.

As might be expected of experimental work directed by engineer trained personnel, a number of the earlier plantations failed completely. The behavior of a number of species planted on spoil banks was quite different from the growth rate and form of trees established on undisturbed land surfaces. In some cases where survival ratios were satisfactory the growth rates were slow and trees so deformed as to indicate that their ultimate value would only be for pulpwood.

In several instances, as the result of errors in shipment of nursery stock, trees were planted far out of their natural range and habitat; and for reasons yet to be determined, are flourishing equally as well as if planted in their natural range.

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Among these, jack pine, native to Michigan, Wisconsin, and Canada, grows well on some southern Illinois sites when planted on high, well drained spoil banks. Sweetgum, native to low, moist soils subject to overflow, has given practically 100% survival and growth rate and form equal to that found in its natural range. Willow and cottonwood, also sycamore and other species natural to low moist sites have propagated naturally on high drained banks and in many cases are now ready for harvest as pulpwood crops.

These random observations indicate that the forestation of spoil banks has many unknown factors and is far more complicated than simply planting species native to an area. To be successful this work must be carried out under the supervision of career foresters capable of analysing soils, selecting proper planting sites, appraising the results obtained and developing the "know how" essential to profitable returns.

#### FORESTRY RESEARCH

Experimental work designed to develop a scientific approach to the problem of spoil bank rehabilitation has been under way in the Central States Forest Experiment Station of U. S. Forest Service since 1945. Illinois operators have cooperated 100% with the Station in this work, and have provided planting sites, forestry seedlings and labor for establishing 30 experimental plots on which 51,000 trees of 35 different varieties have been planted in different sections of the state. Studies of these experimental plots, combined with studies of tree growth and behaviour of the 10,725 acres already planted, will not only develop a scientific planting technique for spoil banks, but will indicate whether areas should be reclaimed by forestation or for some more profitable use such as stock range or horticulture.



*Steers raised on spoil bank pasture*





*Short leaf pine—nine years old*

It is much too early to attempt to calculate the dollars and cents returns which will be obtained from forestation work, but unquestionably the policy of planting trees on lands adaptable to no other form of productive use is four square with sound conservation practice.

#### PASTURE DEVELOPMENT PROGRESS

The conversion of spoil banks into stock range was pioneered in Illinois. This form of land use has proved in some cases to be so successful that many operators have turned almost exclusively to sowing forage grasses on their mined areas. As of the spring of 1947, more than 13,000 acres had been seeded with grasses, and legumes.

In the present year 3,500 acres previously given preliminary seeding of sweet clover and other legumes were planted with permanent pasture mixtures and an initial seeding of 1,600 acres of recently mined land was made by airplane and helicopter broadcast methods. In all, some 15,600 acres of Illinois spoil banks have been either successfully revegetated with pasture grasses, or are well on their way toward productive use for stock range purposes.

#### THRIFT OF ANIMALS GRAZED ON SPOIL BANK PASTURES

The annual returns from about 4,000 acres of this land, some of which has been in pasture since 1938, have not only long since repaid all costs of development, but are continuing to make annual returns much higher than average Illinois pasture lands. The carrying capacity of spoil bank stock ranges and the phenomenal growth and rapid

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gain of cattle, sheep and hogs ranged on them are difficult for agronomists and stock men to believe. A few random instances will illustrate this point.

One 600-acre range carried 248 head of cattle through the summer of 1947. Among these were 107 steers averaging 570 pounds in weight when first turned into the range about October 1, 1946. These steers were pastured until November 1, 1946, then turned into stalk fields for 60 days to clean up corn left by picking machines, and then placed on light feeding of corn silage and hay for the balance of the winter, a period of 100 days. They were return to the range on April 10, 1947, and after 143 days on summer pasture, were placed on a finishing feed ration of corn and supplement. After 128 days of finishing feed the animals averaged 1,257 pounds in weight—a gain of 687 pounds or 120%, and were sold on January 5, 1948, on the Chicago market at prevailing top prices of \$35.50 and \$36.00 per hundredweight for a net of \$46,276 after deducting freight and commissions.

The short finishing period of 128 days on full corn feed, as compared with an average of 180 to 200 days required for completely finishing cattle ranged on average Illinois pasture is a remarkable showing of the quantity and forage value of grasses grown on the new soils on which the pasture was established.

The experience of another operator with sheep presents another advantage of spoil bank range not as yet explained. A band of 550 breeding ewes purchased late in the summer of 1946 and ranged on spoil banks until about November 1, of that year, produced a lamb crop in the spring of 1947 equal to 120% of the number of ewes. These ewes were bred again in the fall of 1947 and the lamb crop produced in the spring of 1948 was 150% of the number of ewes.

A lamb crop of 100% is considered good; 120% is a record few sheep raisers attain; but a crop of 150% is a remarkable multiple birth rate, which stems possibly from the high mineral content of the forage grasses on which the ewes were grazed. The quality of the lambs was excellent. One-third of the 1948 crop averaged 104 pounds when seven months old and topped the Chicago market to bring \$25.75 a head. Another third weighed 112 pounds and established a new high price of \$26.75 per hundred weight on the Peoria market and brought \$31.00 per head. The remainder brought \$28.00 per head on a slightly lower market top.

Two operators have used spoil bank pastures for hog raising. Their records indicate that pigs ranged on such lands average about 225 pounds in weight at six months of age and are ready for market with only 30 days of heavy corn feeding. The exceptional thrift of animals grazed on forage produced by spoil banks is a provoking problem for experts in animal husbandry, which is now undergoing scientific attack.

#### RESEARCH WORK ON PASTURE DEVELOPMENT TECHNIQUE

A comprehensive cooperative research project sponsored by Illinois Coal Strippers Association is now under way in the College of Agriculture, University of Illinois. This project established on a five-

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*Herd of cattle on spoil bank range*

year basis, will explore all of the possibilities of establishing forage grasses on the various types of top soils found on spoil banks, the species of grasses best adaptable to such sites, the forage yields per acre, their chemical composition and food values, and the resulting gains in weight and other characteristics of animals grazed on the different grass mixtures.

More than 1,000 test plots in which 70 different forage species planted alone and in combinations have now been established. A scientific study of cattle gains and feed necessary to prepare them for market is also under way. Under this study the growth and weight gains of cattle ranged on spoil banks will be compared with those made on the most highly productive pastures in the State. These studies will be later extended to cover hogs and sheep.

The facts developed by this project will not only remove the uncertainties of this type of land development and permit great savings to our operators, but will dispel many conjectures regarding the value of spoil banks which now seriously affect the public relations of the strip mining industry.

#### HORTICULTURE DEVELOPMENTS

Since 1942 one large company with extensive operations in the Southern Illinois fruit belt has been engaged in exploring the possibilities of developing spoil bank orchards and vineyards. The results have been so encouraging that the experiment now extends over 75 acres of mined and unmined land on which 100 varieties of fruits, grapes, nuts and berries were planted; and plans for utilizing a considerable additional spoil bank acreage for fruit production are now under development.

It has been found, as with forest species, that fruit trees develop more rapidly on spoil banks than those established on unmined areas.

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Peaches and grapes planted in 1943 and 1944 bore fruit in 1947 in sufficient quantity to permit the shipment of about 125 bushels of peaches and 500 pounds of grapes to friends of the industry and horticulturists who had expressed a friendly interest in the project. The letters of acknowledgment almost without exception commented on the deliciously different flavor of the spoil bank fruit. One horticulturist wrote for samples of the soil for comparison with that in his own orchards. The different flavor probably stems from trace elements not present in surface soils, that can only be discovered by complete chemical analysis. This possibility is being explored and it is hoped that some facts along this line can be established before our next report.

On some of the orchard sites the banks have been practically levelled; on others only the peaks have been struck off. The degree of strike-off most economical and satisfactory for orchard development has not yet been determined. Some leveling is, of course, necessary for roadways required for spraying and harvesting the crops; but it now appears quite likely that best results will be obtained where the banks are least disturbed.

The behavior of fruit trees on these new soils indicates that, as in the fields of forestry and agronomy, the science of horticulture also has some blank pages that will only be filled as these experiments progress. Many soil experts assert that the hardpan lands of southern Illinois produce more thrifty crops after strip mining than when in their natural contour. It is hazardous to forecast, but it is not entirely improbable that horticulturists of the future will resort to deep plowing to a depth far below existing land surfaces in order to break up hardpan and bring new soil horizons and plant nutrients to the surface as a preliminary step in orchard development.

These developments are the result of private initiative and a free hand in exploring methods of land use not covered by existing sciences of forestry, agronomy, horticulture or ecology. They demonstrate the futility of state laws, however well intentioned, which now require various amounts of spoil bank grading work followed by tree or grass planting in line with the academic practices recommended for undisturbed top soils. Too often such laws stifle the incentive and imagination of operators to the point where they are content to merely comply with the minimum of the statute requirements rather than explore the possibilities of more profitable land uses. Under free enterprise, Illinois operators have progressed further along the road to profitable and diversified reclamation of spoil banks than any other state, in which coal stripping is a factor in the coal industry, and in following this line have made progress in public education to the value of mined land, as well as great strides in reclamation technique.

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Business Research, Urbana, Illinois.)*

## TRENDS IN RAILROAD FUEL

By NINA T. HAMRICK  
Illinois State Geological Survey

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Less than twelve years ago the first passenger Diesel locomotive made its appearance as a competitor of the steam engine, and not until 1939 was the first main-line Diesel freight locomotive placed in service. Yet, in these post war years more than 90 per cent of the new locomotives ordered are Diesels. Much interest is being shown in this changing trend in locomotive power and the attendant shifts in demand upon railroad fuels.

This current shift from the picturesque but somewhat obsolescent steam engine to the ultra-modern Diesel locomotive has aroused interest and concern, not because the proportion of Diesels in service is large as yet, but rather because their increased use parallels a rapid decline in the number of steam locomotives. Although the railroads use only 13 per cent of the commercial Diesel horsepower in the United States, they burn nearly one-fourth of all Diesel fuel consumed in this country.

Since a Diesel locomotive costs fully twice as much as a steam locomotive capable of hauling the same load at practically the same speed, why are the railroads finding Diesels a better investment? The answer lies in the Diesel's high efficiency. In the process of fuel combustion, which releases energy in the form of heat, the conventional steam engine is about 7 per cent efficient, the steam turbine from 25 to 30 per cent efficient, and the Diesel from 33 to 37 per cent efficient. Moreover, the Diesel's savings in operation will equal its purchase price within six to eight years, and frequently in far less time than that. Passenger Diesels assigned to preferred runs often earn their entire cost within two and a half to four years. At least one is said to have paid for itself within one and a half years.

With this degree of efficiency, it is not surprising that railroads not dependent upon hauling coal for a large part of their revenue are making as rapid a transition as possible to Diesel locomotives. Roads dependent upon coal for their revenue cannot afford to put Diesels on their freight-hauling trains. It is these roads that will profit from the coal-burning gas-turbine locomotive when (or if) it becomes an assured success in actual road operation.

Conversion of roads which are almost entirely Dieselized is frequently hastened in order to eliminate expensive facilities needed to keep the few remaining steam locomotives in operation. In late

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1945 it was estimated that 75 percent of all steam locomotives then in service were more than 22 years old, and that more than 18,000 had outlived their life expectancy of 30 years. Many of these have since been retired either temporarily, to be repaired, modernized, and returned to service, or else permanently.

Although the life expectancy of a steam locomotive is said to be thirty years, constant overhauling and replacement of parts is necessary, so that in many cases long before thirty years have elapsed not a piece of the original engine remains intact, and it has completely lost identity with the locomotive originally placed in service. This constant loss of time is expensive from the standpoint of availability, as well as from the necessary overhead for repairs and replacements. So far, the Diesels have required very little loss of time for repairs. This is one factor which has cut their operating expense to the minimum.

Furthermore, the average steam locomotive is said to cover approximately one and a half million miles in its thirty-year life span, whereas it appears from the eleven-and-a-half-year record that the Diesels will have completed three times this mileage before they are fifteen years old. The two oldest Diesels on the road, the Zephyrs running between Chicago and Denver, have already covered nearly four million miles in their eleven-and-a-half years.

The number of Diesel passenger locomotives almost exactly doubled during the eighteen months between January 1, 1946, and July 1, 1947. On the latter date, the total freight Diesel inventory was ten times as great as in 1943.

Max Ball, of the Oil and Gas Division, Department of the Interior, recently said that the "present demand by the railroads for Diesel locomotives may soon force coal burning locomotives off the road at a time when the country is already short of oil and has little chance of getting relief." He predicts that the trend to Dieselization will continue unless manufacturers of coal locomotives modernize their product.

#### FUEL CONSUMPTION BY RAILROADS

Although coal constituted 80 per cent of all fuel used by Class I railroads, ranging normally from 80 to 125 million net tons a year a fifth of our annual national production of coal is purchased by the railroads in 1940, it had decreased to 70.3 per cent by 1946. More than depending upon the level of business activity.

Bituminous coal used by Class I railroads increased from 86,391,000 net tons in 1936 to 132,049,000 net tons in 1944 because of heavy war demands. Since the war, and also because of increased use of Diesel locomotives, coal consumption dropped to 110,406,486 tons in 1946, and 113,372,673 tons in 1947. Increased efficiency in coal consumption by steam locomotives accounted for some of this drop in tonnage used.

Fuel oil consumption increased from 54,322,524 barrels in 1935 to 115,563,270 barrels in 1943 (year of highest consumption), dropping to 98,442,414 barrels in 1946, and 96,754,622 barrels in 1947.

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On the other hand, Diesel fuel increased from 43,898,000 gallons in 1939 (earliest year for which data are available) to 559,187,983 gallons in 1946 and 800,591,612 gallons in 1947. It is estimated that 1948 consumption will be approximately 16 per cent above that for 1947.

These figures give some idea of the sharp rate of increase in Diesel fuel consumption as contrasted with gradually dwindling coal consumption. Because of the necessity of retaining obsolete steam locomotives in service during the war, coal consumption naturally was high. Since the war, it has declined; large numbers of obsolete steam locomotives have been retired, and the efficiency of those retained has been increased. Although coal is the most widely distributed and generally the most available type of locomotive fuel, yet curtailed production at the mines and extensive exports, amounting to about 5 per cent of the national bituminous coal production, made it difficult for the railroads to secure adequate supplies of coal during 1947, particularly the grade of coal which they wanted and needed. Stockpiles in some cases were dangerously low on January 1, 1948.

The practice of expecting railroads to accept and burn whatever kinds of coal were not currently needed by industry and for other purposes has resulted in decreased efficiency of railroad service and in increased operating costs. Some locomotives designed for burning high-grade coal proved unable to give satisfactory service with the poor coal supplied to them in 1947. There seems to be a possibility that a better balance between demand and supply may be reached in 1948, so that railroads will be better able to obtain the grade of coal needed. The railroads may share the responsibility for this situation, if, as has been reported, they were willing to accept an inferior grade of coal because of its lower price. Had they made the same demands upon the coal industry that other industrial concerns made, they too might have been able to obtain a better grade of coal, if, of course, they were willing to pay the difference in price.

Anti-smoke ordinances, as well as the need for increased efficiency in steam locomotives, have been instrumental in bringing about many improvements recently in steam locomotive design that will add greatly to their over-all efficiency and also eliminate much of the smoke menace.

Diesel fuel likewise presents some grave problems. Diesel fuels, light heating oils, and kerosene come from the same fraction in the refining process, and are thus competitive from the supply point of view. To increase the production of one, it might become necessary to curtail production of another.

At present, competition does not limit production of any of these fuels, nor would the demand of 26 million barrels of Diesel fuel predicted for 1950. However, should railroads ever approach complete Dieselization, as some sources predict, it would mean a demand for at least 100 million barrels of Diesel fuel annually.

For those interested in maintaining an ample supply of light heating oil and kerosene, the production of an adequate supply of Diesel

fuel without materially reducing the supply of these other fuels is important.

Fuel, particularly for the heavily Dieselized roads, gives promise of being one of the major problems for Class I railroads in 1948. Coal-burning steam locomotives require six times as many B.t.u. as Diesels for each passenger-car mile, more than seven times as many B.t.u. for each ton-mile of freight, and thirteen times as many B.t.u. for each hour of switching operation. When fuel cost factors were applied to these figures, it was found that Diesels saved 45 per cent of fuel cost in passenger service, 56 per cent in freight service, and 75 per cent in switching service.

#### EFFECT OF SYNTHETICS ON PRICE TRENDS

Not only must railroads face the problem of an adequate supply and desirable quality of fuel, but fuel costs have risen to approximately 10 per cent of their total operating expenses. Total fuel costs in 1947 for Class I railroads are estimated to have reached \$675,835,000. The following tabulation shows purchases of fuel by these railroads, 1940-1946.

<i>Year</i>	<i>Fuel Purchases (000)</i>
1940.....	\$273,556
1941.....	349,765
1942.....	426,335
1943.....	527,296
1944.....	585,832
1945.....	555,155
1946.....	553,153

Prices of all fuels have risen sharply since the war, and doubts are currently expressed that liquid fuels will long continue to be available at a price competitive with raw coal. Although our reserves of crude oil are rapidly being depleted by the recent unprecedented demands, yet the knowledge of methods for synthesizing almost any hydrocarbon assures a future supply of liquid and gaseous fuels if the costs do not prove to be prohibitive.

It is true, however, that the price of all petroleum-based fuels is likely to approach constantly nearer the price of gasoline at the refinery, gasoline being the largest single component in the demand for liquid fuels. An article in *Railway Age* for January 31, 1948, says, "To meet the almost insatiable demand for gasoline, the oil refineries have developed cracking processes which can convert increasing amounts of each barrel into distillate fuels, thus leaving less and less residual oil. Even that residue which is now left can be largely converted into gasoline by the process of adding more hydrogen to the hydrocarbon molecules."

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Nevertheless, the ability to produce synthetic fuels from coal and natural gas does not alter the fact that they are certain to cost substantially more than an equivalent B.t.u. content of either natural gas or raw coal. Plants required would be expensive; huge quantities of steel would be required; and under present methods of synthesis, extravagant quantities of coal or natural gas would be consumed. Much opposition is being expressed to any immediate plans for building synthetic fuels plants, because of the seemingly unnecessary expenditure of vitally needed steel and the waste of natural resources involved.

Bruce K. Brown, President of the Pan American Petroleum Transport Corporation, maintains that it would take a smaller expenditure of steel and less waste of natural resources to import and store against future need adequate supplies of oil than to launch an ambitious program of synthetic fuel oil production. According to Mr. Brown, to provide the suggested 2 million barrels of oil daily (Krug-Forrestal plan) would necessitate using 468 million tons of coal a year, which is more than two-thirds of our highest annual production. This would revolutionize the coal industry. Or again, to secure even 500,000 barrels daily would require consumption of half as much gas annually as was produced in 1946, in addition to the large quantities of steel needed.

Emphasizing the fact that he is not opposed to synthetic fuel production, Mr. Brown maintains that such a development should come gradually over a period of years and not like a forced wartime measure.

High steel requirements for the synthesizing process are also a factor that cannot be ignored in view of the inability of the steel industry to supply the already unprecedented demand today. Production of 500,000 barrels of oil daily from natural gas would require 3,500,000 tons of steel, and production of the same amount from coal would require twice as much steel, whereas preliminary estimates by promoters of the government plan reach the staggering figure of 16,000,000 tons of steel, with no assurance that even that amount would prove adequate to do the job. Oil people are convinced that even a small proportion of the steel involved in this suggested government project would be of great help in balancing oil demand and supply, and that moderately increased amounts would help to create a great reserve capacity for future emergency needs.

Based on prices paid by a number of American railroads in August, 1947, of \$3 to \$5 a ton for coal and 6.5 cents to 8.3 cents a gallon for Diesel oil, the estimated cost at that time per million B.t.u. was approximately 16 cents for coal and 65 cents for Diesel oil.

Although railroads are still paying approximately the same for coal, Diesel fuel has risen to around 11 cents a gallon, bringing the cost to approximately \$1.00 per million B.t.u. at present.

#### THE PRESENT OUTLOOK

The facts thus far discussed lead to the question: What effect will the cost and uncertain future of Diesel fuel have on the present trend toward complete Dieselization by Class I railroads?

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At present, using 1947 figures of locomotives on order as a basis, it seems that the efficiency and satisfaction given by the Diesels have as yet outweighed any factors to the contrary. Of a total of 2,155 domestic orders in 1947, 2,075 were for Diesels, 79 for steam, and one electric. This was the largest number of locomotives ordered in any one year since 1922, when 2,600 were ordered. Of new locomotives placed in service during 1947, 72 were steam, 2 electric, and 769 Diesel. Thirty steam and 1,192 Diesel locomotives were on order January 1, 1948. These figures indicate the immediate large demand for distillate oils.

Consumption of Diesel fuel by Class I railroads in 1947 is estimated to have risen about 42 per cent from 1946 and shows signs of increasing still further in 1948. Although oil imports may ease this situation slightly, the picture is dark in spite of the voluntary rationing of consumers by some oil producers. While the situation is not critical, it depletes stocks that are none too large now.

TABLE 1. — LOCOMOTIVES IN SERVICE, 1940-1947

Year	Total	Steam	Electric	Diesel
1940.....	41,696	40,041	858	797
1941.....	41,748	39,624	857	1,267
1942.....	42,013	39,491	855	1,667
1943.....	42,718	39,725	868	2,125
1944.....	43,593	39,681	863	3,049
1945.....	42,413	38,683	*	*
1946.....	41,362	37,072	725	3,565
1947 (10 mo.).....	40,072	35,258	725	4,089

\*Electric and Diesel locomotives listed together, 3,730 in all.

Although 1947 brought a further rapid extension in the use of Diesel locomotives, with a number of railroads announcing plans for complete Dieselization of certain divisions, the great bulk of rail transportation service is still rendered by reciprocating steam locomotives, which are also being improved in design, maintenance, and efficiency. Table I shows the types of locomotives in service in recent years, irrespective of size or capacity. Figures for 1940 to 1944 are those reported by the Interstate Commerce Commission; data for 1945, 1946, and 1947 were published in *Railway Age*.

Equipment owned by railroads declined in 1945 and 1946, as retirements exceeded installations. In 1947, the roads had the fewest steam locomotives since 1900, and ownership of Diesel locomotives continued

its upward trend. The number of steam locomotives owned December 31, 1947, was 2,272 less than at the end of 1946, whereas the number of Diesels owned had increased by 675 in the same period. In spite of the great increase in Diesel orders during the past few years, only slightly more than 10 per cent of the locomotives in service today are Diesels. The rapidity of the trend toward Dieselization obscures the fact that nearly 90 per cent of road-freight-hauling service is still performed by steam locomotives. The proportion of Diesel operation in passenger service is somewhat higher — roughly one-fourth — and in switching service is approximately 30 per cent.

The decrease in the total number of locomotives is also significant. During the eight years between January, 1940, and January, 1948, one out of every twenty locomotives had disappeared from service. This means that today the railroads, because of their increased efficiency, are able to handle a considerably greater volume of business than in 1940 with nearly 5 per cent fewer locomotives. This, again, results largely from the high efficiency of the Diesels.

A large manufacturer of locomotives predicts that by the end of the first postwar decade 20 per cent of all locomotives will be Diesels, and that these will be doing 40 per cent of the total rail-haulage. Many roads, particularly in the western part of the United States, judging from the large percentage of Diesel orders, are moving toward complete Dieselization. In the East, the proximity of coal fields will make the process much slower. The economy of fuel costs, high availability (actual percentage of time locomotive is available for service), ease of replacement of necessary repairs, shortened schedules because of generally higher speeds, and ease and speed of starting because of greater tractive power give reason to believe that the Diesel is the answer to over-all efficiency in rail transportation today.

#### COAL-BURNING GAS TURBINE

These trends of questionable availability and consistently rising costs of the two chief locomotive fuels have given added impetus to the program of the Locomotive Development Committee of Bituminous Coal Research, Inc., which has been in operation since May, 1945, developing a coal-burning gas-turbine locomotive.

Much interest is being shown in turbine-type power and gas turbine locomotives, both powdered-coal and oil-fired. Hopes are currently expressed that this committee will be able to place at least one of its locomotives in actual road service before the end of 1948.

A recent progress report by the directors of the coal-burning gas-turbine research program gives an account of what has been accomplished to date, some of the problems encountered and solved, others as yet not solved satisfactorily, and a general description of the principles of operation in this type of locomotive.

The general principles of the coal-handling system are based on the assumption that the gas turbine must be able to burn any ordinary locomotive fuel without special wayside preparation. "Drying, crushing, pressurizing, feeding, and atomizing must be accomplished as



the coal is being fed from the bunker by the stoker." A magnetic pulley has been added to remove any iron before the coal enters the hammer mill which pulverizes it. Oil is used as a starting and stand-by fuel.

The use of Diesel fuel suggests the possibility that, if and when this type of locomotive proves successful it may be appropriated by the oil interests since it will carry an auxiliary supply of Diesel oil. This seems to be a very doubtful conclusion. The superior efficiency of the present-day Diesel leaves little to be desired that the gas-turbine is likely to supply, because there is much doubt, even within the coal industry, that the coal-burning gas-turbine locomotive can ever attain the over-all efficiency of the present Diesel. It definitely is the hope and dream of those roads forced to retain coal-burning locomotives, not of the roads that can avail themselves of the advantages of the Diesel and are doing so.

Two gas turbines for coal-burning power are now under construction: one by the Elliott Company to be housed in a locomotive being designed by the Baldwin Locomotive Works, and another by the Allis-Chalmers Company to be housed in a locomotive being designed by the American Locomotive Company.

As soon as these units operate satisfactorily in extensive tests at the manufacturer's plants, they will be installed in the locomotives being built for them and will be given road tests. Operator's cabs will be provided at each end to eliminate the necessity for turning the locomotive. Six-wheel trucks, identical to those now used on Diesel-electric locomotives, will be employed to provide for interchangeability and to make use of maintenance facilities now available.

It is anticipated that these locomotives will be able to carry from 17 to 20 tons of coal, approximately 4,000 gallons of water for the train-heat boilers, and about 1,500 gallons of Diesel oil. Full-load fuel consumption is expected to be approximately one pound of 13,000-B.t.u. coal per rail hp.-hr.

The major advantage of the gas turbine will be its ability to burn low-cost coal. Although the thermal efficiency of the Diesel is higher, the cost of fuel for the gas turbine will probably be about one-third that of a Diesel, one-third to one-fourth that of a modern steam locomotive, and approximately one eighth to one-tenth that of the older steam locomotive. The gas turbine will likely be able to burn the cheapest type of coal on the market.

#### WHAT LIES AHEAD FOR COAL ?

In considering coal as a railroad fuel, the question that immediately presents itself is: What will be the probable over-all coal requirements of the railroads for the next several years? More than half of the steam locomotives in service are more than thirty years old and fewer than 5 per cent have been built within the past ten years. Naturally, locomotives which have out-lived their normal life span are not doing efficient work according to modern standards for even the regular reciprocating type of steam locomotive. However, this picture of the comparative efficiency of steam and Diesel locomotives is somewhat distorted, in view of the fact that the rate of coal consumption for

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obsolete models is naturally much greater than that of modern steam locomotives. Moreover, the older models, which were kept in service during the extreme pressure of wartime demands long beyond the period of normal retirement, are now being retired in large numbers and, if practicable, improved, repaired, modernized, and returned to service. Thus, despite the preponderance of new Diesel locomotive orders placed in 1947, if these reconditioned steam locomotives are counted, there were actually more steam than Diesel installations during the year. Consequently, unless coal-burning locomotives continue to be modernized and improved, even further inroads into the locomotive market are certain to be made by the Diesel.

As to the effect of trends in steam locomotive operation on fuel consumption, naturally the improvements in efficiency and design have materially reduced fuel consumption per unit. The coal industry is particularly interested to know what type of locomotive will be selected to replace many of the steam locomotives in service today. Availability and cost of fuel, traffic influences, and cost of maintenance and operation are determining factors in the choice of locomotives.

If the coal-burning gas-turbine locomotive now under development proves to be all that its inventors expect, it may revolutionize coal production, reduce railroad fuel costs, and effectively turn the tide of Diesel competition. Otherwise, there seems little doubt that both increased use of Diesels and increased efficiency in the newer steam locomotives will bring about a gradual but constant decline in coal consumption by the railroads. However, industrial demands upon the coal industry are increasing so rapidly that they will undoubtedly more than absorb any such decrease.

By 1946, 2,000 fewer steam-locomotives were maintaining approximately the same aggregate tractive effort as in 1940, and increased use of Diesels was taking care of more than the increase in traffic. This is another proof of the increased efficiency in the steam locomotives which remain in service. One of the most important details contributing to this increased efficiency is improved combustion of fuel. Anti-smoke ordinances have been a contributing factor in these improvements because black smoke means imperfect combustion. In some cases, over-fire air jets, injecting extra air into the firebox to insure better combustion, have been adopted.

If the coal-burning gas-turbine locomotive proves successful, it is possible that the trend toward increased Diesel oil consumption and decreased coal consumption may suddenly be reversed, because the turbine locomotive is expected to have an initial cost approximately that of a Diesel, but decidedly lower fuel costs, to be able to use the same maintenance facilities, and to have equal or greater efficiency.

The future trend of locomotives will depend, after all, upon the economics of the situation. Railroads will put into use the type of locomotive which will net them the greatest return for the capital invested. Factors to be considered are: initial cost, economic life (including frequency of repair and cost of operation, as well as life expectancy), thermal efficiency of the fuel required, and adaptability to traffic demands.

Whether the coal-burning gas-turbine locomotive is coming too late to affect the trend toward Dieselization, or whether in time it will produce as revolutionary changes as has the Diesel in the field of rail transportation, are questions of current interest, but cannot be answered today. The Association of American Railroads makes the following conservative and qualified report of the coal-burning gas-turbine and its possible effect:

"When this locomotive has been developed, it will have most of the advantages of the Diesel as well as those of the steam-turbine locomotive, without the complication of reciprocating parts and steam boilers possessed respectively by those motive-power units. If calculations of attainable efficiency are correct, it is hoped that more than twice the Diesel mileage can be achieved per dollar of fuel cost, because of the lower price of coal as compared with oil. When and if petroleum reserves approach exhaustion, and coal becomes the principle source of oil, this type of coal-burning locomotive, if successful, may make it unnecessary to convert coal into oil to burn in locomotives to secure the advantages of Diesel motive power, but the economics of this question remain to be determined."

#### CONCLUSIONS

In summary, then, what do current trends indicate as to the future of railroad fuel?

(1) Neither constantly increasing fuel prices, nor the current alarm concerning shortages of petroleum reserves, has caused any decline in the large proportion of orders for Diesel locomotives or, so far as can be determined, in the planning for the ultimate complete Dieselization of many lines.

(2) There is no indication at present that fuel prices, particularly those of Diesel fuel, are not on the permanent upgrade, especially if and when synthetic fuels become necessary.

(3) The fact that coal furnishes the railroads more revenue than any other commodity has not deterred them from transferring, wherever possible, to Diesel locomotives for greater efficiency. Even the major coal-hauling roads are using Diesels on their passenger trains and for switching service.

(4) If successful, the coal-burning gas-turbine locomotive could produce as revolutionary a change in the trend of locomotives and locomotive fuel as the Diesel has within the past decade — or it might even give added impetus to the trend away from coal as railroad fuel. There are those who believe it will. However, at present neither of these possibilities seems likely, although predictions as to the effects of this type of locomotive are anyone's conjecture. There is no definite assurance as yet as to what or how far-reaching they will be.

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## SYNTHETIC LIQUID FUELS

By FRANK H. REED

Chief Chemist, Illinois State Geological Survey

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The Third World War is undeclared as yet; the odds seem to be heavily against such a war in the near future. However, the tension is sufficiently great and incidents frequent enough that anything except preparedness by the United States would be foolhardy. Even a cursory study of the history of World War II, particularly the methods of waging it and the means of stopping it, indicates clearly that no shooting war can be waged without adequate means of transportation on land, on water, and by air. The most modern and best designed transportation equipment is totally valueless unless the proper fuels are available to speed such equipment to its destination and return.

The very nature of World War II made necessary the unprecedented development of the science of Logistics, which may be defined simply as "the method by which the right amount of men and materials is located at the right place and at the right time." No country can hope to win a shooting war unless it excels in Logistics, and no country can excel in this field unless it is better prepared than its adversary in the transportation of equipment and has the fuels necessary to operate this equipment at the highest efficiency. The time required for the Allies to overcome Germany was a function of their ability to cut German transportation lines, immobilize the enemy equipment and reduce German fuel supplies below the quantity and quality necessary for the efficient use of the German transportation facilities.

Thus, it appears that the greatest problem facing the United States today in preparing for a possible Third World War is that of the assurance of an adequate fuel supply, as to both quality and quantity. The total fuel reserves of this country are enormous and far exceed in quantity any demand that a Third World War would put upon this nation. However, these reserves do not occur in the form necessary for use in most modern transportation equipment — internal combustion engines used in airplanes, motor cars and trucks, Diesel engines, and oil-burning steamships. Estimates by the Federal agencies best qualified, and knowledge of the extent of fuel reserves, indicate that 98.8 per cent of the known United States fuel reserves consists of the solid fuels which are known as coal and lignite, 0.8 per cent of these reserves is in the form of oil shale, and that the remaining 0.4 per cent is divided equally between petroleum and natural gas deposits.

The best-known source of supply and the easiest to convert to the desired liquid fuels is petroleum. However, with reserves estimated

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at 21 billion barrels, and present annual consumption just over 2 billion barrels and expected to rise 40 per cent by 1955, it is possible that the petroleum industry will not be able to satisfy even peacetime demands from production within the continental United States. On the other hand, American oil companies own and control sufficient petroleum in the Middle East and other parts of the world to satisfy practically everyone's needs for an indefinite period. The world political situation, however, is not stable enough for the United States to gamble on this source for an adequate supply of liquid fuels in case of another World War. It is not to be forgotten that the Big and Little Inch pipe lines were made necessary because enemy submarines were able to sink so many coastwise tankers on the route from Texas to the eastern seaboard of the United States.

Facing these facts, Secretary of Defense Forrestal and Secretary of the Interior Krug have recommended to Congress the immediate start of a five to ten-year program to establish a synthetic oil industry in the United States.

Much technical information is already available for such a program. For more than fifteen years laboratory and pilot-plant research along this line has been pursued by some of the larger oil companies and also by the United States Bureau of Mines. Oil can be made from almost any material having a high carbon content, but most of the synthetic liquid fuel will be made from coal, shale, and natural gas.

Natural gas and petroleum differ chemically from wood, lignite, and coal, in that they have a higher percentage of hydrogen and are practically devoid of oxygen, as illustrated in Table I. Likewise, the processed fuels contain from 12 to 15 per cent of hydrogen and have only very small amounts of oxygen.

#### PROCESSES

Conversion of solid fuel into a desired liquid or gaseous fuel consists in the addition of hydrogen (hydrogenation) and simultaneous removal of oxygen along with change in size and structure of the chemical molecules. Two general processes have been developed:

(1) *The Bergius Process*—direct hydrogenation. Coal is ground to below 40 mesh, mixed with oil to form a stiff paste, and treated with hydrogen gas in the presence of a catalyst at 700 atmospheres pressure and a temperature of about 480° C. The reaction products are released from the pressure chamber, cooled and separated, the unreacted and partially hydrogenated material being recycled. Operating conditions may be so controlled that the principal product will be regular gasoline, aviation gasoline, or fuel oil. Phenols, including the cresols and xylenols, may be recovered in amounts equal to 5 per cent of the weight of the dry, ash-free coal.

(2) *The Fischer-Tropsch Synthesis*—indirect hydrogenation. In this case the solid coal is converted as completely as practicable into a mixture of carbon monoxide and hydrogen (known as synthesis gas), either by burning in air in the presence of steam or by the use of oxygen

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TABLE 1.—APPROXIMATE COMPOSITION OF VARIOUS FUELS  
(Dry Mineral—Matter-Free Basis)

Fuel	Percentage of		
	Carbon	Hydrogen	Oxygen
A. Natural Occurring Fuels			
Wood (oak or pine) .....	50	6	44
Lignite .....	71	4.5	22
Coal, bituminous .....	88-76	5-6	5-16
Coal, anthracite .....	94	3	2
Methane .....	75	25	....
Natural gas (mainly methane) .....	82-77	13-22	....
Petroleum, crude .....	86-84	12-14	....
B. Processed Fuels			
Gasoline .....	84	15.5	....
Kerosene .....	84	15.5	....
Fuel oil .....	85	13-14	1
Lubricating oil .....	88-85	12-15	....
Diesel oil .....	85	14	....

and steam. Treatment of the synthesis gas at one or ten atmospheres pressure and a temperature of 180-200° C. results in the production of regular gasoline of relatively low octane number, fuel oils, waxes, and a large number of organic chemicals of industrial importance. Operating conditions may be adjusted to control to a limited extent the type of products obtained.

Synthesis gas may be produced also from natural gas, and this source has proved to be the more attractive for immediate exploitation by a number of the oil companies. Thus, the first synthetic liquid fuel to be produced in this country will be made from natural gas by a modification of the Fischer-Tropsch Synthesis.

Carthage Hydrocol, Inc., organized by the joint efforts of eight companies, is building a gasoline-from-natural-gas plant near Brownsville, Texas. The plant is expected to produce 7,000 barrels of liquid fuels and 150,000 pounds of chemicals a day. The Standard Oil Com-

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pany of Indiana, through one of its subsidiaries, is building a plant of like capacity in the Hugoton Natural Gas Field in Kansas, at an estimated cost of \$32 millions as compared with \$21 millions for the Brownsville plant.

Although at present natural gas seems to be the cheapest and quickest source of synthetic gasoline, it is thoroughly understood that this is a relatively temporary procedure. The known natural gas reserves are limited to 30 to 35 years' production at the present rate of 5 trillion cubic feet a year. Therefore, it is not surprising that some of the same large oil companies that are interested in the production of gasoline from natural gas are also very active in research on the production of synthetic fuels from coal by the Fischer-Tropsch Synthesis.

The Standard Oil Company of New Jersey and the Pittsburgh Consolidation Coal Company of Pittsburgh have joined in the construction of a coal-to-oil pilot plant at Library, Pennsylvania. As soon as results from the pilot plant can justify the construction of a full-scale plant, it will be built. The cost of such a plant is now estimated at \$120 millions.

#### GOVERNMENT RESEARCH

The Synthetic Liquid Fuels Act of 1944 allocated, under certain restrictions, \$30 millions to the United States Bureau of Mines for operation of a five-year program of laboratory and pilot-plant investigations on the technical and economic aspects of the production of synthetic fuels from coal, lignite, natural gas, and oil shale. Work on this program has proceeded rapidly. On March 15, 1948, President Truman signed Public Law 443 (H.R. 2161) authorizing an additional \$30 millions for continuing this program for another three years ending April, 1952.

A \$2,000,000 demonstration plant for the production of liquid fuel from oil shale was completed and put into operation at Rifle, Colorado, in May, 1947. The reserves of oil from shale in this section of Western Colorado and adjacent territory are estimated at 200 million barrels. Total United States deposits, estimated at 300 billion barrels, would be sufficient to satisfy in quantity, though possibly not in quality, United States demands for 150 years at the 1946-1947 rate of consumption, or for more than a hundred years at the expected 1955 demand of 7 million barrels per day.

Large-scale equipment is being used to determine mining and preparation costs. Shale crushed to 3.5 inch size is retorted to produce a crude which closely approximates No. 6 petroleum fuel. The best average monthly direct cost reported to date (March, 1948) is 9.6 cents a gallon of crude. However, the same source reports that it is believed that the cost will drop to 5 cents a gallon if two retorts are operated continuously. Crude shale oil is reported to be of low quality and difficult to refine into high-grade fuels.

Also, in May, 1947, a new building to house laboratories and offices for oil shale research and development was completed adjacent to the campus of the University of Wyoming at Laramie. In addition to research on problems of the retort process, a second process for extract-

ing oil from shale is being studied — extraction of the oil by the solvent leaching at an elevated temperature.

For several years research and development work on the production of synthetic fuels has been carried on by the Bureau of Mines station at Pittsburgh; last year this work was moved to new quarters at Bruce-ton, Pennsylvania. This division has been investigating the production of hydrogen (since the cost of high pressure hydrogen is approximately half of the total cost of producing fuel oil); the separation of tar acids which are the major valuable by-products of coal hydrogenation; the development of new and improved catalysts; and an experimental unit for gasifying powdered coal with oxygen and steam.

A synthesis gas production division has been established in laboratories at Morgantown, West Virginia. This group is studying two processes for the production of synthesis gas from coal. One of these processes is for the gasification of pulverized coal entrained in super-heated steam containing oxygen. The other process under study is that of gasification of coal in place underground. A preliminary experiment along this line was conducted near Gorgas, Alabama, in early 1947. Results were considered sufficiently encouraging to justify another large-scale experiment, which is now being planned.

Recently the University of North Dakota at Grand Forks donated 13 acres of its campus to the Bureau of Mines to be used as a site for the location of a new lignite research laboratory to cost \$750,000. The Bureau's work on the production of carbon monoxide and hydrogen from lignite is to be continued in the new laboratory.

Two processes for the production of liquid fuels from coal are to be tried by the Coal-to-Oil Demonstration Branch of the Bureau of Mines at the site of the Louisiana, Missouri, Ordnance Plant, which produced ammonia during World War II.

A \$7,000,000 coal-to-oil demonstration plant with a capacity of 200 barrels of gasoline a day produced by direct hydrogenation of coal (Bergius Process) will be completed and put in operation during 1948.

Also a contract was let in March to the Koppers Company for the construction of a \$4.4 million demonstration plant with 80 barrels a day capacity for production of liquid fuels by indirect hydrogenation of coal (Fischer-Tropsch Synthesis), to be constructed at Louisiana, Missouri, adjacent to the Bergius plant. This plant also is expected to go into operation before the end of 1948.

#### SECRETARY KRUG'S PROGRAM

In his annual report to Congress Secretary Krug proposed a ten-year program for the establishment of a synthetic liquid fuels industry in this country. The goal set is a production capacity of two million barrels of oil a day, or approximately 40 per cent of the average daily production of petroleum in 1947. It is recommended that this program be developed along four major lines of production, each to produce 500,000 barrels of oil a day:

- (1) From coal by direct hydrogenation — Bergius Process

*You'll discover good merchandise advertised in this good publication.*

- (2) From coal by indirect hydrogenation — Fischer-Tropsch Synthesis.
- (3) From natural gas — Fischer-Tropsch Synthesis.
- (4) From shale oil.

As previously noted, demonstration plants to determine engineering and operating details for the first two processes are now under construction at Louisiana, Missouri, and should be in operation before the end of 1948.

The Bureau of Mines demonstration plant at Rifle, Colorado, is already in operation. The Union Oil Company of California also is reported to be putting up a plant to process about 50 tons of shale a day. Based on the estimate of 30 gallons of oil per ton of shale, this unit would have a capacity of about 35 barrels of oil a day.

According to Dr. W. C. Schroeder, Chief of the Synthetic Liquid Fuels Program of the Bureau of Mines, the production of oil from natural gas will be left to the large oil companies, as they already have solved many of the technical problems and are in the best position to develop this phase of the program.

P. C. Keith, President of Hydrocarbon Research, Inc., reports that the natural gas conversion plant of Carthage Hydrocol at Brownsville, Texas, to produce 7,000 barrels of oil a day, is under construction and planned for completion in May 1949. The plans for the plant of the Stanolind Oil and Gas Co. in the Hugoton field in Kansas are still in the drafting stage.

As the next step toward establishing a synthetic fuels industry it is expected that Secretary Krug will ask Congress for an appropriation (tentatively set at \$100 millions) for the construction of three commercial units, each of 10,000 barrels daily capacity. Two of these would start from coal, one by direct hydrogenation (Bergius Process) and the other by the indirect Fischer-Tropsch Synthesis, and the third would produce oil from shale.

It is no surprise to find that considerable information is available in regard to the requirements of each of these proposed plants for raw materials, equipment, and plant site.

The first hydrogenation process to be operated on a commercial scale was developed by Bergius in Germany. This plant, located at Lena, was designed to use brown coal and was started in 1927. Early difficulties in operating the process caused a switch in source of raw materials from brown coal to brown coal tar. However, by 1931 these difficulties had been overcome and the process was operated with brown coal. By 1937 Germany had erected her first hydrogenation plant for the use of bituminous coal. This plant was similar in design to one which had been erected by the English at Billingham and was operated by them from 1935 on. This type of hydrogenation plant was the most important of the German synthetic fuel processes, as it provided practically the entire aviation fuel requirements of Germany in World War II.

The first commercial Fischer-Tropsch plant was put into operation in Germany in 1936. Though this type of plant produced no aviation gas

and provided only 14 per cent of the total German production of oil from coal in World War II, nevertheless it contributed greatly to the production of Diesel oil, waxes, and chemicals for the German war machine. The German production units were small, because they had not solved the problem of heat dissipation. That problem has been solved in this country since the war.

Thus we now have available both German and English industrial experience to guide the research and pilot-plant work planned. Most of the following information in regard to industrial plant requirements for direct hydrogenation of coal was furnished to the writer by Dr. L. L. Hirst, Chief, Coal-to-Oil Demonstration Plants, United States Bureau of Mines, Louisiana, Missouri, who has contributed greatly to the research and development work of the Bureau of Mines in this field for many years.

The optimum size of plant for direct hydrogenation of coal will probably be 30,000 barrels capacity a day — not 10,000 — largely because of labor requirements. Because larger units of process equipment can be used to advantage in a larger plant, the labor requirements for a 30,000 barrel a day unit would not greatly exceed those for a 10,000 barrel a day plant. Consequently, the figures given here are based on requirements for a plant producing 30,000 barrels a day.

If operated for the production of regular gasoline, the daily yield of products is estimated at: 21,604 barrels of gasoline of 78 to 79 octane rating; 5,126 barrels of commercial propane; and 2,040 barrels of butane containing 75 per cent isobutane. (Mixtures of propane and butane in various proportions are sold as bottle gas; mixtures of butane and isobutane may be reformed to produce isotane and aviation gas stock).

When operated for aviation gasoline, the daily yields would be: 11,000 barrels of aviation gasoline of 100-130 octane grade; 12,250 barrels of aviation base of 78 to 79 octane rating without lead; and 3,720 barrels of regular gasoline.

#### LABOR REQUIREMENTS

For each shift, 350 men would be required. The total number working in a plant with the assumed capacity would be approximately five times that number or 1,600 to 1,800 employees, 15 per cent of whom would be classified as supervisory and technical personnel.

#### COAL REQUIREMENTS

The coal actually processed is one half of the total plant requirement. The other half is used in the manufacture of hydrogen and as boiler fuel. Coal to be used in the liquefaction should preferably have not more than 3 per cent ash. A cleaning plant will be a necessity, and in many plants the high ash portion will be used as boiler fuel. The low ash portion will be pulverized to — 60 mesh, with a minimum size of — 200 mesh, in a ball mill; at the same time it will be dried to 0.9 per cent moisture content by heating to 300° F. with combustion gases.

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Each ton of processed coal yields four barrels of liquid fuels. However, as only half of the coal is processed, the net yield is two barrels of liquid fuel for each ton of coal. Thus, a 30,000 barrel a day plant would require 15,000 tons of coal a day, or 5.5 million tons a year. As the life of such a plant is estimated at 15 to 20 years, it is only logical that it be located as near as possible to a coal deposit sufficiently large to meet the 20-year requirements—110 million tons—a seam of coal 5.5 feet in thickness and 20 square miles in area.

Secretary Krug's program of 500,000 barrels a day by direct hydrogenation would make necessary 17 such plants. Total annual coal requirements for these plants would therefore be approximately 94 million tons.

As the Secretary's program calls for an additional 500,000 barrels of liquid fuels a day by indirect hydrogenation of coal—Fischer-Tropsch Synthesis—those requirements must be considered also. The synthesis gas is to be made at the Louisiana, Missouri, demonstration plant by a modification of the German Koppers process. The coal should be clean and the softening temperature of the ash should be above 2200° F. About 50 per cent of the coal is used in evaporating water. The coal requirements in this case will be as much or a little more than those for direct hydrogenation.

Thus the program to produce 500,000 barrels of oil by direct hydrogenation of coal and a similar amount by indirect hydrogenation will require about 200 million tons of coal per year—an amount equal to a third of our present national production. Assuming that 400,000 miners are needed to obtain our present annual production, an additional 135,000 miners would be required. These figures on coal requirements for the Krug program do not include any coal which may be used for power generation in the production of oil from natural gas or shale.

#### NATURAL GAS REQUIREMENTS

On the basis of 12,000 cubic feet of gas being required to produce one barrel of oil, a 10,000 barrel a day plant would require 120 million cubic feet of natural gas each day. Fifty such plants would be necessary to produce the 500,000 barrels of oil projected in the Krug program. The natural gas demand would then become six billion cubic feet a day, or 2.2 trillion cubic feet a year. That figure is more than 40 per cent of our present annual production.

#### WATER REQUIREMENTS

While it is desirable to locate a hydrogenation plant as close as possible to an adequate coal supply, it is absolutely necessary that a sufficient quantity of clean water free from suspended solids be available.

For each ton of coal 8½ tons of make-up water is required. By "make-up water" is meant the amount of fresh water from the source of supply which must be added to the plant system. For instance, in a plant producing 30,000 barrels of oil a day 360,000 gallons of water will be circulated each minute, but only 1/18 of this amount, or 20,000

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gallons per minute, will have to be added to the system. This make-up water would be utilized as follows:

	GPM
Evaporation in induced draft cooling towers.....	12,150
Blow-down from cooling system.....	3,625
Boiler make-up for hydrogen manufacture.....	1,000
Boiler make-up for boiler blow-down and losses.....	500
High-pressure injection water.....	150
Sanitary waste requirements.....	575
Miscellaneous (10%).....	2,000
TOTAL.....	20,000

As two-thirds of the make-up water is evaporated, 6,000 to 7,000 GPM would be discharged as plant effluent. Whether or not the effluent will require treatment before discharge from the plant will be a local problem.

According to Dr. Hirst and his co-workers, if the water supply were plentiful it would be desirable to use 30,000 GPM of make-up water, in which case the additional 10,000 GPM would increase the effluent to that extent.

As the water used is largely a function of the heat generated in the process, it naturally follows that a plant of one-third the assumed size — 10,000 barrels of oil a day capacity — would use approximately a third of the water required by the larger plant.

Since the over-all plant efficiency is estimated to be about the same for direct or indirect hydrogenation of coal, theoretically the water requirements should be the same. It is believed, however that the Fischer-Tropsch process will require 50 per cent more make-up water than a Bergius plant of the same size. Thus a 30,000 barrel a day Fischer-Tropsch plant would require 30,000 GPM of water instead of the 20,000 GPM of make-up water needed for a Bergius plant of the same capacity.

#### STEEL REQUIREMENTS

In the *Oil and Gas Journal* for February 5, 1948, Bruce F. Brown, President of the Pan American Petroleum Transportation Company, is credited with the following estimates of steel requirements for the production of one ton of oil a day from various sources: To produce a ton of oil a day from a new field in a new refinery in the United States requires 26 tons of steel, but it would require 34 tons of steel per daily ton of oil from shale, 49 tons from natural gas, and 70 tons from coal.

Thus Secretary Krug's program would require 16 million tons of steel — 10 million tons for the two processes from coal, 3.5 million tons for the oil from natural gas plants, and 2.5 millions for the oil from shale. These figures do not include steel for production of raw materials. Also, the figures do not distinguish among kinds of steel. The direct hydrogenation of coal takes place in reactors operating under 10,000 pounds pressure per square inch and at a temperature

of 480° C., whereas the indirect method — Fischer-Tropsch — operates at a maximum pressure of 150 pounds per square inch and at a temperature of 180 to 200° C.

In speaking of high-pressure reactors, it is interesting to note that *Industrial and Engineering Chemistry* for April, 1948, in an editorial report states that the total large-capacity forging facilities in this country can turn out in one year only 50 full-size high-pressure reactors — just about enough to equip one plant producing 30,000 barrels of oil a day.

### COSTS

Direct costs are used to evaluate and compare on an empirical basis the sum total of raw materials and labor entering into a unit quantity of finished product. These costs are accurate only on the basis of assumptions made. Identical plants built in different parts of the country will not show identical costs. Wages differ from one area to another; transportation charges for equipment and raw materials vary in accordance with distances and routes; and the relation between supply and demand of both labor and materials has a decided effect on the cost to the purchaser.

Bearing such uncertainties in mind, it is not difficult to understand why the estimated costs of synthetic fuels differ greatly from one estimator to another. This does not mean necessarily that one estimator is less careful or less well-informed than another; it may mean only that the two estimators made different assumptions, had different figures and information available, or used different formulas in making their calculations.

For instance, what is the direct refinery cost of motor gasoline today? In 1944 the OPA price was 4.75 cents a gallon. At present, the estimated cost is 7 to 9 cents per gallon, with the narrow-range estimates around 8¼ to 8½ cents. In contrast, one authority states that with equipment newly constructed and operated for maximum yield of gasoline the cost would be 14 cents per gallon. It is very difficult to set up a sound amortization schedule under present conditions.

Motor gasoline produced by direct hydrogenation of coal in a commercial plant of 30,000 barrels a day capacity is estimated by the Bureau of Mines to have a direct plant cost of 16.9 cents a gallon. This is on the basis of crediting butane and propane at 8.5 cents a gallon, taking no credit for phenols, realizing no return on investment, and amortizing the plant over a 15-year period. A 3 per cent return on investment would add 2½ to 3 cents to the cost of each gallon. By crediting phenols at 10 cents a pound, and assuming no return on the investment, the cost of regular gasoline would be about the same as that of gasoline from petroleum.

Assuming a 3 per cent return on investment, taking phenol credit, and using a 15-year amortization period, the Bureau of Mines estimates a direct plant cost of 18.65 cents a gallon for aviation gasoline.

Also, assuming a 10,000 barrel a day plant built and operated principally for the production of fuel oil, the cost would be 10 to 11 cents a gallon.

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Assuming natural gas to be available at 10 cents per thousand cubic feet, R. W. Krebs, of the Esso Laboratories (Standard Oil of New Jersey), estimates the cost of gasoline from natural gas at 13 cents a gallon compared with the above mentioned 14 cents a gallon for gasoline obtained from petroleum by new equipment operated for maximum yields of gasoline. He states that a similarly estimated price for gasoline from coal might be 16 to 17 cents a gallon, and that from shale might cost 16 cents.

In many of the calculations made on the use of natural gas, the cost is estimated at 5 cents per thousand cubic feet. Mr. Krebs assumed a cost of 10 cents per thousand cubic feet. However, it seems only fair to ask what the cost of natural gas would become if the annual consumption for liquid fuels should reach more than 2 trillion cubic feet — about 40 per cent of our present annual production.

#### PLANTS COSTS

The Bureau of Mines estimates that a 30,000 barrel a day Bergius plant in Illinois would cost \$350 millions — about \$10,000 for each barrel a day capacity. The cost of seventeen such plants over the country would approximate \$5.5 billions. Similarly the cost of a 10,000 barrel a day plant for fuel oil would be about \$6,000 per barrel per day capacity.

Although the optimum size for a plant to produce oil by indirect hydrogenation of coal (Fischer-Tropsch Synthesis) is a capacity of 10,000 barrels of oil a day, no final estimates are yet available from the Bureau of Mines on the costs of these plants, 50 of which would be required in the Krug program.

Mr. Krebs is reported to have given the following estimates for plant costs of synthetic fuels: "The investment per barrel per day of oil products capacity for crude oil production, transportation to consuming area and refining is about \$4,300 for maximum distillate yield and \$6,500 for maximum gasoline yield, and for oil synthesis from natural gas \$7,400 and \$8,200 on the same basis. For synthesis starting with coal, \$7,600 and \$8,200 is estimated and from shale \$6,100 and \$8,400. With coal and shale product transportation is not included which may be required in areas west of the Mississippi. High housing costs, also, must be added for such a location.

"It is evident from these figures, that construction costs play a large part in determining the price of synthetic gasoline. Despite these high costs, however, the average motorist need feel little concern over the future supply of gasoline for his automobile, for even at the present stage of development of the gasoline-from-coal process, estimates show that it will cost him only 10 to 15 cents per day more to operate his car on gasoline from coal than he now pays for petroleum gasoline."

#### COMMENTS

There appears to be no doubt that the world reserves of petroleum are adequate to supply all needs for an indefinite period. The United

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States, with 31 per cent of the proven reserves, accounts for 63 per cent of world production. In addition, the large oil companies of this country own or control a sizable portion of the other major oil deposits, particularly those in Saudi Arabia and other countries in the Near East. Were it not for the specter of war again rearing its ugly head on the horizon, a synthetic liquid fuels program would not be projected by the Federal government at the present time but would develop slowly and naturally in the laboratories and plants of the large oil and coal companies. The oil companies have a tremendous stake in any old or new industry which may produce liquid fuels. As over 98 per cent of our known fuel resources are available in the form of the solid fuels, coal and lignite, these resources are the logical raw materials for liquid fuels as petroleum reserves dwindle. Thus cooperation between large oil companies and large coal companies is the logical starting-point in developing a synthetic fuels industry on a sound basis and with the least dislocation of related industries.

Particular reference should be made here to the chemicals which will be produced as by-products in the Fischer-Tropsch process plants that produce oil from natural gas or coal. Alcohols, aldehydes, ketones, and acids now produced by the synthetic organic chemical industry will be produced in many times the quantity now required. One estimate shows that 10 plants of 7,000 barrels of oil capacity a day — such as the Carthage Hydrocol Plant at Brownsville, Texas — would produce an average of 68 per cent of the corresponding products now produced by the present organic chemical industry of this country, varying from 28 per cent for acetaldehyde to 87 per cent of the present acetic acid production. On the same basis Secretary Krug's plan would produce from natural gas alone seven times that amount of organic chemicals, or on the average  $4\frac{3}{4}$  times the average yield of these chemicals from the present organic chemical industry. In addition, the Krug program would entail the production of a similar quantity of these same chemicals from the Fischer-Tropsch plants producing oil from coal. Fortunately, so large a quantity of chemicals cannot be thrown on the market in a short space of time.

It is well known that there is a considerably greater demand for natural gas for home and industrial use than can now be met. Were 2 trillion cubic feet of natural gas allocated to liquid fuel production, the question of filling the needs of established markets for natural gas would have to be answered. Also, what justification is there for spending raw materials and labor on a process to produce a liquid fuel from natural gas which results in a loss of a large proportion of the heating value of the raw material and yields a product — fuel oil — which is more costly and not so satisfactory for the end use of house heating?

The nature of the operations involved in recovering and refining petroleum and producing fuel oil, aviation gasoline, and a host of other products gives this industry much more of the necessary "know-how" to produce synthetic fuels from natural gas than is available to any other industry or to government agencies. The Bureau of Mines recognizes this fact and has wisely left this phase of the problem to the oil industry.

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The only real difference between the production of oil from natural gas and oil from coal by the Fischer-Tropsch Synthesis is the method of producing the Synthesis Gas (carbon monoxide and hydrogen). One of the major questions in either case appears to be that of a cheap method for the production of oxygen. Again the major oil and coal companies appear to be in a strategic position to design and operate plants for oil from coal by indirect synthesis (Fischer-Tropsch).

Apparently some of the oil companies, after years of laboratory and small-scale experimentation, have begun to favor the Fischer-Tropsch process over the Bergius process for production of oil from coal, in spite of, or because of, all the information available on German and British experience.

Although the recovery of oil from shale is a relatively simple process, the tonnages of materials to be handled are enormous—10 tons of shale per ton of oil. Methods for economical handling and processing will necessarily have to be developed, as the principal shale deposits lie in areas remote from the larger markets. Transportation methods and costs will have to receive due consideration. Already, Standard Oil of California is experimenting with pipe lines for oil from shale. Methods of refining shale oil are still in the experimental stage.

It is to be sincerely hoped that there will be no unwary rush into this gigantic program which is many times the size of the synthetic rubber program undertaken and successfully fulfilled during World War II. The Synthetic Fuels Program is too huge to be put into operation overnight—or over a year's time. It must be done over a period of years as required to amplify dwindling supplies of fuels from petroleum; otherwise, many appalecarts and markets will be upset and disorganized. It appears logical that one demonstration plant of commercial size for each of the major processes be built and operated to produce liquid fuels from shale and from coal by Bergius and Fischer-Tropsch procedures. The greatest progress would undoubtedly come by cooperation between government and industry—with industry operating the commercial plants and government aiding in the financing when necessary.

As the Krug plan calls for an expenditure of 9 or 10 billion dollars and requires 16 million tons of steel, it evidently will require some years to put into operation. Also it is exceedingly doubtful whether the funds suggested for this program could be raised from private capital. Only the specter of war and a policy of national preparedness can justify consideration of such a program. Many of the top administrators in the oil industry have stated their belief in the ability of industry to satisfy the nation's and the world's requirements for liquid fuels with a fraction of the steel and expenditures demanded by the Krug plan. Should not the ideas of these top-flight executives be given due weight in the shaping of any synthetic liquid fuels program? In any case, however, the prices of gasoline and fuel oil to the consumer are due to increase.



*Reprinted from April 1946 issue of Scientific Monthly, thru courtesy of the author and American Association for the Advancement of Science.*

## COAL BALLS—A KEY TO THE PAST

*This brief story of the plants of the Coal Age is respectfully dedicated to the coal miners of Iowa and Illinois for their friendly interest and willing cooperation which have rendered possible our study of the plants of one of the earth's most interesting periods.*

By HENRY N. ANDREWS  
Washington University, St. Louis

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More than 200 million years ago vast areas of the United States, from Massachusetts to Kansas, were covered with low humid swamps—a “Great Dismal Swamp” on a magnificent scale. There is no sound basis for belief that it was necessarily a steaming tropical jungle as we are so often led to believe, but it certainly was composed of a lush growth of plants most of which would appear weird and strange to a modern field botanist.

In the stagnant swamp waters there accumulated a vast quantity of plant debris, most of which partially decayed and became compressed to form the plant-mineral we call coal. A microscopic examination of this all-important natural resource rarely reveals any distinguishable plant structure other than spores and pollen grains, yet by indirect methods we have learned a great deal about the vegetation that was responsible for it. This information has been gleaned very largely from *coal balls*, aggregations of petrified plants found in the coal seams of Midwestern mines.

Through southern Illinois, to select a typical and productive hunting ground, the coal seams often lie within 20 to 50 feet of the surface of the ground, and if they are thick enough it is profitable to employ the open-pit, or “stripping,” methods of mining. Gigantic electric shovels, scooping up as much as 25 to 30 cubic yards of earth and rock at a time, clear away the overburden, laying bare the coal below. In exploring such an exposed surface we might, with a little luck, chance upon characteristic rounded knobs projecting a few inches above the level of the seam as a whole. Upon digging down into the coal a few inches we find these knobs to be brownish ball-shaped masses of petrified plants.

These petrifications are called coal balls because of their more or less rounded shape and because they are found in the coal itself. They contain a heterogeneous assemblage of petrified plant remains—stems, seeds, leaves, and other plant organs, often in a nearly perfect state of preservation. They are representative fragments of the millions of tons of forest debris that served as the raw material for coal. Our knowledge of the origin of these fossils is by no means complete, but

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FIG. 1. A STRIP MINE IN SOUTHERN ILLINOIS

*A large stripping shovel as well as the smaller loading shovel are shown in the background. The coal through the right center of the picture has already been removed.*

the essential steps in their formation seem clear — at least in a general way. During Upper Carboniferous times streams of water heavily charged with minerals seeped through the swamps. Scattered here and there fragments of plants served as a nucleus for the deposition of the minerals, and the resulting petrification prevented their being crushed and altered into coal.

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The coal balls are local in occurrence and as sporadically distributed. One may wander along an exposed seam for half a mile or more and not find one, then patches often covering many square yards will turn up. Where there are any at all there are hundreds of pounds, or even tons. In some mines they are never found and in others they are the usual thing. Incidentally, they are a bane to miners, for in addition to dulling drills they will not burn and must be screened out before the coal is loaded for market. In size they vary from specimens smaller than a thimble to huge ones almost too heavy to lift.

It is fitting to point out that this mode of fossilization is quite different from that of the famous nodules of northern Illinois, discussed in "Fossil Plant Miniatures of Mazon Creek" by Raymond E. Janssen (*THE SCIENTIFIC MONTHLY*, March 1945). Although both are concretionary in nature—that is, built up by continued deposition of mineral matter about a central nucleus—the Mazon Creek concretions are found in the shales above the coal and contain as a rule but one com-

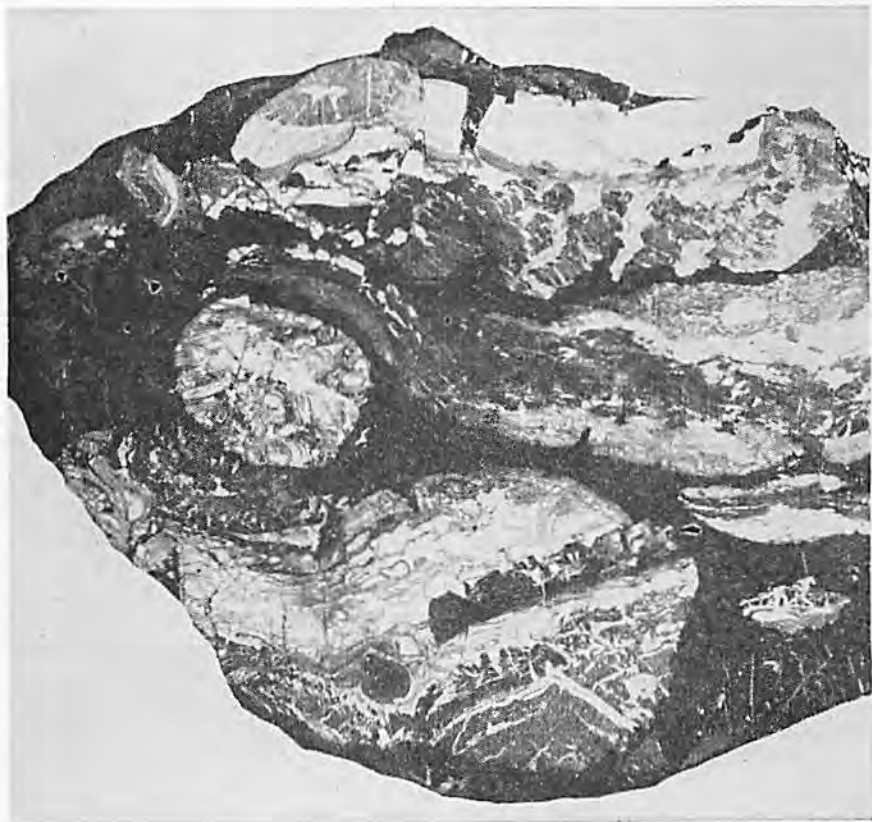


FIG. 2. A FRAGMENT OF A LARGE SHEET OF COAL BALLS  
*Showing them embedded in the coal. About natural size.*

pressed plant fragment. On the other hand, the coal balls occur in the coal itself and are continuous masses of plant parts preserved in cellular detail. They offer a special problem for study, but yield correspondingly greater botanical knowledge.

Since these are a unique type of fossil, as well as one that has added an amazing chapter to our knowledge of the Coal Age forests, it may be of interest to outline briefly the procedure that the paleobotanist follows in order to extract from them their secrets of the past (Fig. 2).

The coal balls are cut in half with a diamond-impregnated saw, and with a specimen 3 to 4 inches in diameter this is a matter of as many minutes. Next, the cut surface is smoothed with carborundum abrasives of No. 100 and No. 400 and then dipped into dilute hydrochloric acid. The acid will dissolve out the mineral matter (chiefly calcium and magnesium carbonate), leaving a very thin layer of the unaffected plant tissues standing in relief. This etching time varies with the strength of acid employed and the relative amount of mineral matter present. After the etched surface is washed and dried a solution of *parlodion* is poured over it and allowed to harden overnight. In the morning the resulting film is peeled off, using a razor, and with it comes a thin section of whatever plants have been exposed.

Unfortunately no amount of experience or knowledge will enable us to determine beforehand what is in the coal balls. We do know that they will contain petrified plants and judging from their specific gravity and the kinds of minerals composing them we can be reasonably sure of the *quality of preservation* but not of the *kinds of plants* preserved. That is possible only by following the above described study procedure. As might be expected the coal balls from any one mine will generally contain the stems, roots, leaves and seeds of relatively few plants, that is, the ones that composed the dominant elements of the vegetation of that time. Yet, just as we find in modern forests scattered individuals of the rarer trees and shrubs, so in these petrifactions every once in a while a new stem or seed turns up which serves to expand our knowledge of the ancient forest and whet our appetite for more and more coal balls!

This so-called "peel" method of studying the fossils was initiated some 20 years ago by Professor John Walton of Glasgow University. For more than a century prior to that time paleobotanists resorted to the time honored method of cutting a thin slice of the fossil material, fastening it to a glass slide, then grinding it thin enough to transmit light so that the plant tissues could be studied under a microscope. While we still use that older technique with some specimens, the peel method has a number of advantages. It is much quicker; we can produce hundreds of peels through an inch of material if necessary and obtain a complete series of preparations, while with the older cutting and grinding technique even a skilled worker could prepare at best 8 to 10 sections to an inch thus losing much valuable material. The possibility of making serial sections, particularly with very small structures, may be readily appreciated. Last, there is no limit to the

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size of a peel that we can prepare — peels have been made of the complete cross sections of petrified tree fern trunks as much as 10 inches in diameter.

My friends and colleagues upon seeing us arrive back from a day's collecting in the coal mines with a quarter to a half ton of specimens will shake their heads and inquire when we are going to erect a new building to house all these "rocks". Actually three quarters or more of the coal balls may be culled out on the first cutting because they contain poorly preserved or very common fossils. When the new or otherwise interesting plants are cut out and peels prepared for study one generally has less than 4 or 5% of the original bulk remaining.

When the peels or ground thin sections are prepared the fun really begins for we may then go to work with our microscopes, our knowledge, and our reference books and unravel the mysteries of these extinct plants of past ages.

From the great open-pit Pyramid Mine south of Pinckneyville, Ill., we have collected tons of coal balls during the past five years. These have revealed a wide variety of plants, although a species of *Lepidodendron* is by far the most abundant (Fig. 3, 4). In fact 90 percent

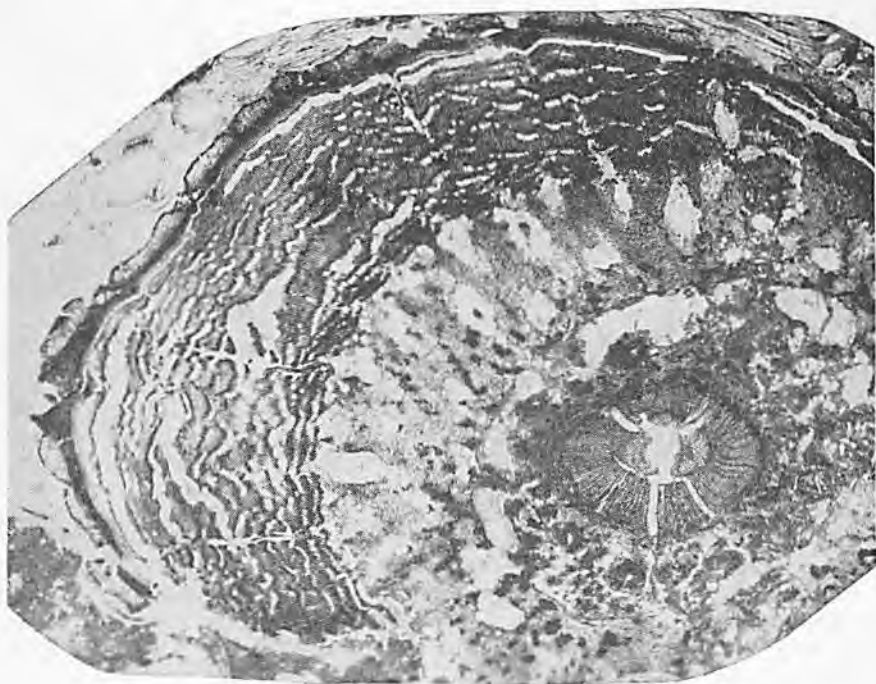


FIG. 3. A CROSS SECTION THROUGH PART OF THE  
STEM OF A LEPIDODENDRON

Note the small central core of wood and the thick outer zone of cork.  
Enlarged about 10 times.





FIG. 4. SPORES FROM A LEPIDODENDRON CONE

*Enlarged about 1000 times.*

or more of the petrified vegetable debris of the coal balls consists of the stems, roots, leaves, and reproductive structures of this plant, suggesting that it probably composed a nearly pure stand in the forests of that region. The *Lepidodendrons*, although related to the modern diminutive Club-mosses of our eastern woodlands, were trees of respectable size, attaining a height of 60 to 70 feet and bearing a profusion of small needle-like leaves. Their superficial appearance was similar to that of a fir or spruce. The stem anatomy reveals some of the distinctive features of these trees. In proportion to the general size, the stem possessed little wood, depending for additional support on a tremendous growth of cork tissue. Since this cork composed a considerable bulk of the stem and was less susceptible to decay than most of the other tissues, we may conclude that it is the chief constituent of the coal of this region, and this conclusion is substantiated in other ways.

The quality of preservation in the coal balls from any mine varies a good deal, depending on the extent to which the plants decomposed prior to fossilization, on the degree of replacement by the

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mineral, and on the nature of the mineral itself. The chief curse of the coal ball hunter is iron sulphide. Some specimens are composed almost entirely of it and in such cases they are of little or no botanical value. Specimens containing small quantities of iron sulphide are workable and may contain well-preserved plants, but in general they are distinctly inferior to those petrified by calcium and magnesium carbonate only. The "sulphur balls" as they are referred to by the miners, are excessively heavy and readily distinguished in the field in this way.

The perfection of preservation of relatively delicate plant tissues is a never-ceasing marvel to the uninitiated and to the professional paleobotanist alike. One of the most striking cases we have encountered is the presence of beautifully preserved fungus mycelium in the cortical cells of a fern stem (Fig. 5). The vegetative filaments (mycelium) of fungi are of common occurrence in petrified plants, but in this instance the mycelium had profusely invaded many of the host cells in a way strongly suggesting the mycorrhizal relationship in living plants. A vast number of modern perennial plants are now known to be dependent upon such a fungal association for certain phases of their nutrition, and it is of interest to find that this association must be one of great antiquity.

Plant structures as delicate as root hairs have turned up on at least one occasion in the Illinois coal balls. The roots, stems, and leaves of plants assigned to the Cordaitales, ancestors of present-day conifers, occur frequently enough to suggest that they were second in numerical importance only to the Lepidodendrons. They were trees that attained a height of 80 to 100 feet and bore long strap-shaped leaves, presenting a close superficial similarity to the foliage of iris or corn. In one of our earlier collections from the Pyramid Mine a stem was found with roots in organic connection, and some of the smaller rootlets retained their epidermal root hairs sufficiently preserved that they might well be used to demonstrate the salient structural features to a student in an elementary botany course.

Contrary to what might be expected, the more fragile plant tissues are often better preserved than the more resistant ones. The integument, or coat, of a seed, likewise belonging to the cordaitan group, found recently, is typical. It consists of three distinct layers: an outer one of large thin-walled cells, probably quite fleshy in life, and two inner layers, the cells of which had walls that were thick to the point of being stony, much like the "grit" tissue of a pear. The outer tissue was very well preserved whereas the inner two had become rather badly decomposed prior to fossilization. This is by no means an isolated case, and the explanation seems clear when one reviews the probable sequence of events. The mineral-bearing waters were able to penetrate the thin-walled cells much more rapidly than the sclerotic ones, thus insuring their petrification before bacterial and chemical decomposition set in to any appreciable extent.

As might be expected, the flora of the coal balls varies somewhat from place to place. For example, specimens gathered in the vicinity of Des Moines, Ia., reveal a different Carboniferous landscape from the

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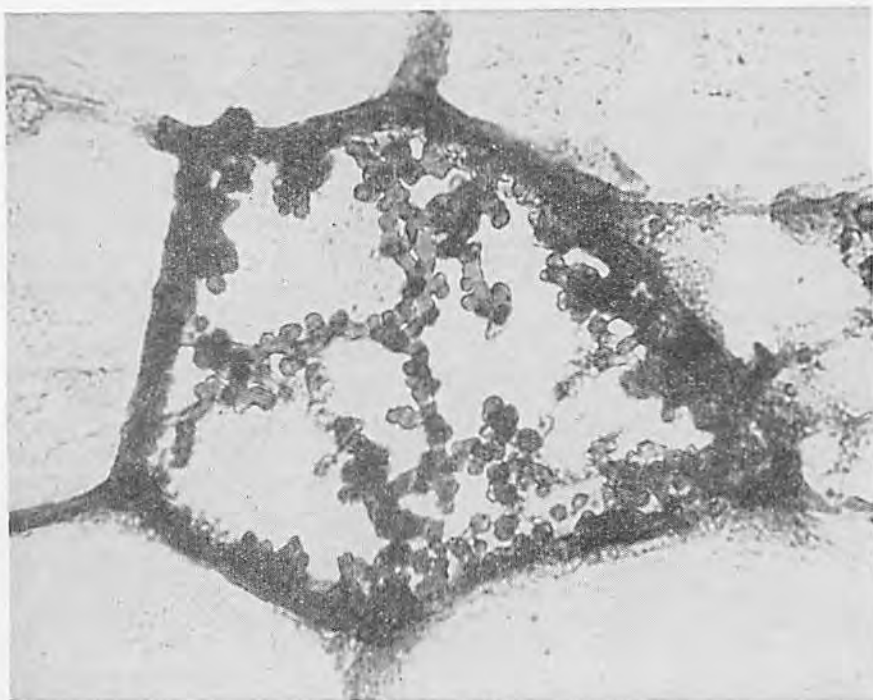


FIG. 5. FOSSIL FUNGUS MYCELIUM

*From the bark cells of a fern stem found in an Illinois coal ball.  
Magnified about 500 times.*

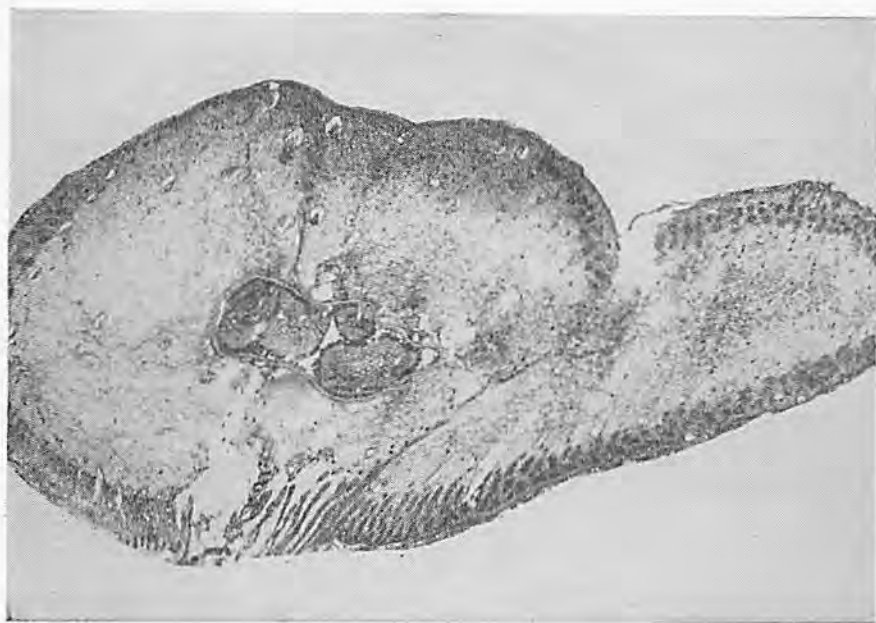


FIG. 6. A SEED-FERN STEM FROM IOWA

*This cross section of Medullosa Thompsonii shows three steles composing the central conducting system of the plant and a leafstalk departing at the right. Magnified about 2 times.*

Illinois mines a few hundred miles to the southeast. In Iowa, seed plants seem to have been dominant, including members of the Cordaitales, and a considerable variety of species belonging to that most fascinating of all extinct fossil groups, the Seed-ferns, or Pteridospermeae (Fig. 6). This does not imply, however, that the plants composing the two floras were entirely different, for in nearly all Upper Carboniferous deposits from Kansas and Iowa east to China, there occur certain common genera of Lycopods and Calamites and a wide variety of fernlike foliage. Some of the latter we know belonged to true ferns, a few have proven to be Seed-fern fronds, and the affinities of a great many remain in question.

The abundance of this fernlike foliage that is found almost everywhere in the shales that overlie coal deposits of Pennsylvanian age has led to numerous learned monographs. Unfortunately much of it is sterile, offering no recognizable clues as to its natural relationships. A suggestion began to grow in the minds of paleobotanists during the latter part of the eighteenth century that these apparent ferns may have borne seeds. The evidence, however, was not forthcoming until about 40 years ago, and in more recent decades a number of

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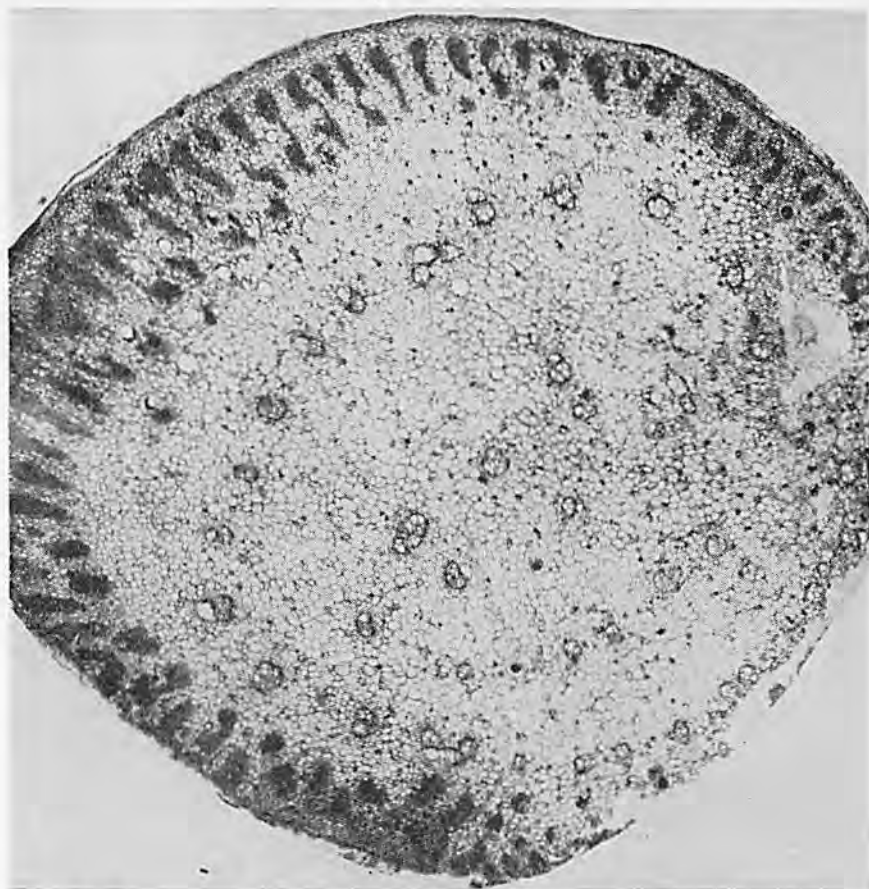


FIG. 7. A LEAF STALK OF THE SEED-FERN STEM SHOWN IN FIGURE 6  
*There is a striking superficial similarity with that of a modern corn stalk.*

these "ferns" have been found to be Seed-ferns, presenting a multitude of distinctive characters, especially in the anatomy of their seeds and stems.

In the Iowa coal balls we have found a number of new and unique Seed-ferns, as well as specimens the same as, or closely related to, previously described European species. Of particular interest is the genus *Medullosa*, distinguished by having more than one woody cylinder, or "stele," composing the central part of the stem. And like the *Lepidodendrons* their wood-producing ability was not sufficient to support a great weight. In lieu of this the outer cortex developed a stout layer of tissue composed of anastomosing, vertically aligned strands of fibrous cells. The seeds of these plants are similar in certain respects to those of modern cycads, having a well-developed pollen

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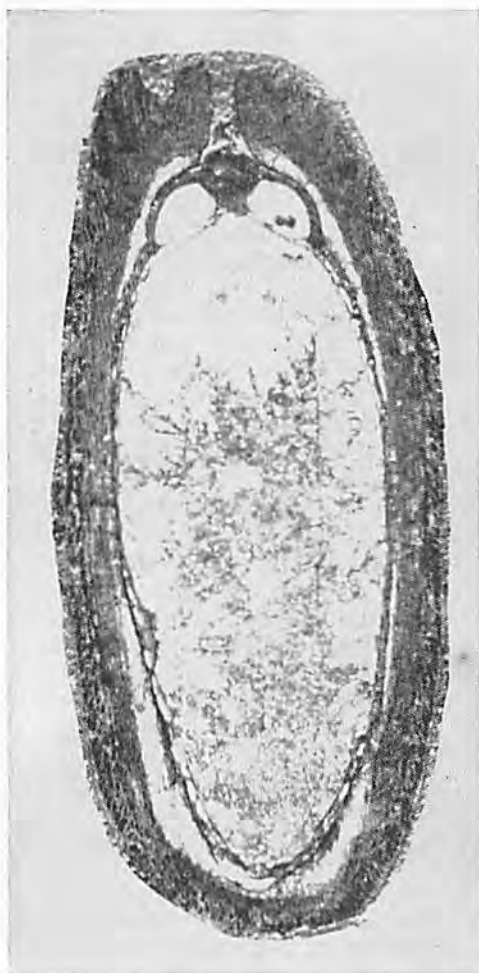


FIG. 8. A FOSSIL SEED

*In this longitudinal section note the pollen grains in the top chamber at the right.  
Magnified about 25 times.*

chamber near the apex of the seed, in which the pollen grains apparently germinated and produced their male sex cells (Fig. 8).

These calcareous concretions have been known for nearly a century from the coal fields of northern England. The earliest authors who gave a clear account of the petrified plants found within them were Joseph D. Hooker and E. W. Binney in 1854. Later in the century the works of W. C. Williamson began to reveal the extent of the prolific treasure of ancient plant life contained in coal balls, and his work was carried on by the late D. H. Scott, to whom we are indebted

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for a rich series of contributions on Paleozoic botany as well as an encyclopedic, yet very readable, text on the anatomy of fossil plants. In more recent years these petrifications have been found in the Dutch, Belgian, and Russian coal fields.

In this country coal balls were discovered in a mine near Des Moines, Ia., as long ago as 1894. They apparently were not then brought to the attention of paleobotanists and consequently remained as dormant as before until years later. About 25 years ago the late A. C. Noe, of the University of Chicago, initiated the first productive interest in coal balls in America through their discovery in open-pit mines through central and southern Illinois. They have since turned up in a number of adjacent states, including Indiana, Kentucky, and Kansas, but the better preserved and largest collections to date have been obtained from Iowa and Illinois. We still lag considerably behind the great contributions of the British paleobotanists. There is now, however, a great deal of active interest in these American deposits which have already yielded such an abundance of beautifully preserved plants of the past.

The paleobotanist, perhaps more than other scientists, is dependent on the good will and cooperation of local amateur collectors—people who have made a thorough study of the occurrence of fossils in a particular region. In this way much more information and material may be accumulated than would be possible for a few professional workers in their limited time. We are particularly indebted in this respect to Frederick O. Thompson of Des Moines, Iowa. During the last 16 years his vigorous collecting activities, often carried on under weather conditions that would have discouraged the most enthusiastic of naturalists, has brought to light a wealth of previously unknown plants. Most of this material has been deposited for detailed study at Harvard University and at Washington University in St. Louis. Unfortunately it is rare that generosity and appreciation of educational values will lead a man to devote almost endless labor and ask for so little return in the way of personal recognition. There is much that remains to be done and the part that such individuals can play in the continued advancement of science is of the utmost importance.

In closing this brief story it seems fitting to outline the objectives of all this labor and study and we may think for the moment in terms of fossil plants in general rather than just those found in the coal balls.

We pry into these secrets of the past not out of idle curiosity, not with the object of pecuniary reward, but to inquire for the sake of the knowledge itself what the forests of past ages looked like and to learn how modern groups of plants came into existence. It is obvious, perhaps, that we shall never know the entire story for only very small portions of the woodlands of by-gone eras have been preserved as fossilized remains. The vegetation of certain ages is almost completely lacking, while that of the Coal Age and others scattered through the earth's history seem remarkably complete.

The problems involved are many, for plants of any size are never preserved intact. We must deal with scattered fragments of stems,

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FIG. 9. A SECTION CUT LENGTHWISE THROUGH A SEED

*Found in an Iowa coal ball. Note the rather well preserved thick outer fleshy layer.*

leaves, seeds and other parts. It requires much patience, long study and a generous admixture of luck to reconstruct a single extinct plant, to say nothing of a complete landscape. Yet in view of the rather small number of professional paleobotanists and the fact that this is a relatively modern branch of science, its really productive period extending back little more than a hundred years, the results thus far are most encouraging. There are probably well in excess of a million species of plants living on the earth today, all differing from each other to a greater or less degree. How did all these different forms come into being? That is the problem that we would solve, at least in part. A century and a half ago almost nothing was known of these representatives of past ages preserved in the rocks but today it would require many pages to simply list the major accomplishments. We know, for example, that plants first emerged on the land

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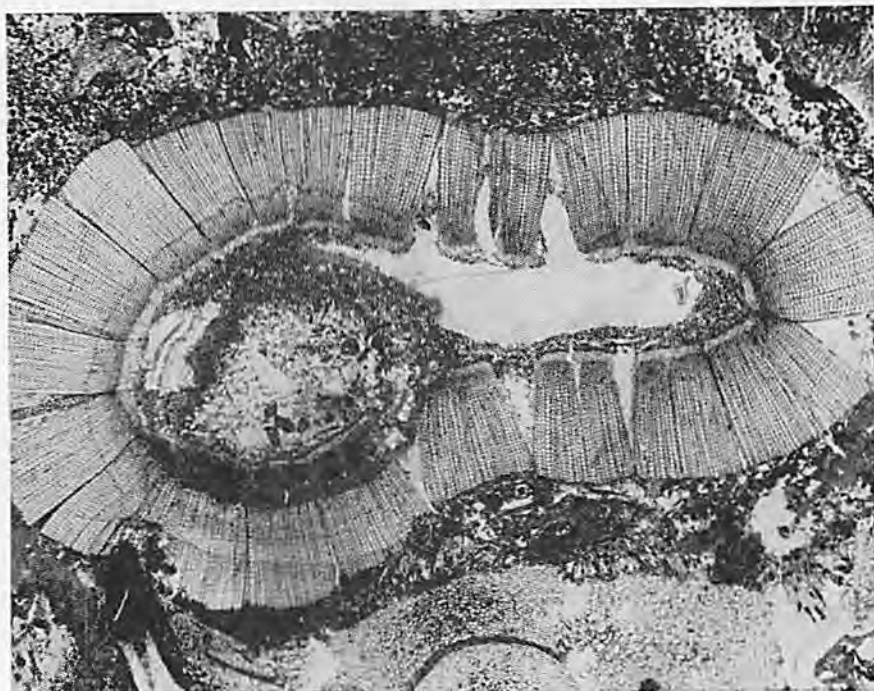


FIG. 10. A CROSS SECTION THROUGH THE ROOTSTALK OF A LEPIDODENDRON.

more than 300 million years ago and we know a great deal about the detailed cellular structure of these curious primitive creations; we have traced three modern families of ferns back into Carboniferous rocks of 250 millions of years ago; we have uncovered major groups of plants such as the Seed-ferns, the fossil Cycads, the Cordaites, and others which have significant bearing on the origin of modern groups; we have a remarkably complete story of the evolution of certain of the evergreens; and much is known of past climatic changes from studies of the fossil plant record. These are the kinds of achievements that are being realized.

The study of fossil plants is also of interest to museum curators whose task it is to reconstruct habitat settings of ancient animals. There are few exhibits that offer stronger attractions to museum visitors than the bizarre dinosaurs, early mammalian groups, and others. But these animals lived in an environment of plants and directly or indirectly they fed upon them and were guided in their racial evolution by plants. Thus it is important that we know as much as possible about the plants themselves.

The economic aspects of paleobotany are not entirely lacking however. Perhaps the most notable application is the use of spores

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and pollens in correlating the various horizons of Upper Carboniferous coal bearing formations. For those who are not familiar with the geology of the central and east central states it may be noted that the coal does not come from just one level or horizon. We have, rather, a great succession of coal deposits which vary in thickness, areal extent, as well as the kinds of plants that compose them. The plants have been so crushed and altered chemically as to have obliterated most of their distinctive structural characteristics. Spores and pollen grains are, however, well preserved and may be isolated by special techniques. Then by studying the particular spores and pollens that characterize a vein of coal it may be possible to correlate that vein, as well as others above and below it, with similar series of veins in another part of the country.

It is very possible that in the future other practical applications of this science will materialize but it is more than probable that its greatest value will continue to be a more cultural one, a quest for the solution of the many problems concerning the evolution of plants as we find them on the earth today.





## CONSTITUTION AND BY-LAWS

Adopted June 24, 1913  
Amended Nov. 12, 1926  
Amended Nov. 8, 1929  
Amended Nov. 8, 1935  
Amended Oct. 21, 1938

## ARTICLE I.

## NAME AND PURPOSE.

The Illinois Mining Institute has for its object the advancement of the mining industry by encouraging and promoting the study and investigation of mining problems, by encouraging education in practical and scientific mining, and by diffusing information in regard to mining that would be of benefit to its members.

## ARTICLE II.

## MEMBERSHIP.

Section 1. Any person directly engaged or interested in any branch of mining, mining supplies, mining appliances, or mining machinery may become an active member of the Institute. Any person desiring to become a member of the Institute shall fill out a blank for that purpose, giving his name, residence, age, and occupation. This application shall be accompanied by one year's dues of \$3.00. Each application for membership shall be submitted to the Executive Board, who shall make an investigation as to the qualifications of the applicant, and shall be authorized to elect to membership and issue a certificate of membership to such applicant subject to the ratification of the next regular meeting of the Institute.

Section 2. Any person of distinction in mining may be elected

an honorary member of the Institute by two-thirds vote of the members present at any regular meeting. Any member who has been an active member of the Institute and shall have retired from active business in mining may become an honorary member.

Section 3. The annual dues for active members shall be \$3.00 and any person in arrears on August 1, of the current year, after having been sent two notifications of dues, shall be dropped from membership. Members in arrears for dues will not receive the printed proceedings of the Institute.

Section 4. Any active member may become a life member by the payment of \$50.00 and shall be exempt from further payment of dues during his lifetime.

## ARTICLE III.

## OFFICERS.

Section 1. The officers shall consist of a President, Vice-President, Secretary-Treasurer and twelve Executive Board members. The services of all officers shall be without compensation.

Section 2. Nominations for officers and the executive board shall be made by nominating committee of three (3) appointed by the President at least thirty days before the annual November meeting, pro-

vided that anyone can be nominated on the floor of the meeting for any office for which an election is being held.

Section 3. The President, Vice-President and Secretary-Treasurer shall be elected by ballot, annually, at the regular November meeting and shall hold office for the ensuing year.

Four Executive Board members shall be elected by ballot, annually, at the regular November meeting and shall hold office for the ensuing three years.

To make effective this change, at the regular November meeting in 1938, in addition to the four Executive Board members who shall be elected for the three year term, there shall also be elected by ballot eight other Executive Board members, four for a two year term and four for a one year term.

Section 4. In case of death, resignation, or expulsion of any officer, the executive board may fill the vacancy by appointment until the next regular meeting, when the vacancy shall be filled by regular election. In case of a vacancy in the office of president, the duties shall devolve upon the vice-president.

Section 5. The executive board shall consist of the officers and twelve other board members.

## ARTICLE IV.

### DUTIES OF OFFICERS.

Section 1. The president shall perform the duties commonly performed by the presiding officer and chairman. He shall sign all orders for payment of money by the treasurer, and with the executive board shall exercise a general supervision over the affairs of the Institute between sessions.

Section 2. The vice-president shall preside in the absence of the president and perform all the duties of the president in his absence.

Section 3. The secretary-treasurer shall keep a record of each meeting, shall read and file all resolutions and papers that come before the Institute, countersign all orders for money which have been signed by the president, and shall purchase necessary supplies under the direction of the executive board.

He shall keep a true record of all money received by him and payments made on account of the Institute. He shall pay out no money except on an order signed by the president, and countersigned by himself, and shall retain these orders as vouchers. He shall give bond in such sum as the Institute may provide, the premium on said bond being paid by the Institute.

He shall act as editor-in-chief for the Institute and may furnish the newspapers and other periodicals such accounts of our transactions and discussions as are proper to be published. His own judgment is to prevail in such matters unless objection is lodged at a regular meeting or by the executive board.

The retiring president shall act ex-officio in any capacity for the ensuing year.

Section 4. The president shall appoint an auditing committee annually to audit the accounts of the secretary-treasurer, and said audit shall be submitted to the November meeting of the Institute.

Section 5. The Executive Board shall perform the duties specifically prescribed by this constitution; it shall supervise the expenditures and disbursements of all money of the Institute, and no expenditure other than current expenses shall

be authorized without first having the approval of the Executive Committee; it shall act as program committee for each meeting to determine what is to be published in the proceedings and shall perform such other duties as may be referred to them by regular or special meeting of the Institute.

## ARTICLE V.

### MEETINGS.

Section 1. Regular meetings shall be held in June and November of each year and on such days and in such places as may be determined by the executive board of the Institute. Notice of all meetings shall be given at least thirty days in advance of such meetings.

Section 2. Meetings of the executive board shall be held on the call of the president, or at the request of three members of the executive board, the president shall call a meeting of the board.

## ARTICLE VI.

### AMENDMENTS.

Section 1. This Constitution may be altered or amended at any regularly called meeting by a majority vote of the members present, provided notice in writing has been given at a previous semi-annual meeting of said proposed change of amendment.

## ARTICLE VII.

### ORDER OF BUSINESS.

At all meetings, the following shall be the order of business:

- (1) Reading of minutes.
- (2) Report of executive board.
- (3) Report of officers.
- (4) Report of committees.
- (5) Election of new members.
- (6) Unfinished business.
- (7) New business.
- (8) Election of officers.
- (9) Program.
- (10) Adjournment.

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LOEWENHERZ, WALTER.....	K. W. Battery Co., 3705 N. Lincoln Ave., Chicago 13, Ill.
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MAC DONALD, JOHN.....	Superior Coal Co., Gillespie, Ill.
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- McCOY, J. M., Mining Engr.....  
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- McCULLOCH, WM. C.....Roberts & Schaefer Co., 130 N. Wells St., Chicago 6, Ill.
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- McCUTCHEON, R. B., Supt.....  
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Bell & Zoller Coal Co., 307 N. Michigan Ave., Chicago 1, Ill.
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- McFADDEN, NAT., Div. Engr.....Peabody Coal Co., Taylorville, Ill.
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Gilmore Wire Rope Div., Jones & Laughlin Steel Corp., 135 S. La Salle St.,  
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- McKEE, ROBERT.....Superior Coal Co., Gillespie, Ill.
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- McLAREN, W. S.....McLaren Coal Co., Marion, Ill.
- McLAUGHLIN, FRANK.....  
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- McPHERSON, H. S.....  
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- MEALS, C. D.....Bethlehem Steel Co., Williamsport, Pa.
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- MEDILL, W. L.....Dept. Mines & Minerals, Springfield, Ill.
- MEISSNER, JOHN F., Consul. Engr.....37 W. Van Buren St., Chicago 5, Ill.
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- MELVILLE, J. B. F., Vice Pres.....  
Fairview Collieries Corp., 430 Big Four Bldg., Indianapolis 5, Ind.
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- MERLE, JAMES J., Asst. Prep. Mgr.....Fairview Collieries Corp., Danville, Ill.
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- MESHORER, SYLVAN A.....  
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- MEYER, CHARLES, Supt.....Mine Rescue Station, DuQuoin, Ill.
- MEYER, FRED.....C. B. & Q. Railroad, Centralia, Ill.
- MEYERS, EDMUND L., Asst. Ch. Elect.....Superior Coal Co., Gillespie, Ill.
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- NELSON, I. C.....Beall Bros. Supply Co., Marion, Ill.
- NESLAGE, O. J., V. P.....  
Joy Mfg. Co., 333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.
- NEWTON, CHAS. A.....Midvale Coal Co., 721 Olive St., St. Louis 1, Mo.
- NEWTON, H. W.....Barber-Greene Co., Aurora, Ill.
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- NOEL, WILLIAM, Asst. Dist. Mgr.....Cardox Corp., Benton, Ill.
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- NORTON, R. C., Asst. to Pres.....  
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Illinois Coal Operators Assoc., Annawan, Ill.
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- OAKLAY, WALTER H., JR., Sales Engr.....  
Bethlehem Steel Co., 400 N. Michigan Ave., Chicago 11, Ill.
- OBERJUERGE, W. W.....  
Oberjuerge Rubber Distributing Co., Third & Walnut Sts., St. Louis, Mo.
- O'BRIEN, C. M., Mgr., Fuel Div.....  
Better Business Bureau, 373 Arcade Bldg., St. Louis 1, Mo.
- O'BRIEN, W. L.....Illinois Power Co., Belleville, Ill.
- OETTEL, GILBERT B.....  
Power Transmission Equipt. Co., 640 W. Washington Blvd., Chicago 6, Ill.
- O'HARA, JOHN A.....  
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- OLDANI, JOHN V., Inspect.....  
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- O'LOUGHLIN, IVAN, Engr.....  
Northern Illinois Coal Corp., 310 S. Michigan Ave., Chicago 4, Ill.
- O'NEAL, BYRON.....Mt. Olive & Staunton Coal Co., Staunton, Ill.
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- PALMER, JOHN H., Sales.....Franklin County Coal Corp., Herrin, Ill.
- PARIS, J. A., Mng. Engr.....  
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- PARKER, ELTON L.....  
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- PARKHILL, WAYNE A., Industrial Sales.....Cities Service Oil Co., Marion, Ill.
- PARLIER, HENRY W., Shop Foreman.....  
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- PARMLEY, S. M., Consulting Engr.....  
Coal Preparation, Nelson L. Davis Co., 343 S. Dearbon St., Chicago 5, Ill.
- PATTERSON, MOSS, Dist. Mgr....Cardox Corp., 307 N. W. Fifth, Evansville, Ind.
- PATTERSON, V. E.....  
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- PATTISON, THOS. T.....National Mine Service Co., P. O. Box 43, Benton, Ill.
- PAUL, R. J.....Allis-Chalmers Mfg. Co., 1205 Olive St., St. Louis, Mo.
- \*PEABODY, STUYVESANT, JR., Pres.....  
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- PEARSON, T. W., Gen. Supt.....Little Sister Coal Corp., St. David, Ill.
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- PIPE, FRANK E., Slsmn.....  
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- \*PLATTS, E. M.....Joy Mfg. Co., 333 Oliver Bldg., Pittsburgh, Pa.
- PLESCHNER, O. J., Mng. Engr.....  
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- \*POLING, GILBERT.....  
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- \*POWERS, F. A.....1033 Butler St., Peoria 6, Ill.
- PRATT, STEWART M.....Superior Coal Co., Gillespie, Ill.
- PRIEST, LLOYD M., Office Mgr.....Little John Coal Co., Victoria, Ill.
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- PSCHIRRER, JOHN.....Pschirrer & Sons Coal Co., Canton, Ill.
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- REBSTOCK, JOE.....Coal Yard Supplies, 2550 W. Sullivan, St. Louis 7, Mo.
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- REES, ERNEST L.....Truax-Traer Coal Co., Elkhaville, Ill.
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- REESE, B. F., Pres.....Coal Dealers Sales Co., 175 Salisbury St., St. Louis 7, Mo.
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- REICHLING, R. L., Sales Engr.....  
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- REID, H. A., V. P. in Charge of Oper.....  
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- REITHER, E. C.....Timken Roller Bearing Co., 416 Craig St., Pittsburgh, Pa.
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- REUTER, WM. D.....Peabody Coal Co., 829 S. Virginia, Marion, Ill.
- REYNOLDS, GEORGE J., Elect. Engr.....  
Morgan Mines, Inc., 19 W. 38th St., Indianapolis 8, Ind.
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- RICE, RICHARD, Sales Repr.....  
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ROBERTSON, JACK F., Engr.....	Ecanleerf Engineering Service, Fairmont, Ill.
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- WILSON, WILLIAM.....Superior Coal Co., Gillespie, Ill.
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Their willingness and efficient cooperation  
have helped make this yearbook possible.

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We urge our membership to consult the Advertising Section in this and other issues of our Proceedings when in need of equipment.

Many of our friends — the advertisers — have carried copy with us in each issue. They have expressed satisfaction with the results obtained through their support.

This is the twentieth consecutive yearbook we have published.



**Hulburt Oil & Grease Company**

Philadelphia, Pa.

*Specialists in Coal Mine Lubrication*



# **WEST VIRGINIA TRACKWORK FOR MINES**

## **PREFABRICATED TRACK**

### **What it is —**

It is a track system designed to fit your needs. All rails are cut to length, curved, or bent as required and equipped with permanently attached fastenings. The total number of parts are held to a small minimum and all are interchangeable. The turnouts are interchangeable and may be used right hand or left hand. All parts have easily seen, permanent identification markings.

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### **What it costs —**

Its original cost is only slightly more than rails, frogs, switches, and ties purchased without prefabrication but its ultimate cost, due to the labor saved in its installation and removal, is materially less. West Virginia engineers will make a study of your mine and submit to you a plan best adapted to your needs.

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Rails and Accesories, Steel Ties, Crossings and Layouts, Frogs, Switches, Switch Stands, Derails, Rerailers, Rail Benders.

## **WEST VIRGINIA STEEL AND MANUFACTURING CO.**

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*Preferred by*

**COAL  
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*because  
they want  
FACTS!*

A recent impartial survey shows that coal men from foremen to president prefer Mechanization to other magazines by nearly three to one!

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*Coal Age*

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by continuously giving these men the kind of information and job-help they can put to immediate use. The material must be balanced by job-interests; it must be accurate and practical; it must be timely and interestingly written. *Above all, it must be planned and edited to serve the BUSY reader.*

Another important factor in the readers' choice of COAL AGE is the *quantity* and *quality* of informative product advertising. Because it carries the advertisements of all the major manufacturers from whom coal mines purchase equipment and supplies, COAL AGE constitutes a handy, up-to-the-minute buyers catalog.

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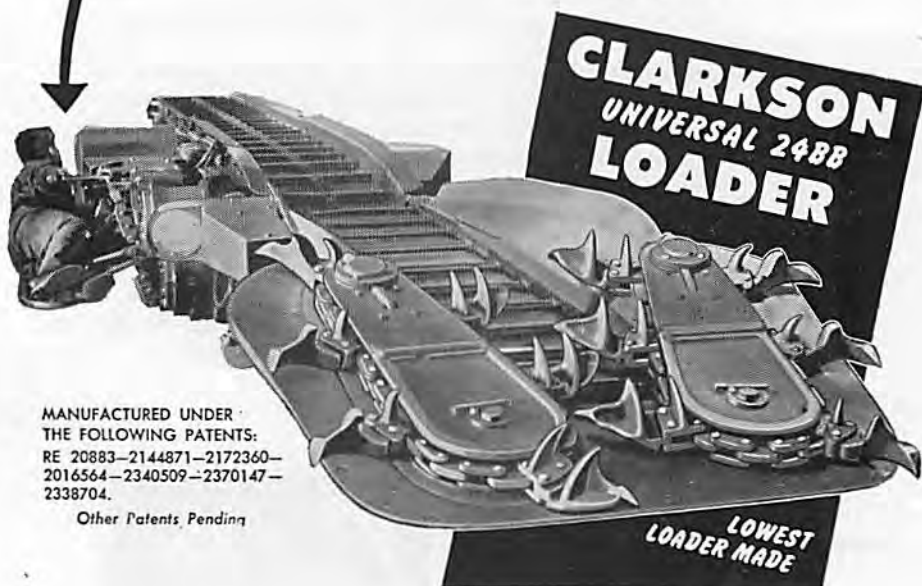
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***- One Operator  
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No other Loader offers these advantages.

***The CLARKSON MANUFACTURING CO.***  
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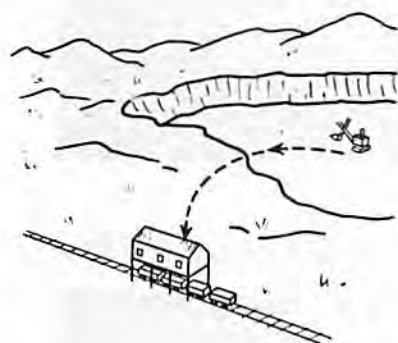
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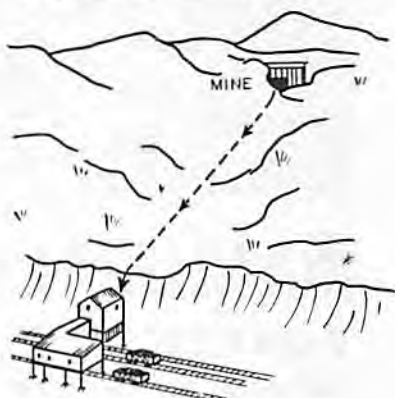


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Open pit mine moves coal from pit to railroad shipping pocket via belt conveyors.



Belt conveyor lowers coal from mine opening to tippie. Over 6 million tons have been handled with minimum maintenance.

## **Stephens - Adamson Belt Conveyors, Elevators, Screens and Feeders handle coal at reduced Cost**

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S-A heavy duty SACON type belt conveyor carrier shown at right, is furnished with ball or Timken roller bearings. This carrier is built for severe service, long life and utmost in economy of operation. Available for belts 18 to 60 inches wide.



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MFG. CO.

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**increase output with safety**

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**MANHATTAN** Conveyor Belts are made with **FLEXLASTICS**\* and specially designed Strength Members to distribute load strain uniformly, and cushioned to resist loading impact. Tough covering resists abrasion. Longitudinal and transverse flexibility provides power-economy, traction and easy troughing. Compensated to equalize ply stresses over small pulleys. Mildew-proofed for underground service. Made oil-proof for treated coal. A type and size for every service.

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\*The term **FLEXLASTICS** is an exclusive **MANHATTAN** trade mark. Only **MANHATTAN** can make **FLEXLASTICS**.

**MANHATTAN**  
Conveyor Belts

**BURONIK**  
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Guard

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Mine Dusting Hose  
Mine Suction Hose

**CONDOR**  
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There's no place for slack in the coal industry's program—or in a vital mining cable. To accelerate production, to strengthen your defense against equipment shutdowns, you need the workability and durability of Preformed Yellow Strand. With this time-tested wire rope handling the load, giant stripping and loading shovels can take the full bite. Main hoists can utilize their high speeds with safety. Above and below ground, cable-using machines can move closer to capacity operations and put off replacements.

These gains result from pointing up Yellow Strand's stout, drawn-to-order steel wires with the limberness of preforming. The rope reeves easily . . . runs freely around small sheaves . . . spools evenly despite overloads. Still every length is as tough as ever—highly resistant to shock, abrasion and drum crushing. Today time-and-labor-saving cable counts *double* in production. Install Preformed Yellow Strand and help your men and machines deliver to the limit.

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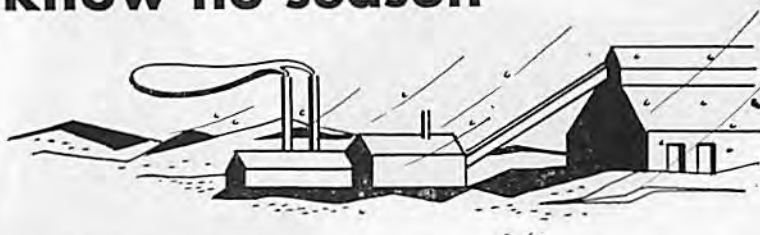
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**YELLOW  
STRAND**  
**PREFORMED WIRE ROPE**



# MINE ACCIDENTS

## know no season



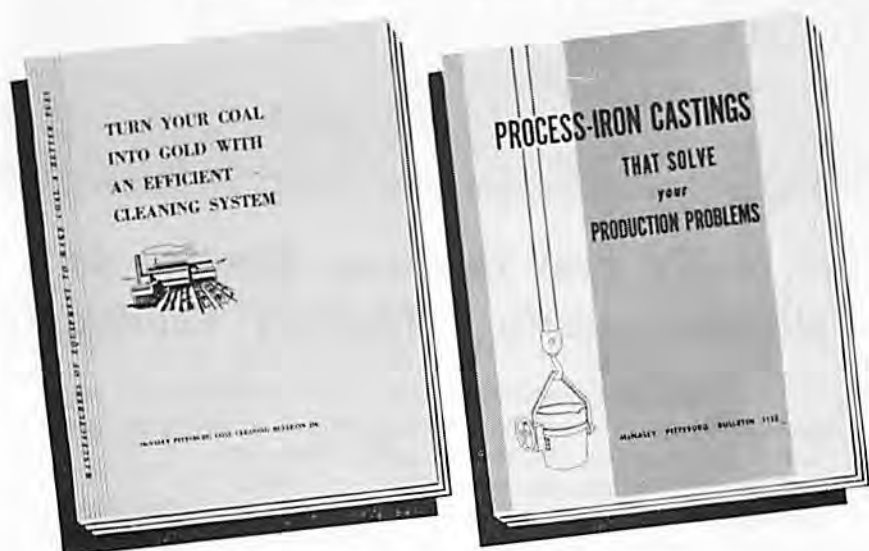
Winter . . . Spring . . . summer . . . fall, mine accidents know no season. And neither do Bituminous Safety Engineers. For they are "on guard" constantly, striving to help save lives, and reduce the frequency and severity of accidents in the mines of Bituminous Workmen's Compensation policyholders. To do this, Bituminous Safety Engineers maintain an exhaustive safety program involving regular mine inspections . . . analysis of hazards . . . recommendations based on surveys . . . accident prevention activities . . . reduction of operating expenses resulting from accidents . . . and establishment of production efficiency. The safety program benefits extend not only to the mine workers but operators and mine owners as well.

With Bituminous Workmen's Compensation insurance, you are protected against mine accidents . . . you get "SECURITY WITH SERVICE."



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*Bulletin No. 1115.* Features the processes and products of the new McNally Pittsburg Foundry. In this foundry all of the castings used in McNally Pittsburg equipment are made by the latest method of producing Process-Iron Castings. Two pages in this bulletin are devoted to tabular data and a description of Process-Iron Characteristics. The foundry takes on job production for those needing Process-Iron Castings.



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Timken bearings permit easier starting and higher speeds over Winding Gulf's 15,000 ft. haul-

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No other bearings can give you *all* the advantages you get with Timken bearings. Be sure every mine car you buy is equipped with Timken bearings, and always look for the trade-mark "TIMKEN" on the bearings you use. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address "TIMROSCO".

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**TAPERED ROLLER BEARINGS**



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CONSULTING AND CONSTRUCTING ENGINEERS

DESIGN AND CONSTRUCTION

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Every item for a complete mine-track set-up. After studying a blueprint or sketch of your workings, Bethlehem will figure the trackwork, cut the rails to length and precurve them in its own plant, and ship the entire outfit ready to assemble—rails, steel ties, switches, switch stands, turnouts, frogs, guard rails, joints, bolts, etc. A prefabricated track job saves installation time, cuts maintenance costs, reduces derailments.

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Bethlehem ties are made in a wide range of sizes and weights to suit individual conditions. Slip them under the rails, tap the clips into place with a hammer . . . that's all there is to it. No gaging, no spiking. Removal is just as easy. Install them for long-range economy; they outlast several sets of wooden ties and save maintenance too.

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For shafts, slope operations, incline planes, machine feeds, slusher hoists, conveyors, dragline excavators, power shovels. Bethlehem wire rope is available in all standard grades, sizes, and constructions, either preformed (Form-Set) or non-preformed.

Also recommended is the Bethlehem Lay-Lock Safety Clamp for shaft hoists. This device is bolted to the hoist rope several feet above the cage. Heavy chains connect the clamp to the cage so that, in case of rope failure at the socket, the cage is prevented from dropping.

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Fatigue-resisting drill steel—equally suitable for forged-on bits or threaded rods used with detachable bits. Easy to make up and heat-treat. The smooth, round, well-centered hole speeds up drilling by providing easy passage for air or water. Standard lengths, 17 to 25 feet.

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Type	Capacity	Type	Capacity
33-M .....	¾ cu. yds.	4161 .....	5 cu. yds.
362 .....	1½ cu. yds.	151-M .....	6 cu. yds.
372 .....	1¾ cu. yds.	5323 .....	18 cu. yds.
* 93-M .....	2½-3 cu. yds.	5561 .....	40 cu. yds.
492 .....	3 cu. yds.	**7200 .....	5-7 cu. yds.
*111-M .....	3½-4 cu. yds.	**7400 .....	8-12 cu. yds.
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\* Diesel Clutch type and Ward-Leonard electric.

\*\* Size of bucket depends on length of boom.

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POWER SHOVEL COMPANY

Marion, Ohio, U.S.A.



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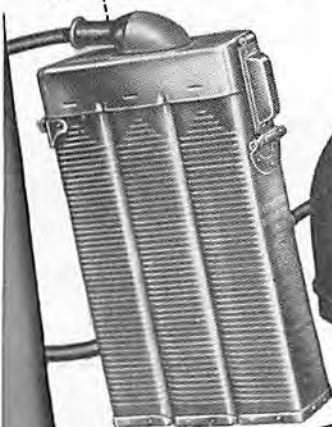
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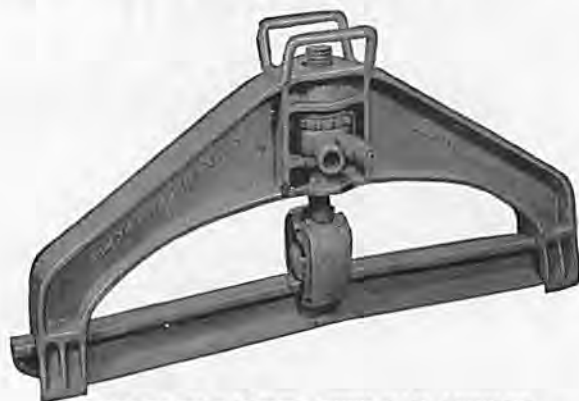
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*A Century of Confidence*



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HEAVY DUTY RATCHET TYPE RAIL LEVELER

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with a Complete Assortment of

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TO SERVE YOU EVEN BETTER WE HAVE ENLARGED OUR PLANT AND OUR ACTIVITIES. We are now able to supply you better and quicker than ever before. Same high standards of quality, workmanship, material, and engineering. Get full details on the performance of "GEMCO TRU-BLU" mining tools and their ability to reduce your costs. Here are a few of those "Miners Helpers" to cut your cost per ton of coal mined: RAIL PUNCHES, RAIL BENDERS (with "Friction Fighter" thrust bearings) Rail Levelers, Re-railers, Carstops, Derailers, Mine Jacks, Grease Guns, Spike Bars, Car Movers, Mine Cars & Wheels, Special Combination Tools, Key-seaters. TRACK-gauges, levels, spot boards,

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### **PILOT PLANT PERFORMANCE**

### **CLEANING PLANT EFFICIENCY**

***Coal Specialists Since 1908***

The trend in all coal preparation is toward design of cleaning plants based on test data. The reasons for this trend are:

Different coals have different washing characteristics.

All types of cleaning equipment do not perform in exactly the same manner.

Cleaning plant problems are becoming more difficult with the depletion of reserves of the more easily washed coals and with the demand for cleaning of the finer sizes.

The matching of the proper type of equipment with the washing characteristics of a particular coal is becoming progressively more technical and the result has been an increasing demand for accurate, unbiased technical data. Not only are most new, modern plants being constructed from designs based on washability test data but many older cleaning plants are being tested to secure data for their modernization.

As independent test engineers for the coal industry, we offer you the finest service in the country for securing test data on preparation problems.

*We invite you to write today for our free brochure entitled:  
"Determining the Washability Characteristics of a Coal."*

## **COMMERCIAL TESTING & ENGINEERING CO.**

**307 N. Michigan Avenue  
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Cleveland 15, Ohio

Norfolk 4, Virginia  
Baltimore 2, Maryland  
Philadelphia 2, Pennsylvania

Terre Haute, Indiana

Affiliated: Commercial Testing Co., Inc., Rochester 4, N. Y.

# **HENRY O. ERB**

COAL PREPARATION CONSULTANT

**Washability Studies**

**Plant Design**

**Plant Operation and**

**Control for Maximum Yield**

**And Efficiency**

Representative

**"VIKING" HOT VAPOR  
OIL TREATING PROCESS**

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Crawford 2086

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# **M I N E R**

## **DRAFT and BUFFER GEARS**

Mine car haulage costs can be definitely reduced by the use of Miner Draft and Buffer Gears. These devices should be specified for your cars because they provide necessary protection against the shocks of mine train operation. These shocks must be properly absorbed in order to prevent high maintenance expense and premature breaking down of car structure. Miner Gears are made in both center and double bumper arrangements.

**W. H. MINER, INC.**

THE ROOKERY BUILDING

CHICAGO, ILLINOIS



## TO THE WORKING FACE WITH ABC BRATTICE CLOTH

Air circulating into worked out areas is wasted air...air needed by the miners to keep energy and morale high for top production; better health; better job satisfaction. ABC Jute Brattice Cloth seals off inactive areas and routes ALL the fresh air to the working face.

ABC is the first choice of miners and mine owners because they know from experience that it will withstand the most severe use and abuse...that it won't double-cross the miners by developing leaks or catching on fire...that it does the best job and KEEPS doing it.

Selected jute fibres are uniformly and tightly woven to rigid specifications. Every square inch is specially treated to resist flame, fungi, shrinkage.

Chemicals are non-injurious; won't flake off. Send for samples.



VINYL Plastic Coated Mine Vent Tubing now shipped in Stapak fiber drums for protection, easier storage, convenient handling. Send for Bulletin 748.



**AMERICAN BRATTICE CLOTH CORP.** WARSAW, INDIANA



**SEAL-TITE  
TAMPING  
BAGS**

## KEEPS DUMMIES SAFE from BREAKING and SPILLING

Blasting procedure is streamlined with dummies made with Seal-Tite Tamping Bags. Labor, time and cost is reduced... A supply of dummies is quickly and simply made up at one time—and stored underground, safe from breaking and spilling—in Seal-Tite Tamping Bags.

Under humid conditions, the high wet-strength chemically-processed Sealtite Kraft won't tear or break—and the safety-seam won't open.

They're tough, too—they can stand the gaff in rough handling.



**SEND FOR SAMPLES TO TRY OUT**

Of course, you'll want to put them to the test. Send for free samples of Seal-Tite Tamping Bags in the sizes you want or we'll send an assortment of sizes—Just write!

**Tamping Bag Co.**

**212 SO. THIRD ST.  
MT. VERNON, ILL.**





# ....A MARK OF QUALITY

- Trolley Line Materials

Hangers  
Clamps  
Splicers  
Expansion Bolts  
Section Insulator Switches  
Frogs  
Turnbuckles

- Railbonds

Mechanically-Applied Bonds  
Steel Metallic Arc-Weld  
Process Applied Bonds  
Copper Metallic Arc-Weld  
Process Applied Bonds  
Welding Machines  
Portable Track Drills

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Safety Feeder Switches  
Feeder Slings  
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Trolley Wire Lubricators  
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- Couplers

Automatic Mine Car Couplers

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Canadian Ohio Brass Company, Ltd. Niagara Falls, Ont., Canada

COMPLETE O-B PROTECTION FOR CONTINUOUS PRODUCTION





## **BECK & CORBITT CO.**

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### **STEEL WAREHOUSE PRODUCTS**

HOT ROLLED BARS  
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"Since 1852"

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Garfield 2440

# DON'T GET YOURSELF IN A BARREL



CINCINNATI DUPLEX CHAIN

But If You Do . . . Cincinnati  
Chains Will Help Get You Out

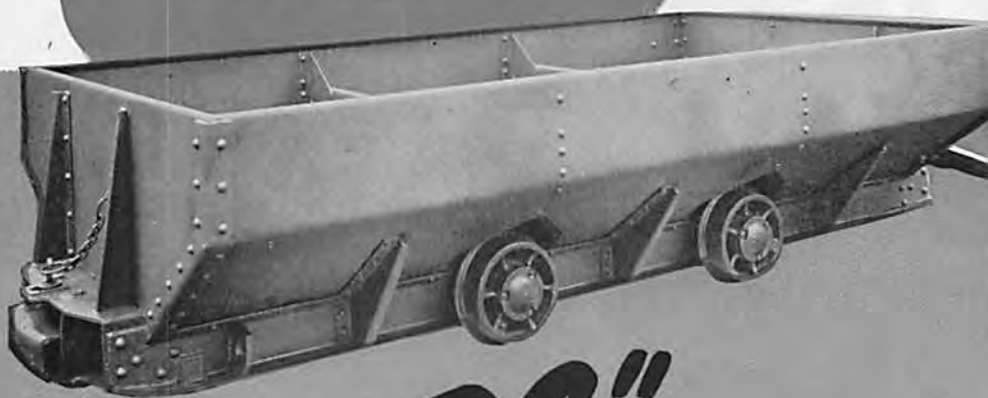
DON'T gamble on anything but the best in  
Coal Cutting Equipment. Production is too  
important . . . man hours can't be wasted by  
unnecessary shut downs . . . use Cincinnati,  
the tested, time saving, dependable coal cut-  
ting equipment. Mine after mine has swung  
to sturdy, well engineered Cincinnati Chains  
and reversible, double-ended Duplex Bits.  
Made of high grade alloy steel, especially heat  
treated by skilled metallurgists and designed  
for long wear and efficient performance, Cin-  
cinnati Chains, Bits and Cutter Bars are out-  
performing all competition. Reduce operating costs  
. . . increase production . . . save man hours  
. . . use Cincinnati Coal Cutting Equipment.

## THE CINCINNATI MINE MACHINERY CO.

2980 SPRING GROVE AVENUE • CINCINNATI, OHIO



a.c.f.



**"TOPS"  
IN DROP BOTTOMS!**

The unloading operation in A.C.F. Drop-Bottom Mine Cars is automatic—smooth in operation—without stopping the progress of the train. Cars moving without interruption, bring out a lot more coal and at lower cost per ton! All-welded end sill construction and drop action spring bumpers are only a few of the many exclusive features of A.C.F. Mine Cars. Ask our Representative to demonstrate the reasons why A.C.F. "Tops" in Drop Bottoms!



a.c.f.

**AMERICAN CAR AND FOUNDRY COMPANY**

New York • Chicago • Philadelphia • St. Louis • Cleveland  
Berwick, Pa. • Pittsburgh • Huntington, W. Va.



where ordinary ties last 4 years—

## KOPPERS PRESSURE-CREOSOTED TIES LAST 5 TIMES AS LONG!

Here's a story of substantial savings! It's typical, not unusual. A certain coal mine found that ordinary, untreated ties averaged only four years' service. Then, Koppers Pressure-Creosoted Ties were installed. Twenty-one years later, over 97% of these ties were still in use, and were still giving good service.

In other words, by installing Koppers Pressure-Creosoted Ties—the Ties that resist decay and stand up under the punishment of heavy traffic—this mine eliminated five costly replacements. Such savings have always been important, but with today's high labor and replacement costs, they are now imperative.

Koppers Pressure-Treated Wood can save money for you. It's easy to find out how. Just send for our free book—"10 Proven Ways to Cut Mining Costs."



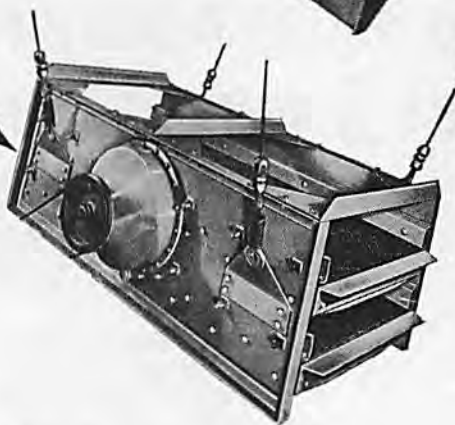
KOPPERS COMPANY, INC.  
Pittsburgh 19, Pa.

**PRESSURE-TREATED WOOD**

# HANDLE ALL TYPES OF COAL EFFICIENTLY *With These--*

## VIBRATING SCREENS for Sizing-Dedusting-Dewatering

*Selectro*



**GYROSET**

8  
POSITIVE  
STROKE  
ADJUSTMENTS

•  
FULL  
FLOATING  
SHAFT

Many alert operators are now enjoying the extra profits earned by the Selectro method which assures peak efficiency in screening coal.

Control of the length of the vibrating stroke makes Selectro-Gyroset equipment more flexible . . . more usable . . . and easier to operate. The selective throw principle, used on these machines, enables workmen to change the "stroke-length" in a matter of minutes.

WRITE FOR FULL PARTICULARS

# PRODUCTIVE EQUIPMENT CORP

2926-28 West Lake Street

CHICAGO, Illinois

# JOY

*The World's Most Complete Line  
of Modern Mining Equipment*

**PRODUCTS FOR  
THE COAL MINES**

## **JOY LOADING MACHINES**

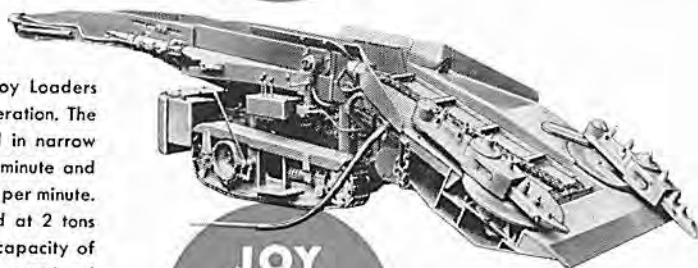
Joy makes two loading machines suitable for low vein work—the 12-BU and 14-BU. The 12-BU is rated at  $\frac{3}{4}$  tons per minute, and has a maximum capacity of  $1\frac{1}{2}$  tons per minute. Primarily designed for very thin seams, its total height is 28 $\frac{3}{4}$ ". The 14-BU is a high production, low vein machine with a rated capacity of 5 tons per minute and a maximum capacity of 8 tons per minute. Heights—30 $\frac{1}{2}$ ", 33" and 36".



**JOY  
14-BU  
LOADER**

*for thin seams*

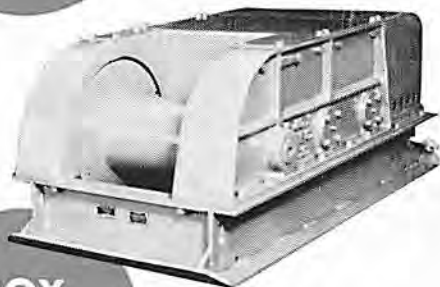
Three high tonnage producing Joy Loaders are available for thick seam operation. The 8-BU (56" wide), primarily used in narrow places, is rated at  $1\frac{1}{2}$  tons per minute and has a maximum capacity of 3 tons per minute. The 7-BU for 48" seams is rated at 2 tons per minute and has a maximum capacity of 4 tons per minute. The 11-BU, an exceptional tonnage mover in 60" seams, is rated at 5 tons per minute and has a maximum capacity of 10 tons per minute.



**JOY  
11-BU  
LOADER**

*for thick seams*

For spotting cars, pulling a trip of mine cars past a loading point or other heavy pulling jobs. Fully enclosed working parts—anti-backlash brakes to prevent over-spinning—automatic motor-shaft brake holds cars on grade when motor is not running—Alemite pressure fittings for easy lubrication. Carpullers of 5, 7, 10 and 15 H.P. with varying rope pulls and speeds are available.



**JOY  
CARPULLER**

*for moving cars  
and heavy loads*



# JOY MINING EQUIPMENT MOVES

## JOY CUTTING MACHINES



Licensed under the patent to  
E. C. Morgan, No. 1,953,325.

### JOY 10-RU

#### **Trackless Cutting Machine for thick seams**

Designed specifically for trackless mining, this versatile machine will top-cut, middle-cut, bottom-cut and shear. Horizontal cuts, made from 5' below floor level to 7½' above bottom. Hydraulic steering, short wheel base and ability to turn sharp corners are incorporated in this cost-saving unit.



### JOY 7-AU

#### **Track Cutting Machine**

With its long reach, this machine will cut and shear room necks from straight track, making two cuts with one track laying. Universal cutting positions, and its ability to keep approximately a square face and straight rib, aid faster mechanical loading.

Licensed under the patents to E. C. Morgan  
No. 1,953,325—1,953,326



### JOY 11-RU

#### **Trackless Cutting Machine for thin seams**

Only 30" high, this fast tramping machine cuts 30' room from 10" below bottom to 5' 4" above with a 6" kerf. Cutting feed at end of 9' boom (variable) is 0 to 70 ft./min. Turning radius 14' 6"

Licensed under the patent to  
E. C. Morgan, No. 1,953,325

## SHORTWALL CUTTERS



### JOY 11-B

#### **Shortwall**

Joy builds three shortwall cutters, each designed for a specific mining system. The 11-B is a short length, narrow machine for conveyor mining. The 7-B is a heavy duty cutter for high capacity production. The 5B-1 is a 10 H.P. machine for small mines. Both the 11-B and the 7-B can be equipped with the Joy Bugduster

## SULMET COAL CUTTER BITS, ROCK BITS AND AUGER BITS with Tungsten Carbide insert for lasting sharpness



Sulmet Bits have a cutting life many times greater, by actual test, than the hardest alloy steel bit. They consume less power; stay sharp longer; give more footage with less bit changing.

Consult a Joy Engineer for "The World's Most"



**TONNAGE FAST... at Low Cost**

## **JOY SHUTTLE CARS**

One of the several variations of the Joy Shuttle Car used in thin seam operations. Makes 90° turns easily; has hydraulic steering; low, wide loading end; 3 ton capacity; cable reel power only. Other 32" models available with automatic hydraulic cable reel or battery power.

There's rapid and economical handling of coal from loader to main haulage system in average height coal with this 42" car. Regular and hydraulic steering; two or four wheel drive; high or low loading and discharge ends are features of the various models in this size (including the 5-SC). Will haul 5 to 8 tons depending upon model.

The Joy 60E is an extra-large capacity Shuttle Car engineered for use in ore mines and very thick coal seam operations.

*for low seams*

### **32" JOY 6-SC FOUR WHEEL DRIVE**



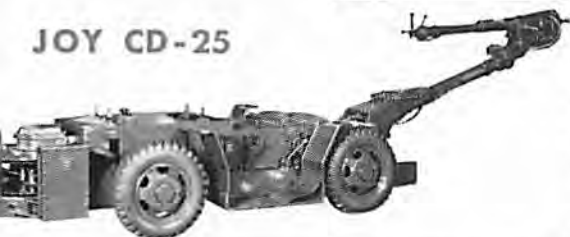
### **JOY 42" SHUTTLE CAR**

*for high seams*



## **COAL DRILL**

### **JOY CD-25**



The Joy CD-25 is a self-propelled, off-track, one-man coal drill, fast enough to keep ahead of any loading machine. Graduated dials enable operator to pre-select drill and feed speeds insuring highly-efficient, high speed performance. The CD-25 has an overall height of 36" and will drill a 9' hole from 6" to 5½' above bottom. A special boom can be provided for drilling up to 7' above bottom. Another all-hydraulic mobile coal drill, the CD-22, has a 30" height for thin seam operation.

## **JOY AXIVANE VENTILATION FANS**

*featuring Vaneaxial  
Aerodynamics*

These fans are designed for lower speed operation which reduces noise, increases bearing life and simplifies bearing lubrication. Spherical hub construction permits a wider range of blade adjustment. Simultaneously adjustable blades eliminate guesswork settings. Thus, Joy Axivane Mine Fans can easily be kept at peak performance and efficiency even when air volume demand increases or decreases considerably.



**1 H. P. PORTABLE TUBING BLOWER**



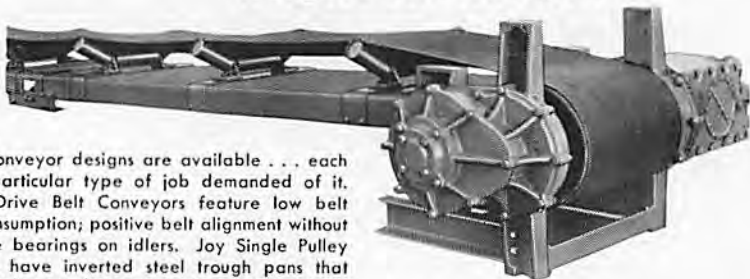
*Complete Line of Modern Mining Equipment"*

# JOY MINING EQUIPMENT

*Moves tonnage fast at low cost*

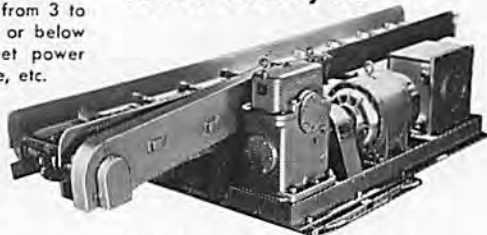
## JOY CONVEYORS

### Troughed Belt Conveyors



Three series of belt conveyor designs are available . . . each engineered for the particular type of job demanded of it. Joy Tandem Pulley Drive Belt Conveyors feature low belt tension; low power consumption; positive belt alignment without guides; sealed-for-life bearings on idlers. Joy Single Pulley Drive Belt Conveyors have inverted steel trough pans that rigidly support return idlers and protect belt. Joy "Type C" conveyors offer a complete line of conveyors with interchangeable parts. These units, available in various widths from 3 to 20 H.P., are adaptable to most operations, above or below ground. Joy conveyors furnished in sizes to meet power demands, depending upon length, gradient, tonnage, etc.

### Chain Conveyors



For mechanical mining in thin seams, Joy Chain Conveyors are available in a variety of sizes and powers for face loading, room and gathering work.

### Cushion-Drive

### SHAKER CONVEYORS

Joy Shaker Conveyors will move coal in inclines up to 15%, over rolling and dipping mine bottoms without spilling. Cushion Stroke reduces shock loads on all parts, adds greatly to the life of each unit.

### Shaker Conveyors



## JOY TIMBER SETTER



Will lift timbers to a height of 7'8", straight up on a free, full swiveling platform for safe, accurate positioning. A second jack, which can be lowered to mine floor, provides a solid prop from bottom to roof. A built-in, fully protected, hydraulically operated saw enables operator to cut timbers to exact size at point of work.

**JOY** MANUFACTURING COMPANY  
General Offices: Henry W. Oliver Bldg.  
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*Consult a Joy Engineer for*  
"THE WORLD'S MOST COMPLETE LINE OF MODERN MINING EQUIPMENT"



# NEW!

## Permissible Tramdrill one-man operation

Here's the ideal tramdrill for the trackless mine. Mobile, easy to operate. Equipped with a CP Drill Arm. Drills shot holes in coal up to  $4\frac{1}{2}$ " in diameter; drills at any angle, within four inches of roof or bottom. Also drills in rock, except sandstone.

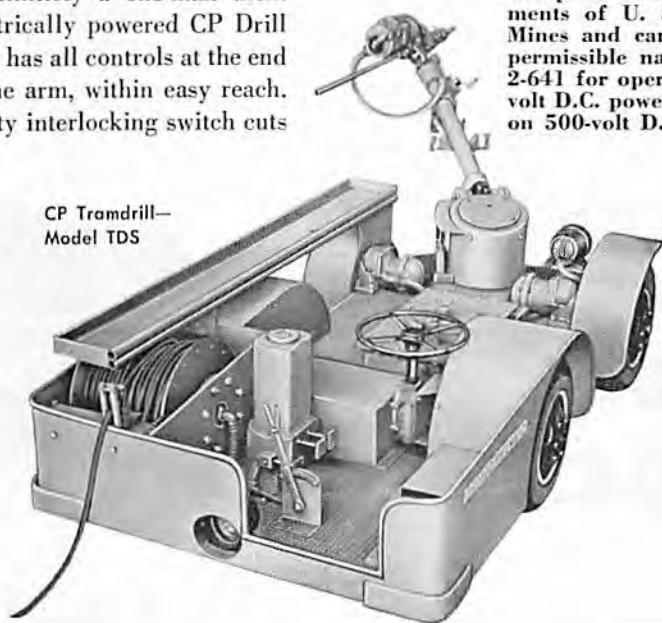
Definitely a one-man drill. Electrically powered CP Drill Arm has all controls at the end of the arm, within easy reach. Safety interlocking switch cuts

off drill motor while tramming; prevents truck moving while drilling. CP Tramdrill can also be equipped with two CP Drill Arms (model TDD).

Truck has nine inches road clearance; handles easily in narrow working places or entries.

Complies with all requirements of U. S. Bureau of Mines and carries Bureau's permissible name plate No. 2-641 for operation on 250-volt D.C. power; No. 2-641A on 500-volt D.C.

CP Tramdrill—  
Model TDS



Write for  
further information.



**CHICAGO PNEUMATIC  
TOOL COMPANY**

8 East 44th Street, New York 17, N. Y.

Hand-Held and Post-Mounted Electric Coal Drills • Electric Drill Arms  
Electric Tools • Pneumatic Tools • Air Compressors • Rock Drills

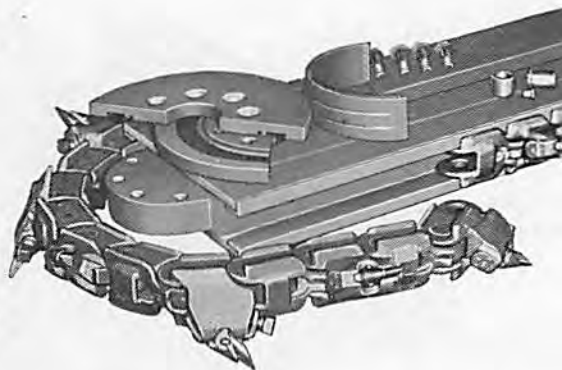
# BEALL BROTHERS SUPPLY CO.

COAL MINERS' TOOLS  
*and*  
MINE SUPPLIES

ALTON, ILLINOIS

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get more \$ \$ \$  
from that  
**MINE** of  
**YOURS...**



BOWDIL equipment is specially designed to meet present day demands for extra strength and power saving. BOWDIL CUTTER BARS, the sturdiest bars in mine use today are standardized to fit all coal cutting machines. Famous BOWDIL CONCAVE BITS cut coal faster, easier . . . last longer, save time as well as power. Write for information about BOWDIL AUGERS, DRILL BITS, MINERS REPLACEABLE POINT PICKS, SPROCKETS, ROPE SOCKETS, SPIKE PULLERS.

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CANTON, OHIO



# **EUCLIDS** *are tops . . .*



## *. for Open Pit Coal Mining*

There's a Euclid to fit your job—off-the-highway hauling of coal, overburden or gob. Capacities range from 15 to 40 tons . . . rugged construction is combined with plenty of power and traction for tough hauls. Engineered and built as complete units by one manufacturer . . . conveniently located distributors have adequate stocks of

genuine Euclid parts and excellent service facilities at your disposal.

Repeat orders year after year from leading operators prove that Euclids move big tonnage at exceptionally low maintenance and operating cost. Descriptive literature on Euclid models best suited to your needs is yours for the asking.

**The EUCLID ROAD MACHINERY Co. . . . CLEVELAND 17, OHIO**





# DIAMOND

## ROLLER CHAINS



**1 1/4" PITCH • No. 470 x 3/4" Single Strand Chain**

Diamond Roller Chains are the result of 58 years of concentration on the development of a product of highest quality, uniformity and dependability. The entire Diamond line, 1/4 inch through 2 1/2 inch pitch, single and multiple strands, conforms throughout to American Standards, and is widely available from authorized distributors.



**1 1/4" PITCH • No. 470 x 3/4" Double Strand Chain**

**WRITE FOR GENERAL ENGINEERING DATA BOOK No. 649**



**DIAMOND CHAIN COMPANY, INC.**  
Dept. 493 • 402 Kentucky Ave. • Indianapolis, Indiana

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## of MAKING and HANDLING

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#### *Manufacturers*

Trolley Wheels	Bronze Castings
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Wheel Truing Brake Shoe Co.....	Tire Truing Shoes



#### *SERVICE*

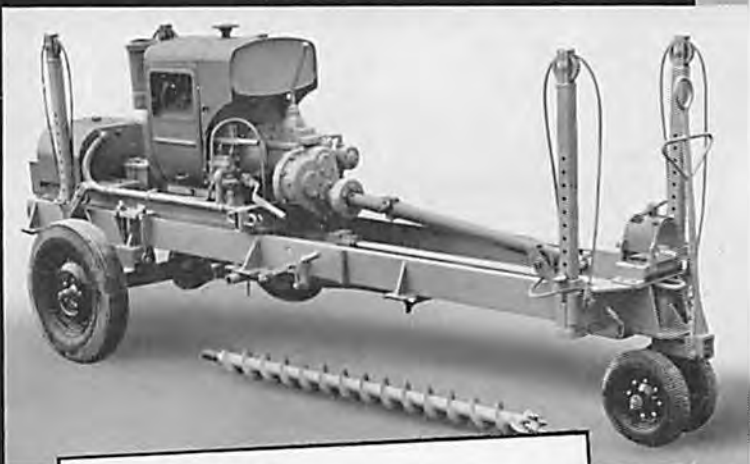
## Evansville Electric & Manufacturing Co.

600 W. Eichel Ave.

Evansville 7, Ind.

Phones 3-4283—3-4284

# Announcing!



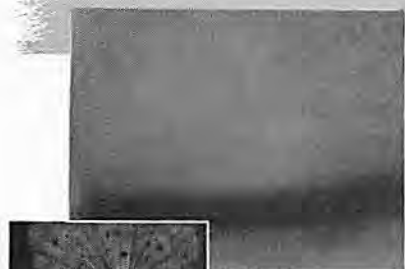
**NEW** SELF-PROPELLED  
**CARDOX-HARDSOCG**  
HYDRAULIC HORIZONTAL DRILL

- Drills up to a 9-in. hole to depths of 70 to 80 feet.
- Powered with Wisconsin 4-cylinder air-cooled engine or 20 H.P. electric motor (220-440 volts, 60 cycle, 3 phase).
- Designed for one-man operation.
- Ruggedly built to give long service under rough usage ...with low operating, maintenance and repair service.

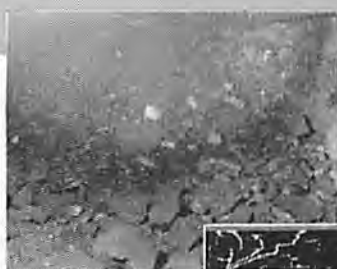
Write for full information on the many outstanding features of this new low-cost, high-production Cardox-Hardsocg Horizontal Drilling Unit; also latest developments on 30' auger for drilling coal and full line of deep mine drilling equipment.

**HARDSOCG DIVISION of the**  
**CARDOX CORPORATION**  
BELL BUILDING • CHICAGO 1, ILLINOIS

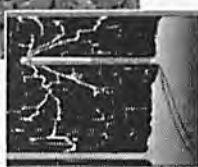
# Here's the Money-Saving Way to Cut DUST HAZARDS !



Photograph taken 3 minutes after coal was shot down with permissible explosives. Visibility reduced 86% by dust put into suspension.



Photograph taken 3 minutes after dislodging coal with CARDOX. Visibility reduced only 14%.



CARDOX mining reduces dust hazards all along the line. Its mild, heaving, shearing action does not pulverize the coal into fine dust particles. There is no shattering detonation to raise clouds of accumulated dust. As a result, less watering and rock dustings are required . . . even in very dusty mines . . . and resumption of work can be resumed immediately after face is broken down.

Other economies made possible

by CARDOX mining include (1) A reduction in cost of roof control, (2) Faster loading with less wear and tear on the loading machine, (3) Less shattering of impurities, reducing cleaning cost, (4) Greater realization due to reduction of degradation at the working face, during extensive mechanical handling, long shipment by train, boat or truck, and rough handling in the dealer's yard. Write for full details and free demonstration.

## CARDOX

"THE NON-EXPLOSIVE MINING METHOD"

and **CARDOX HARDSOGG**  
Drilling Equipment

**CARDOX CORPORATION** • BELL BUILDING • CHICAGO 1, ILLINOIS

# "C-M-I"

## CONTINUOUS CENTRIFUGAL DRYER

Delivers the finer coal sizes with so little surface moisture that freezing and clogging are eliminated. Slurry coal can also be cleaned and dried.

Both at the lowest ultimate cost.

### **CENTRIFUGAL & MECHANICAL INDUSTRIES,** INCORPORATED

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## **Coal Mining Screens**

### **PERFORATED METALS**

We manufacture Coal Mining Screens of every type—flat—flanged end—cylindrical or special shape. Any size or style screen in whatever thickness of metal you desire. Perforated with the exact size and style of holes you require. We are supplying Coal Screens to many leading coal mines—made to their exact requirements and specifications. We can duplicate the Screens you are now using.

Write for Quotations

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2445 W. 24th Pl., Chicago 8, Ill.

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to the  
ILLINOIS MINING INSTITUTE



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*Fittings — Valves*

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**BUETTNER SHELBURNE MACHINE  
COMPANY, INC.**

**Manufacturers of Repair Parts for  
COAL MINING MACHINES**

**Established**

**1901**

**SOUTH THIRD AND MINSHALL STREETS**

**TERRE HAUTE, INDIANA**

**Telephone: Crawford 8854**

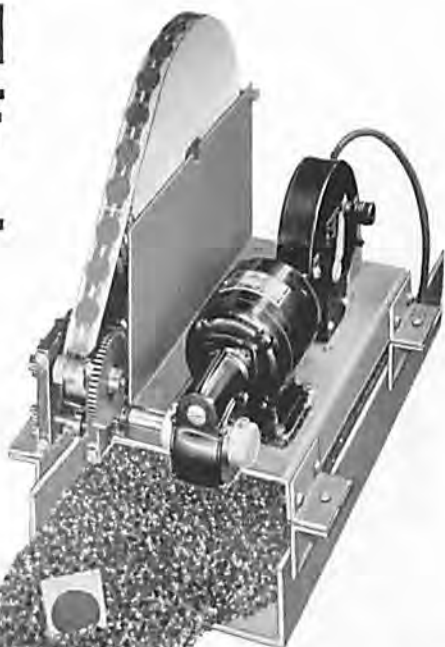
# SEND A SALESMAN WITH EVERY TON OF COAL YOU SELL . . .

Your Trade mark, in your coal, is your best salesman. It goes right into the users' bins with every ton of coal. It stays right on the job . . . working for you night and day . . . and it tells and sells the quality of your coal with every shovelful.

Trademarking is the surest way to build user confidence and a steady repeat demand for YOUR coal. Your trade mark SELLS your coal and enables the user to re-order . . . and be sure of getting your coal . . . every time.

Dustlix Labels stay put—cannot roll.

Labels furnished in a variety of materials.



U. S. PAT. NOS. 2,169,226—  
2,209,768

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Developed to solve the problem of recovering coal from ever-greater depths, today's Bucyrus-Erie coal-stripping machines like this 1150-B walking dragline provide the capacity, range and economy of operation that permit profitable production from strip properties previously considered unworkable.

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**Bucyrus-Erie Company**  
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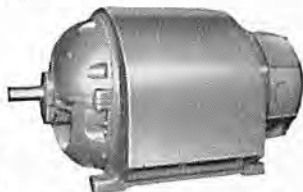
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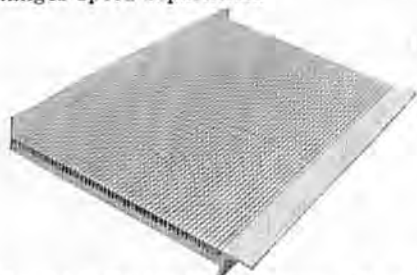
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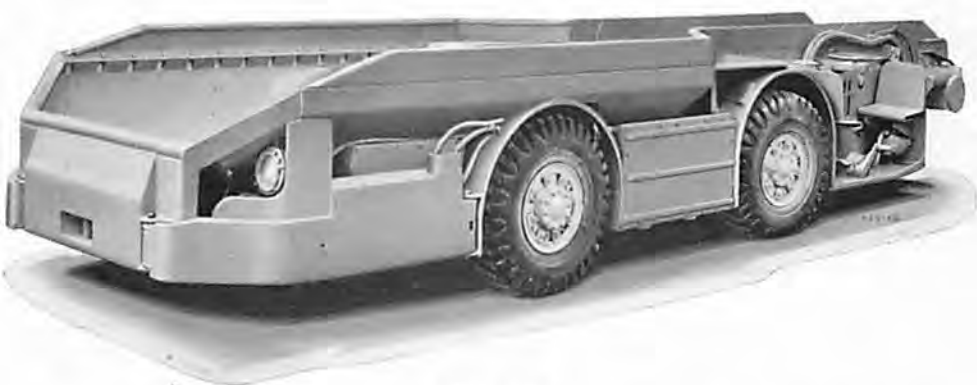
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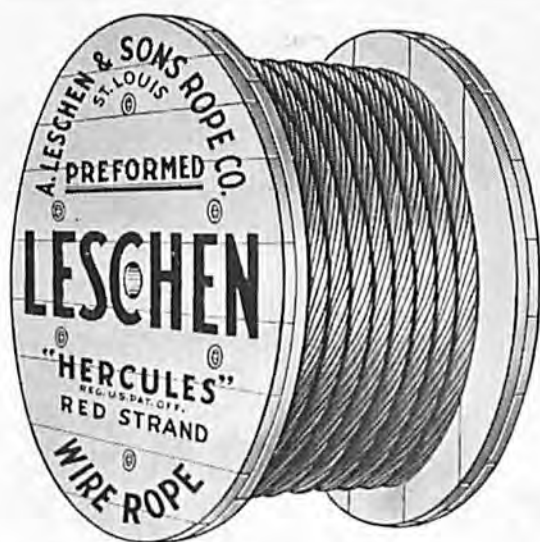
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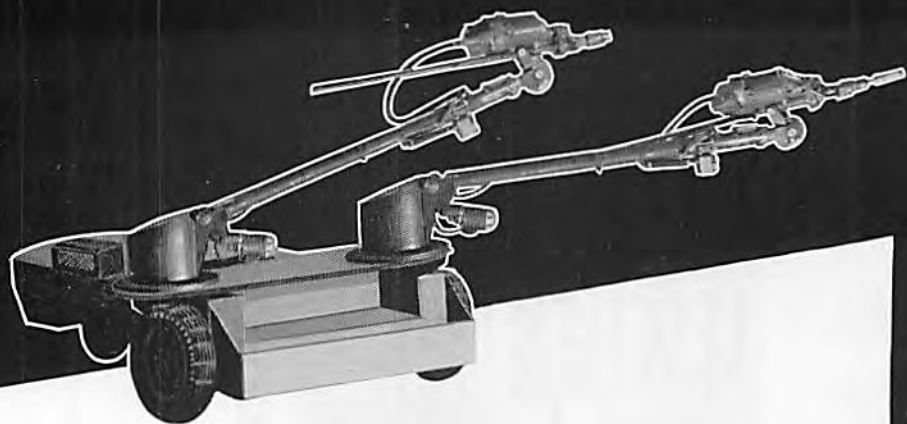
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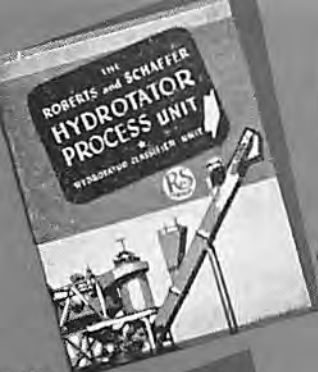
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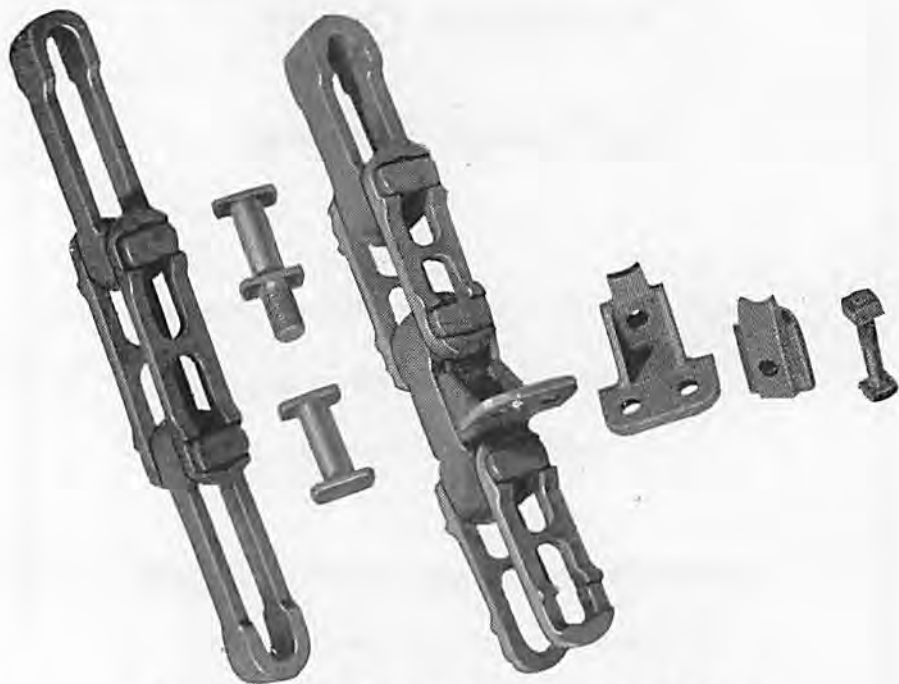
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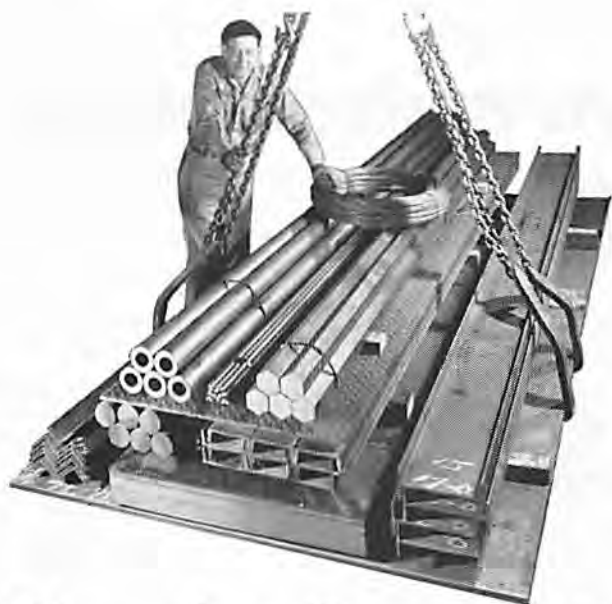
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TELEPHONES

LOADERS

SHOVELS

DRILLS

PUMPS

A complete catalog of Simplex - TIREX  
Cords and Cables will be sent upon request

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CHICAGO OFFICE: 564 West Monroe St., Chicago 6, Ill.

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- Screen Bars
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Mine Cars



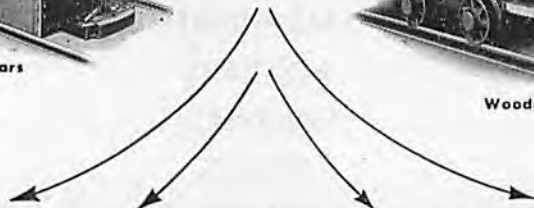
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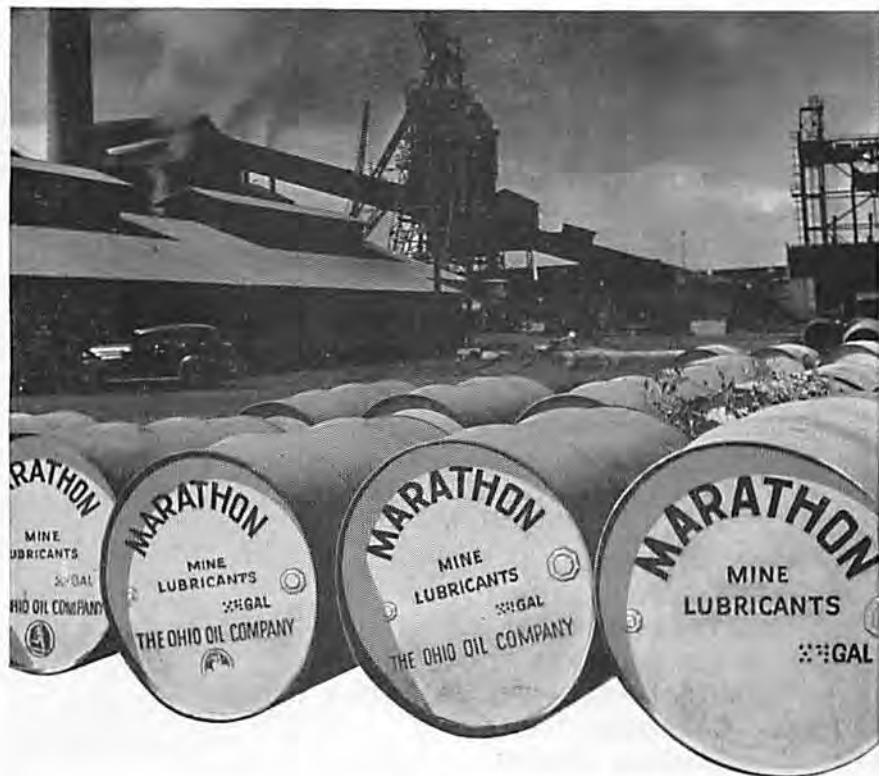
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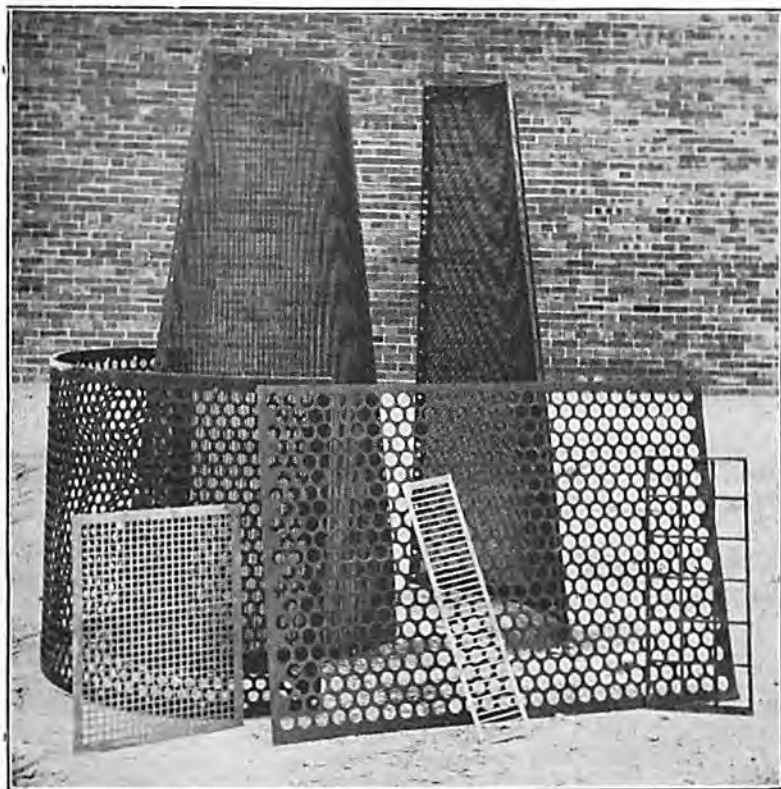
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**GENERAL PURPOSE MINE JACKS** Simplex No. 84A, 85A and 86A Jacks speed handling of equipment. These 5-ton Jacks are standard for use with coal cutting and loading machines, re-railing mine cars and locomotives, mine trackwork and all lifting and moving jobs. Toe lift minimum only 1 1/4". Other Simplex Ratchet Lowering Jacks in 10, 15 and 20-ton capacities! All have the Simplex safety features.



**ADJUSTABLE MINE ROOF JACKS** (Left) Allow more space for loading machines and conveyors to work in, yet are safer than wood posts many times their size. Readily set in place. Capacity of light-duty M-8 Jack is 8-tons. Heavy duty M-16 Jacks, 16-tons capacity. Tested for overload. Three types of heads.

M-9 and M-17 Roof Jacks have screw and base assembly only for use with your own standard pipe.

**MINE TIMBER JACK AND POST PULLER** (Right) Simplex No. 32 is a versatile Mine Jack for putting up cross timbers and steel beams, straightening steel mine cars, as a temporary prop, putting up and removing slack in power cable, pulling and pushing conveyors, lifting, etc. Faster for timber work than the screw type. Capacity 5-tons.

Also Simplex Timber Jacks, Post Pulling Jacks, Cable and Wire Tensioning Jacks, Track Jacks, Journal Jacks and Geared Jacks. Send for new bulletin, Mines-46.



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 Better, Safer Jacks Since 1899



THE BIT THAT HAS PROVEN ITSELF IN ALL COAL FIELDS.

When you have a cutting Problem use Prox Cutting Chains  
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FOR OUR ANNOUNCEMENT IN JANUARY

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ON THE BANKS OF THE WABASH — SINCE 1873  
FRANK PROX COMPANY  
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## FEATURES OF GOODMAN BELT DESIGN

- Ease of assembly, extension or relocation
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- Interchangeability of parts
- Fiber lagging for drive drums
- Suitable control for any belt

Goodman Stocks Supplies To Maintain and Extend Conveyors

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**MINES EVERYWHERE USE  
DUTCH BRAND  
FRICTION and RUBBER TAPES**



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**FOR ALL LEADING BRANDS  
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**Be sure to see  
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**FREEZEPROOF  
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**SOLVAY** **CALCIUM  
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Clean — Colorless — Odorless Method of  
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*Manufacturers*

## THE TRACY CUTTER CHAIN

Last Word in Cutter Chain Efficiency



## TRACY GEARS AND PINIONS

Here at our plant it is recognized that Time is the Essence of the Gear Business, if customers are to be fully satisfied. There is, distinctly, a way of achieving this. The first essential is an adequate inventory of active items; the second is a shop keyed to a production rapid enough to meet both customary and emergency needs.



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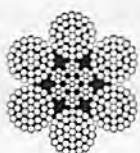
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6 x 19 Seale  
Hemp Center



6 x 37  
IWRC



6 x 7  
Hemp Center



6 x 19 Filler Wire  
Hemp Center



6 x 19 Warrington  
Hemp Center



6 x 19 Filler Wire  
IWRC

## Recommended Constructions of Wire Rope for Use in Coal and Metal Mining

### VERTICAL SHAFT HOIST ROPES (Single Layer on Drum)

$\frac{3}{8}$ " to 2" Dia. 6 x 19 Filler Plow or Perfection Hemp Center "LAY-RITE" (Sometimes Lang Lay)

### VERTICAL SHAFT HOIST ROPES (Multiple Layers on Drum)

$\frac{3}{8}$ " to 1 $\frac{1}{2}$ " Dia. 6 x 19 Seale Plow or Perfection Hemp Center "LAY-RITE"

### MINING MACHINE ROPES (For Jeffrey, Goodman, Sullivan, Motherwell, etc.)

Pull Rope— $\frac{3}{8}$ " or  $\frac{1}{2}$ " Dia. 6 x 37 Plow or Perfection IWRC "LAY-RITE"

Tail Rope— $\frac{1}{2}$ " Dia. 6 x 19 Filler Plow or Perfection IWRC "LAY-RITE"

### HAULAGES

$\frac{1}{2}$ " to 1 $\frac{3}{8}$ " Dia. 6 x 7 Plow or Perfection Hemp Center Lang Lay "LAY-RITE"

### CAR RETARDERS

$\frac{3}{8}$ " and  $\frac{1}{2}$ " Dia. 6 x 19 Filler Plow or Perfection IWRC "LAY-RITE"

### CAR PULLERS OR CAR SPOTTERS

$\frac{1}{2}$ " to  $\frac{3}{4}$ " Dia. 6 x 19 Seale Plow IWRC "LAY-RITE"

### PORTABLE DRILLING MACHINES

$\frac{5}{8}$ " to  $\frac{7}{8}$ " 6 x 19 Warrington Mild Plow Hemp Center Left Lay or Right Lay

### SCRAPERS OR SLUSHERS

$\frac{3}{8}$ " to  $\frac{3}{4}$ " Dia. 6 x 19 Seale Plow Hemp Center or IWRC "LAY-RITE"

$\frac{3}{4}$ " to 1 $\frac{1}{2}$ " Dia. 6 x 19 Seale Plow IWRC "LAY-RITE"

### CONVEYORS—DISC OR BUTTON (As Jeffrey, Roberts & Schaefer, etc.)

$\frac{3}{8}$ " to 1 $\frac{1}{4}$ " Dia. 6 x 19 Seale Plow or Perfection IWRC—Strands Alternate Right Lay and Left Lay "LAY-RITE"

### CRAB WINCH HOIST

$\frac{5}{8}$ " to  $\frac{1}{2}$ " Dia. 6 x 19 Filler Plow Hemp Center "LAY-RITE"

### ROOM HOISTS

$\frac{1}{4}$ " to  $\frac{1}{2}$ " Dia. 6 x 19 Seale Plow Hemp Center "LAY-RITE"

### ROCK DUMP HAULAGES

$\frac{3}{8}$ " to  $\frac{7}{8}$ " Dia. 6 x 19 Seale Plow Hemp Center "LAY-RITE"



Established 1871

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Manufacturers of Wire Rope, Wire Rope Fittings, Tackle Blocks, Brattice Cloth

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# Use **COMPOUND M**

**a. For Mine Dust Control**

**b. For Better Cleaning  
in Coal Wash**

COMPOUND M—used in proportions of 1 part to 1000 parts of water, controls dust on all mechanized operations—cutting loading, conveying dumping, and Tipple preparation.

COMPOUND M—added at the ratio of one-half gallon per hour to the raw coal as it enters wet washer, gives cleaner coal and reduces ash content.

COMPOUND M—tends to dewater coal faster.



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# NO PLANT SHUTDOWNS

*due to hauling failures, when you haul with  
WALTER TRACTOR TRUCKS*



Above: 300 hp. WALTER TRACTOR TRUCK with 30-ton bottom dump coal trailer. 60 tons can be hauled with two trailers coupled together.



Right: 200 hp. WALTER 20-TON DUMPER for economical mine waste removal. Climbs steepest grades, travels slippery surfaces without losing traction. Compact, fast, maneuverable.

How often has your plant been slowed down or shut down by the failure of trucks to keep a flow of coal moving from the pit? The most common cause is the fact that conventional "heavy duty" trucks cannot haul when the weather and running conditions get tough.

The use of big, powerful, 100%-traction Walter Tractor Trucks is insurance against such failures—and keeps your shovels and plant working at capacity, regardless of hauling conditions.

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Adequate stocks of standard size cross ties, switch ties, mine ties and mine material available for prompt shipment.

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**TREATING PLANT, METROPOLIS, ILL.**

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# ***FLEXIPIPE***



Provides dependable ventilation.

Supplies fresh air exactly when and where it is needed. Eliminates ventilation problems.

This flexible air tubing is used extensively as an auxiliary system of ventilation in Coal Mines.

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# Presenting...



The lightweight National Model embodies all the time-proved safety and operating features of the Standard Koehler—plus many new and advanced engineering ideas.

**MORE CONVENIENT AND EASIER TO CARRY**  
Lighter—weight reduced to 1 lb., 12- $\frac{1}{8}$  oz.  
Smaller—height reduced to 8- $\frac{3}{4}$  in.

**DURABLE—LIGHT**  
Newly designed, strong, rigid aluminum alloy construction

**IMPROVED IGNITER**  
Fewer parts, easier to maintain

**MEETS ALL OPERATING AND SAFETY REQUIREMENTS**  
U.S. Bureau of Mines Approved

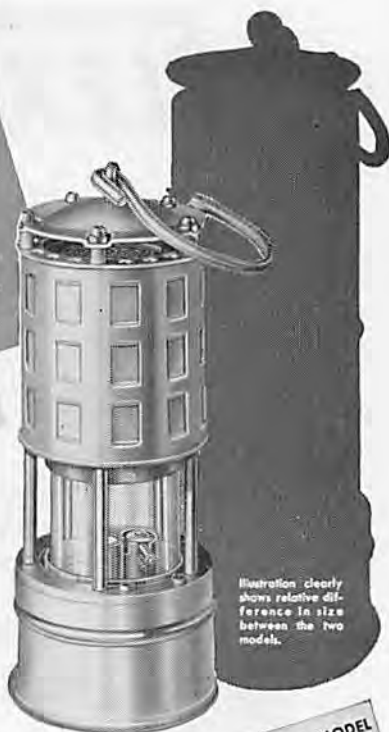


Illustration clearly shows relative difference in size between the two models.

*Write for complete details!*

Distributed Exclusively by

**National Mine  
Service Company**



**Compare THE NEW NATIONAL MODEL WITH THE KOEHLER STANDARD**

	NATIONAL MODEL	STEEL STANDARD	ALUMINUM STANDARD
WT.	1 lb., 12- $\frac{1}{8}$ oz.	3 lbs., 6 oz.	2 lbs., 9 oz.
*HT.	8- $\frac{3}{4}$ "	10- $\frac{5}{16}$ "	10- $\frac{5}{16}$ "

\*Not including handle.

Approval No. 209



*Has the facilities*

*Delivers the goods*

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*Prompt Economical and  
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*and*  
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## THE POSITIVE PLATE

consists of a series of slotted tubes which contain the active material (see small illustration at left). So fine are these slots that, while permitting easy access of electrolyte, they retard active material from readily washing out . . . thus assuring years of safe, dependable, day in and day out mine haulage service.

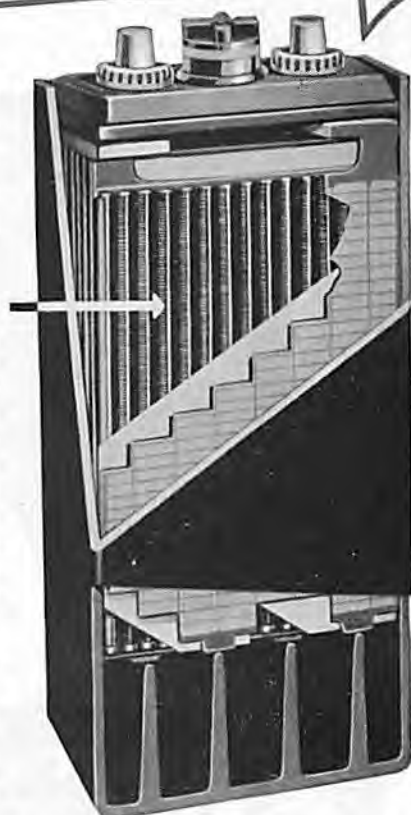


If you have a special battery problem, or wish more detailed information, write:

THE ELECTRIC STORAGE BATTERY COMPANY  
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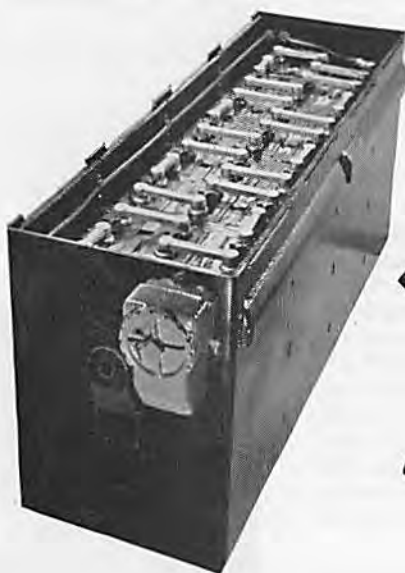
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Modern construction assures trouble free operation necessary for present day production schedules.

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*Illustration shows one tray  
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MANUFACTURED BY MACWHYTE COMPANY

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USE	ROPE DESCRIPTION
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Incline or Slope	6x7D; or 6x19G Monarch Whyte Strand or Macwhyte Plow Steel— <i>PRE</i> formed preferred.
Mining Machines and Loaders	6x37 <i>PRE</i> formed Monarch Whyte Strand or Macwhyte Plow Steel; F. C. (fiber core) or I. W. R. C. (independent wire rope core).
Stripping and Loading (Shovel and Dragline)	6x19F; 6x41F Monarch Whyte Strand <i>PRE</i> -formed Lang Lay with I.W.R.C.
Shaft Sinking	18x7 (non-rotating) Kilindo <i>PRE</i> formed Monarch Whyte Strand or Macwhyte Plow Steel. (Avoids spinning on unguided load.)
Blast Hole Drilling	6x19 "Hi-Lastic" Macwhyte Mild Plow Steel Drilling Line. 6x7 Macwhyte Mild Plow Sand Line.
Car Puller Ropes	6x19F; or 6x19G <i>PRE</i> formed Monarch Whyte Strand F. C. (fiber core) or I. W. R. C. (independent wire rope core).
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Use MACWHYTE *PRE*formed Internally Lubricated WIRE ROPE

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## MINING CABLES



*Look for the State of Pennsylvania seal of approval — No. P-105 — molded in the jacket surface.*

### **TO ASSURE SAFETY and DEPENDABLE SERVICE A MINING CABLE MUST HAVE QUALITY**

ROME 60 MINING CABLE with time-tested Neoprene jacket and fillers meets with flying colors both Federal and State of Pennsylvania flame test requirements. Subjected to rigid plant inspection, Rome 60 Mining Cables provide a new standard of safety, plus unexcelled performance and long life. They are rugged and unaffected by acids or alkalies . . . for longer life; highly resistant to flame and mechanical shock . . . for greater safety.

Single Conductor Locomotive Cable  
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At Salem and Marion, Illinois—in the heart of the coal fields—"Fabick" Service centers bring "Caterpillar" equipment parts and shop facilities close to the mines. Each center is equipped to tackle any job that calls for skill and speed.

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AT  
**SALEM**



**"FABICK"**  
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Tiger Brand-*



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The Salem Tool Co.....	139
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Simplex Wire & Cable Co.....	77
Sligo, Inc.....	80
Socony-Vacuum Oil Co.....	142
Solvay Sales Corp.....	86-B
Southern Electric, Inc.....	150
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Standard Stamping & Perforating Co.....	81
Stephens-Adamson Mfg. Co.....	7 and 153
Sterling Bolt Company.....	132-B
Sterling Steel Casting Co.....	134
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The Tamping Bag Co.....	26
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I-T-E Circuit Breaker Company.....	104-B
The Jeffrey Mfg. Co.....	61
The Johnson-March Corp.....	89
Joy Mfg. Co.....	33-34-35-36
Kelso-Burnett Electric Co.....	117
Kennametal, Inc.....	123
Kennedy-Webster Electric Co.....	68-B
Kensington Steel Co.....	70
Klein Armature Works.....	56-A
Koppers Co., Inc.....	31
K. W. Battery Co.....	98
Lee-Norse Co.....	136
Leetonia Tool Co.....	72-A
A. Leschen & Sons Rope Co.....	65
Link-Belt Co.....	147
Macwhyte Co.....	99
The Marion Power Shovel Co.....	15
Mc Laughlin Mfg. Co., Inc.....	90-B
McMaster Carr Supply Co.....	130-B
The McNally-Pittsburg Mfg. Corp.....	11
Mechanization, Inc.....	3
Michigan Chemical Corp.....	72-B
Mine Safety Appliances Co.....	19
W. H. Miner, Inc.....	24-B
Mines Engineering Company.....	13
Mines Equipment Co.....	155
Mineweld Co.....	144-B
Mining Machine Parts, Inc.....	16
Mississippi Lime Co.....	69
Mosebach Electric & Supply Co.....	76-A
Nail City Bronze Co.....	148
National Electric Coil Co.....	116
National Mine Service Co.....	94
Neiman Bearings Co.....	137
Oberjuerge Rubber Distributing Co.....	75
Ohio Brass Co.....	27
Ohio Oil Co.....	79
The Okonite Co.....	144-A
Peoria Tractor & Equipment Co.....	74
Henry A. Petter Supply Co.....	138
Phillips Mine & Mill Supply Co.....	78
Pittsburgh Knife & Forge Co.....	82-A
The Post-Glover Electric Co.....	121

The Davies Supply Co.....	45
The Deming Co.....	140-B
Diamond Chain Co., Inc.....	40
Diamond Supply Co., Inc.....	108-B
Dooley Bros.....	66
Duncan Foundry & Machine Works, Inc.....	129
E. I. duPont deNemours & Co.....	95
Duquesne Mine Supply Co.....	20-B
Du Quoin Iron & Supply Co., Inc.....	48
Dustlix Corp.....	47
Egyptian Powder Co.....	114-A
Egyptian Sales Agency.....	56-B
Egyptian Tie & Timber Co.....	52
The Electric Storage Battery Co.....	97
Elliott Service Co.....	53
The Equitable Powder Mfg. Co.....	122-A
Henry O. Erb.....	24-A
The Euclid Road Machinery Co.....	39
Evansville Electric & Mfg. Co.....	41
John Fabick Tractor Co.....	101
Fitz Simons & Connell Dredge & Dock Co.....	119
John Flocker & Co.....	115
L. B. Foster Co.....	60-A
Fraser Label Co.....	146-A
Fulton Bag & Cotton Mills.....	60-B
Funk Forging Co.....	114-B
The Garlock Packing Co.....	54-A
General Electric Co.....	57
Gibraltar Equipment & Mfg. Co.....	22
Giles Armature & Electric Works.....	149
Goodman Mfg. Co.....	85
Gould Storage Battery Corp.....	58
Graybar Electric Co., Inc.....	96
Greensburg Machine Co.....	146-B
Grinnell Co.....	140-B
W. M. Hales Co.....	55
H. H. Halliday Sand Co.....	54-B
Brad Harrison Co.....	122-B
Hawkins Electric Co.....	62-A
Helwig Co.....	62-B
Hendrick Mfg. Co.....	59
Hercules Powder Co.....	156
Robert Holmes & Bros., Inc.....	64-A
Hooper-Green Co.....	120-B
Hulburt Oil & Grease Co.....	1
Illinois Bearing Co.....	90-A
Illinois Powder Mfg. Co.....	64-B



## INDEX TO ADVERTISERS

Abraham Lincoln, Hotel.....	63
Allen & Garcia Co.....	143
W. D. Allen Mfg. Co.....	76-B
American Brattice Cloth Corp.....	25
American Car & Foundry Co.....	30
The American Crucible Products Co.....	108-A
American Cyanamid Co.....	109
The American Mine Door Co.....	105
American Pulverizer Co.....	112
American Steel & Wire Co.....	102
The Appuhn Co.....	113
Armco Drainage & Metal Products, Inc.....	50
Atlas Powder Co.....	106
Austin Powder Co.....	127
Barber-Greene Co.....	126
Barrett, Haentjens & Co.....	51
Beall Bros. Supply Co.....	38-A
Bearings Service Co.....	104-A
Beck & Corbitt Co.....	28
Bemis Bro. Bag Co.....	93
Berry Bearing Co.....	103
Bethlehem Steel Corp.....	14
Bituminous Casualty Corp.....	10
Bixby-Zimmer Engineering Co.....	130-A
The Bowdil Co.....	38-B
Bradley Warehouse & Supply Co.....	107
Broderick & Bascom Rope Co.....	9
Bucyrus-Erie Co.....	49
Buettner Shelburne Machine Co.....	46
Cardox Corp.....	42-43
Central Mine Equipment Co.....	4
Centrifugal & Mechanical Industries, Inc.....	44-A
Chicago Perforating Co.....	44-B
Chicago Pneumatic Tool Co.....	37
Chicago Tube & Iron Co.....	141
Cincinnati Mine Machinery Co.....	29
Clarkson Mfg. Co.....	6
Coal Age.....	5
Coal Mine Equipment Sales Co.....	110
Columbia Quarry Co.....	111
Commercial Testing & Engineering Co.....	23
Henry H. Cross Co.....	118
Cummins Diesel Sales Corp. of Ill.....	131
Cutter Bit Service Co.....	71

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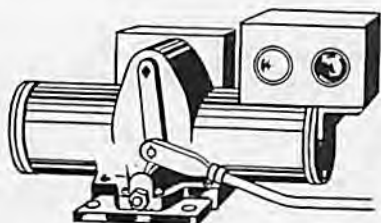
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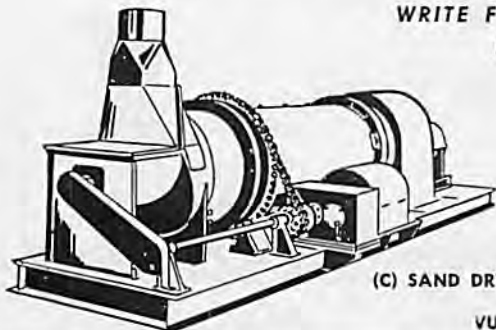
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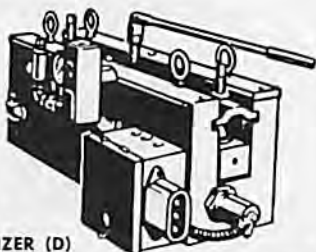
(A) THE ELECTRIC SWITCHMAN



(B) SAFETY CIRCUIT CENTER  
(Permissible Type)



(C) SAND DRYER



VULCANIZER (D)

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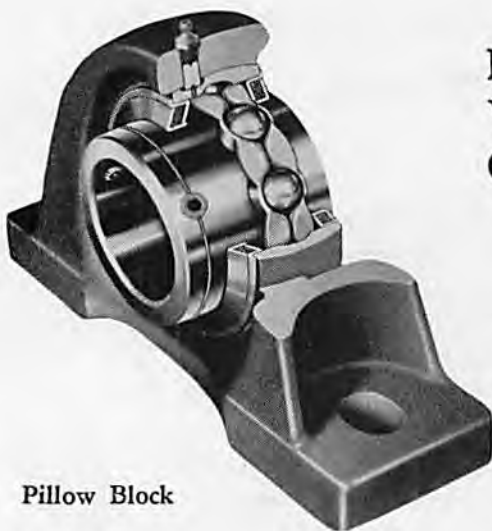
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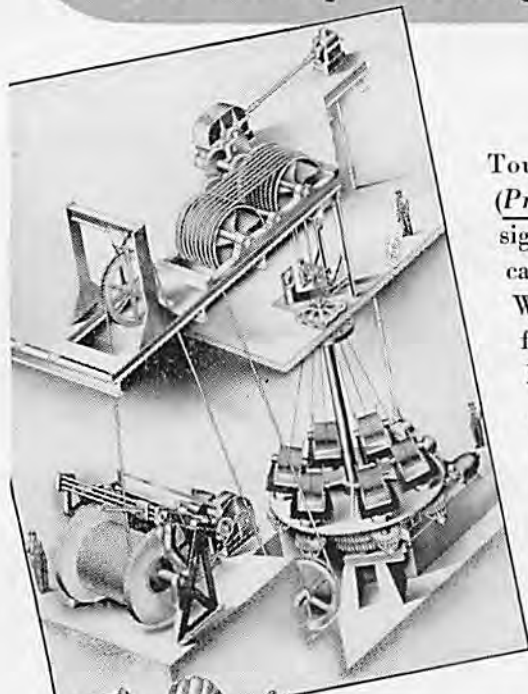
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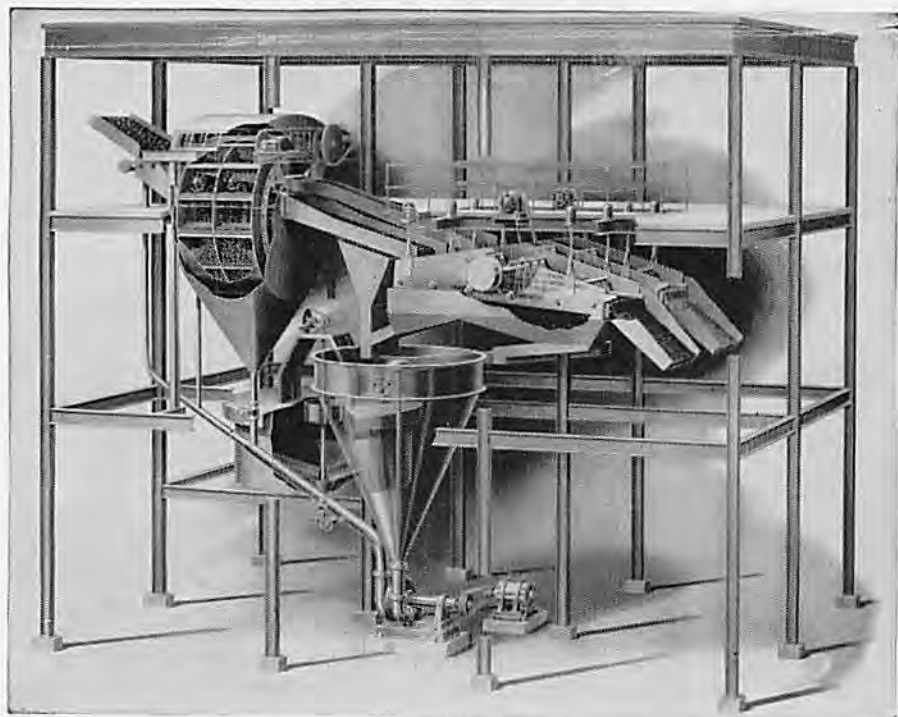
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Fig. 4700

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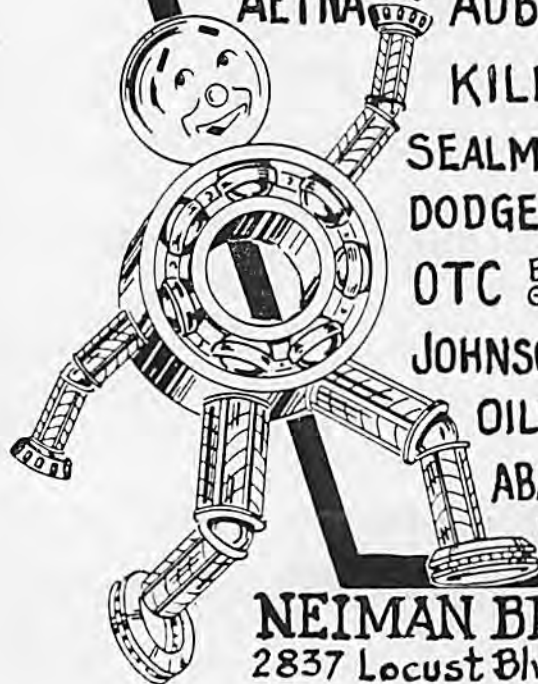
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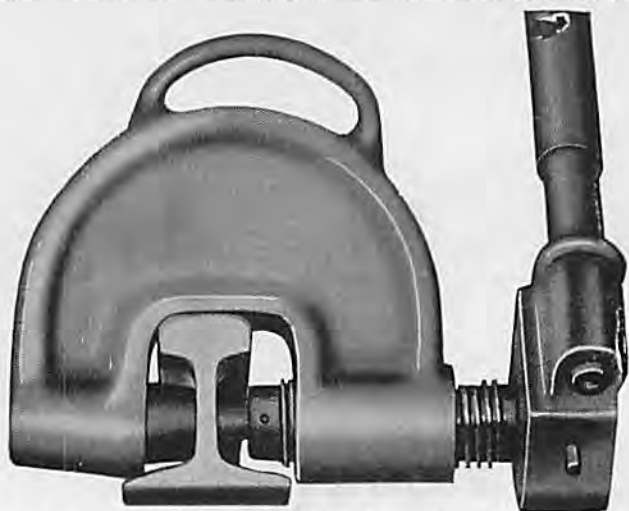
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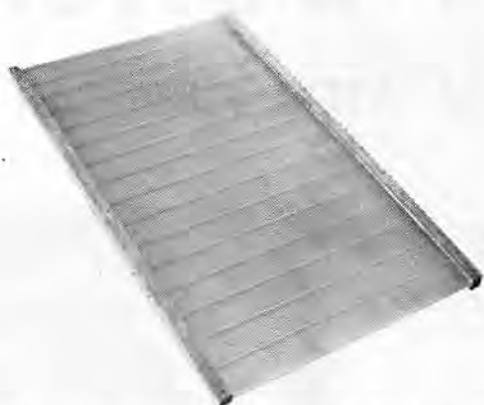
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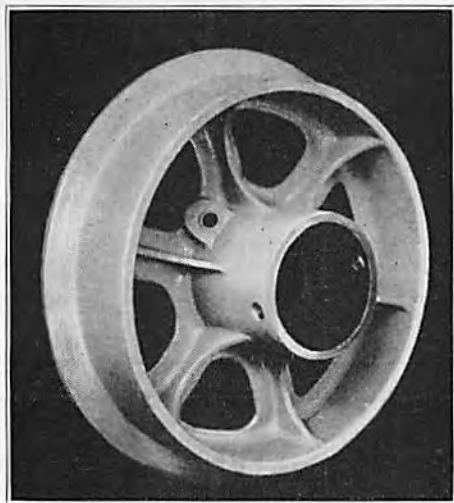
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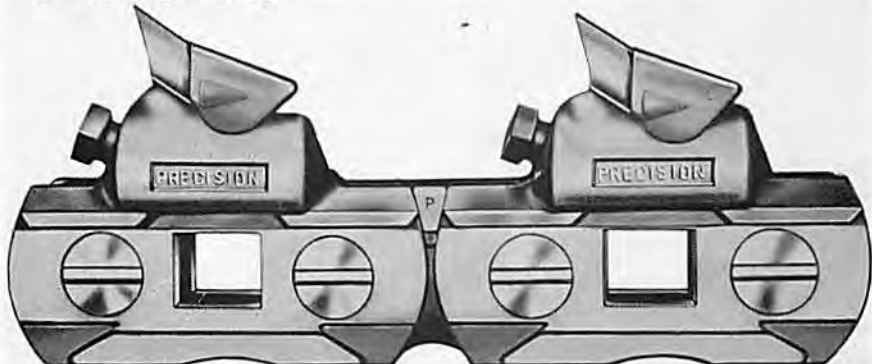
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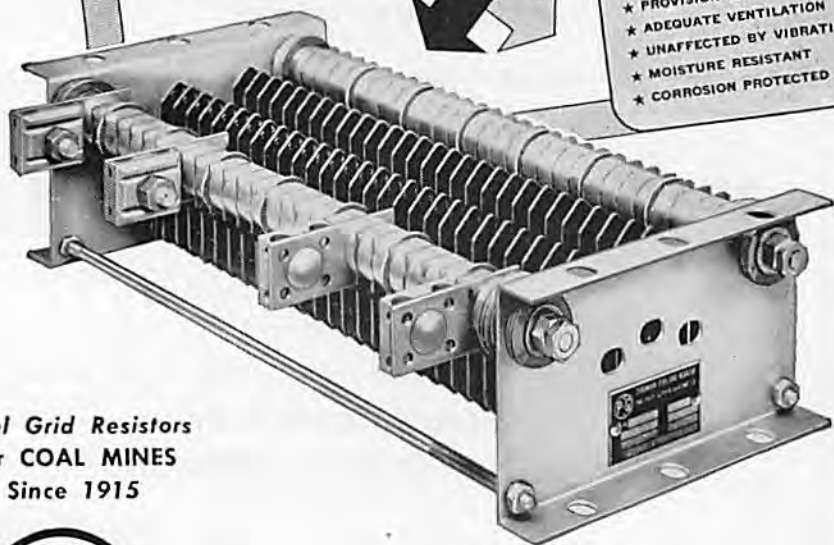
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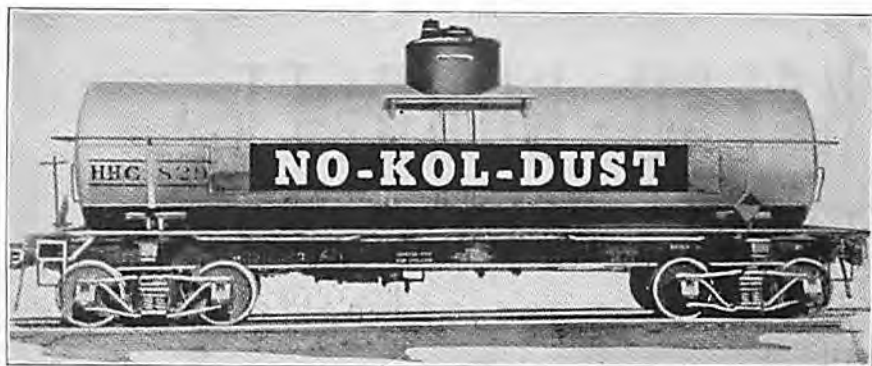
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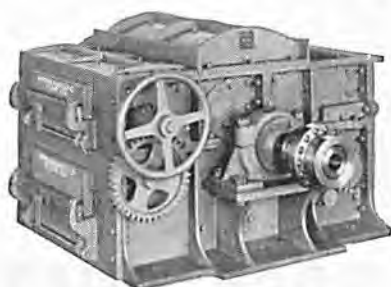
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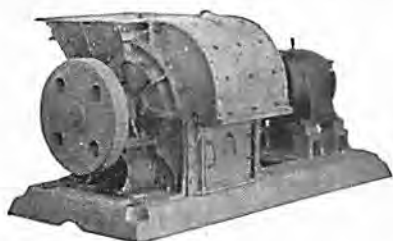
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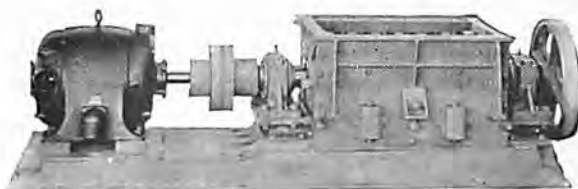
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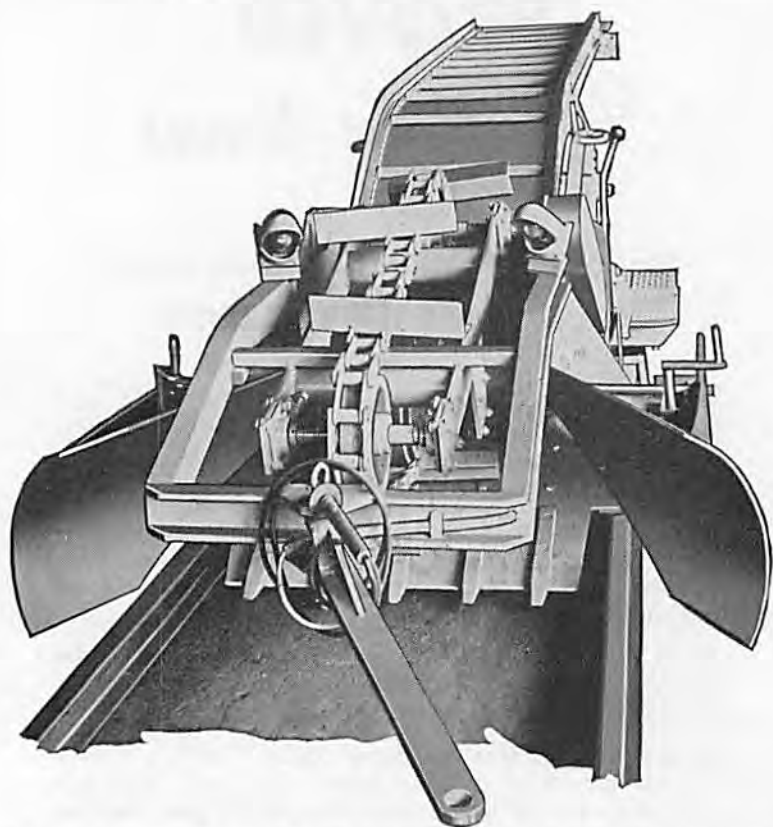
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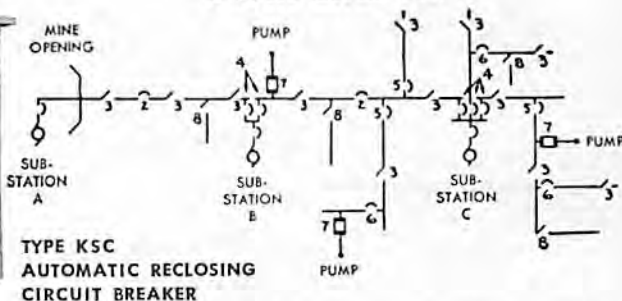
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