# PROCEEDINGS

*of the*

# ILLINOIS MINING INSTITUTE

---

FOUNDED FEBRUARY, 1892

---

*Fifty-Eighth Year*

## 1950

Annual Meeting

SPRINGFIELD, ILLINOIS

November 17th

T. G. Gerow

President, 1950

# 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. McREAKEN, 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
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

# In Loving Remembrance

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
J. W. STARKS, Feb. 3, 1949
D. W. MARSHALL, March, 1949
JAMES WHITE, March 17, 1949
W. W. PAAPE, March 18, 1949
JAMES W. BRISTOW, April 14, 1949
GEORGE F. CAMPBELL, June 18, 1949
E. J. BURNELL, July 22, 1949
LOUIS W. HUBER, August 17, 1949
JOHN RODENBUSH, November 1, 1949
R. G. LAWRY, December 24, 1949
WALTER A. BLEDSOE, March 1, 1950
A. S. KNOIZEN, April 29, 1950
JOSEPH E. HITT, Sept. 21, 1950
ARTHUR C. GREEN, Oct. 31, 1950
A. P. TITUS, Nov. 9, 1950
A. W. DUNCAN, Nov. 20, 1950
GILBERT W. BUTLER, Nov. 26, 1950
FRED W. RICHART, Dec. 10, 1950

* Killed in Action

# OFFICERS 1950

PRESIDENT

T. G. GEROW

Chicago, Illinois

VICE-PRESIDENT

G. S. JENKINS

St. Louis, Missouri

SECRETARY-TREASURER

B. E. SCHONTHAL

28 E. Jackson Boulevard

Chicago 4, Illinois

EXECUTIVE BOARD

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|---|---|
| CLAYTON G. BALL*** | C. T. HAYDEN* |
| D. W. BUCHANAN, JR.** | F. S. PFAHLER** |
| C. C. CONWAY** | H. A. REID*** |
| D. H. DEVONALD* | G. DON SULLIVAN*** |
| JOHN R. FOSTER* | H. H. TAYLOR** |
| A. G. GOSSARD*** | H. L. WALKER* |

* Term expires 1950
** Term expires 1951
*** Term expires 1952

# OFFICERS 1951

PRESIDENT

G. S. Jenkins

St. Louis, Missouri

VICE-PRESIDENT

Clayton G. Ball

Chicago, Illinois

SECRETARY-TREASURER

B. E. Schonthal

28 E. Jackson Boulevard

Chicago 4, Illinois

EXECUTIVE BOARD

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|---|---|
| William Bolt*** | H. A. Reid** |
| D. W. Buchanan, Jr.* | F. E. Snarr*** |
| C. C. Conway* | G. Don Sullivan** |
| Walter Eadie** | H. H. Taylor* |
| A. G. Gossard** | Frank L. White*** |
| F. S. Pfahler* | Henry C. Woods*** |

* Term expires 1951
** Term expires 1952
*** Term expires 1953

# PAST PRESIDENTS OF ILLINOIS MINING INSTITUTE

FOUNDED FEBRUARY, 1892

| | |
|---|---|
| 1892-93 | James C. Simpson, Gen. Mgr., Consolidated Coal Co., St. Louis, Mo. |
| 1893-94 | James C. Simpson, Gen. Mgr., Consolidated Coal Co., St. Louis, Mo. |
| 1894-95 | Walton Rutledge, State Mine Inspector, Alton, Ill. |
| 1895 } 1911 } | Institute inactive |
| 1912-13 | John P. Reese, Gen. Supt., Superior Coal Co., Gillespie, Ill. |
| 1913-14 | Thomas Moses, Supt., Bunsen Coal Co., Georgetown, Ill. |
| 1914-15 | J. W. Starks, State Mine Inspector, Georgetown, Ill. |
| 1915-16 | William Burton, V. P., Illinois Miners, Springfield, Ill. |
| 1916-17 | Fred Pfahler, Gen. Supt., Superior Coal Co., Gillespie, Ill. |
| 1917-18 | Patrick Hogan, State Mine Inspector, Carbon, Ill. |
| 1918-19 | 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, Litchfiield, 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. |
| 1948-49 | J. Roy Browning, Illinois Coal Operators Assn., Chicago, Ill. |
| 1949-50 | T. G. Gerow, Truax-Traer Coal Co., Chicago, Ill. |

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# PROCEEDINGS OF ILLINOIS MINING INSTITUTE
# FIFTY-EIGHTH ANNUAL MEETING

Held in Springfield, Illinois

## FRIDAY, NOVEMBER 17, 1950

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## MORNING SESSION

**10 O'clock A.M.**

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The Fifty-Eighth Annual Meeting of the Illinois Mining Institute convened in the Hotel Abraham Lincoln, Springfield, Illinois, at ten-fifteen o'clock, President T. G. Gerow presiding.

President Gerow: Gentlemen, in view of our rather heavy program today, I'll call the Fifty-Eighth Annual Meeting of the Illinois Mining Institute to order.

The first order of business is the reading of the proceedings and minutes of last year's meeting. It is usually customary to dispense with the reading of the minutes, inasmuch as they are published, and I think all of you have the Yearbook, and for that reason we will not read them.

We'll go on with the meeting, then, unless there is some objection. Next is the report of the Secretary-Treasurer, by B. E. Schonthal.

## SECRETARY'S REPORT

Our Institute has continued its activities during the past year along the same lines as in the past. Our membership has remained fairly constant, and we have a membership of about 1200 at the close of the year.

Our cash balance in the bank on November first was $1,085.46, and we own $10,000 cash value of interest-bearing bonds.

We had the misfortune to lose four members by death this past year. The usual message of sympathy were sent to the families.

You will hear a report regarding the Scholarship Plan and the mining students now at the University through Professor Walker. In addition, your Institute is sponsoring a special scholarship in mining engineering this year at the University of Missouri. Tonight at the dinner session you will have the pleasure of meeting most of these boys.

The 1950 Proceedings is now in process. The response to date from suppliers for advertisements in the book is most gratifying. We now have over 110 pages and have set a goal of 175 pages when we go to press. Some few suppliers are a bit hesitant about carrying an ad in our book. We hope the representatives of all companies who are at this meeting today will use their influence in getting their companies to advertise, as you are well qualified to explain the desirability of supporting this Institute and its work.

Before closing this report I should like to tell you it was my privilege to attend and participate in the "Miniature Mining Congress," as I like to call it – the Manufacturers' Exhibit held by the Mining Electrical Group at West Frankfort, Illinois, in September. To my notion, its uniqueness makes it the most outstanding display of equipment that I have ever seen. The Institute was happy it could help in its small way to promote publicity for this meeting. I most sincerely urge every man within the sound of my voice to make it a "must" to attend when it is held again in 1952.

The year just ended has been marked with the usual fine cooperation given the Secretary by your officers, executive board, committees, and all other members; and I wish to thank them all most sincerely.

Respectfully submitted,

B. E. SCHONTHAL, *Secretary-Treasurer*

* * *

President Gerow: Thank you, Mr. Schonthal. I know the entire Mining Institute is indebted to Bale for his constant work for the Institute.

You have heard his report on the finances. You have heard his report on membership. The attendance at this meeting seems to be up on a par with last year, and possibly somewhat larger. I'm sure we're indebted to Bale for his work on setting up this splendid meeting. I will direct the Secretary-Treasurer to put his report in the minutes, as read.

The next order of business is a report by the Nominating Committee, of which J. Roy Browning is chairman. I believe Herb Taylor is prepared to read the report.

## NOMINATING COMMITTEE REPORT

To the President and Members of the Illinois Mining Institute:

The Nominating Committee of Illinois Mining Institute, consisting of the undersigned, reports that the committee unanimously recommends to the membership the nomination of the following officers and executive board members for the ensuing year:

### OFFICERS

PRESIDENT:

G. S. Jenkins, Consolidated Coal Co.
Railway Exchange Building
St. Louis, Missouri

VICE-PRESIDENT:

Clayton G. Ball, Paul Weir Company
20 North Wacker Drive
Chicago 6, Illinois

SECRETARY-TREASURER:

B. E. Schonthal
28 E. Jackson Boulevard
Chicago 4, Illinois

For Three-Year Term on Executive Board:

William Bolt
Freeman Coal Mining Corp.
Farmersville, Illinois

F. E. Snarr
Chicago, Wilmington & Franklin Coal Co.
Benton, Illinois

Frank L. White
Peabody Coal Co.
231 S. La Salle St.
Chicago 4, Illinois

Henry C. Woods
Sahara Coal Company
59 E. Van Buren St.
Chicago 5, Illinois

To Fill Two-Year Unexpired Term on Executive Board:

Walter Eadie, Director
Department of Mines & Minerals
Springfield, Illinois

Respectfully submitted,
J. Roy Browning, *Chairman*
F. S. Pfahler
H. H. Taylor, Jr.

* * *

President Gerow: Thank you, Herb.

You have all heard the recommendations of the Nominating Committee. Are there any other nominations to be suggested? If not, a motion is in order to accept the report of the Nominating Committee.

Mr. Peter Joyce (Asst. Commissioner, Illinois Coal Operators Assn., Springfield, Ill.): If no more nominations are offered, I move that the nominations be closed and the Secretary be instructed to cast one ballot for those nominated for the respective offices.

Mr. Paul Weir (Paul Weir Co., Chicago, Ill.): Second the motion.

President Gerow: Any discussion? All in favor of the motion that the Secretary be instructed to record the unanimous ballot in favor of the list as submitted by the Nominating Committee, signify by the usual sign of "aye." Opposed?

You will kindly record the action, Mr. Secretary.

We have a very active committee in the Illinois Mining Institute that is doing great work along educational lines, in bringing up the younger fellows into position to qualify for important jobs in the production of coal in the Midwest, particularly in Illinois and adjoining states. I will now ask Professor H. L. Walker of the Scholarship Committee to submit his report to the Institute.

## SCHOLARSHIP REPORT FOR 1950

By H. L. WALKER
Head, Department of Mining and Metallurgical Engineering
University of Illinois

It seems appropriate in making a scholarship report to first review the enrollment data at the University. The undergraduate and graduate enrollments on the Chapaign-Urbana campus, for the first semester of the two years, are as follows:

| | *Undergraduate* | *Graduate* | *Total* |
|---|---|---|---|
| 1949-50 | 15,702 | 3,819 | 19,521 |
| 1950-51 | 13,056 | 4,106 | 17,162 |

The above data shows a decrease in total enrollment of approximately 12 per cent. The undergraduate enrollment dropped 16.5 per cent and the graduate enrollment increased approximately 7½ per cent.

For the College of Engineering the enrollment data for undergraduate students are:

| | |
|---|---|
| 1949-50 | 3,034 |
| 1950-51 | 2,205 |

These data show a decrease in undergraduate engineers of approximately 27.5 per cent. The data for undergraduate engineering enrollment at the Navy Pier Branch of the University are considerably better and did not show as high a percentage of reduction in numbers of students.

For the department of mining and metallurgical engineering the undergraduate student enrollment was:

| | *Mining* | *Metallurgical* | *Total* |
|---|---|---|---|
| 1949-50 | 96 | 116 | 212 |
| 1950-51 | 79 | 106 | 185 |

These data show a decrease in mining engineering students of 17½ per cent, and for metallurgical engineering students of 8½ per cent, or a total departmental decrease of 12.5 per cent.

We believe the decreases in undergraduate student enrollments are accounted for by four factors as follows:

1) The low birth rate for the period 1932-35 during the depression.

2) The number of veteran students, who were delayed in their education and came to the University in great numbers following their release from military service, has greatly decreased.

3) The effect of military service on graduating high school students has decreased the number of students permitted to enter the University.

4) The Manpower Commission some two years or more ago made the announcement that engineering was overcrowded and advised high school guidance personnel that high school graduates should not pursue engineering as a vocation. This pessimistic prediction has since been proven to be erroneous and we still find engineers in demand, and many jobs are awaiting their graduation. This untruth with respect to engineering education needs to be corrected.

There are currently 16 students holding mining engineering scholarship. The students holding the various scholarships are as follows:

ILLINOIS MINING INSTITUTE

1) Mr. James W. Goodrick, Senior
2) Mr. Warren Holland, Junior

OLD BEN COAL CORPORATION

1) Mr. Robert B. Abels, Freshman
2) Mr. Edwin G. Jackson, Sophomore
3) Mr. John T. Keim, Senior
4) Mr. Alfred Risi, Senior
5) Mr. Jack E. Tisdale, Freshman

PEABODY COAL COMPANY

1) Mr. Charles E. Childers, Freshman
2) Mr. Daryl L. Gaumer, Senior
3) Mr. Paul R. Penrod, Junior
4) Mr. Robert L. Pounds, Junior
5) Mr. James P. Snider, Sophomore
6) Mr. Tommy S. Ullom, Sophomore

ALFRED E. PICKARD

1) Mr. Donald E. Scheck, Junior

SAHARA COAL COMPANY

1) Mr. Bruce W. Gilbert, Senior
2) Mr. Charles Mitchell, Senior

There are two applications for scholarships on file in the department for action for next semester, as they came in too late for the fall term. I wish to also report that three scholarship students were graduated in 1950, six scholarship students will graduate in 1951, four students did not have their scholarship renewed in the fall of 1950 because of low scholastic records, one student withdrew from the University, and one student transferred to another curriculum.

We of the department believe we are growing and becoming of greater service to the mining industry of the State. Each and every member of the Illinois Mining Institute is invited to visit the department and inspect our laboratory facilities. We are badly in need of a new building but I am pessimistic about the possibilities of securing the necessary funds for another two or more years.

Ten mining engineering students will graduate and receive their degrees next February, and another thirteen will complete their work in June. I shall be glad to arrange interviews with mine executives who are interested in employing young engineers.

* * *

Professor Walker: I should like to read another little squib here.

## RESOLUTION

November 16, 1950

At a meeting of the Mining Advisory Committee to the Department of Mining and Metallurgical Engineering at the University, held in Chicago on April 11, 1950, a proposal was made and approved by the Advisory Committee to recommend that the Illinois Mining Institute sponsor an annual student technical paper writing contest, the subject of the papers to be any subject related to the Illinois mining industry. Prizes for the papers would be $50 cash for first, $25 cash for second, and $10 cash for third prize. A committee of five members of the Institute, to be appointed by the President, would act as a judging committee to review and award the prizes for the best papers presented.

I wish to place the following motion before the Institute members assembled here:

1) The Illinois Mining Institute sponsor an annual technical paper writing contest for students in mining engineering.

2) Prizes of $50, $25, and $10 in cash be awarded for the three best papers.

3) The President of the Institute annually appoint a committee of five members to review student papers and award prizes.

4) That the prize winning papers be announced at the annual meeting of the Institute and the authors of the winning

papers be invited to attend the annual meeting and receive their awards.

5) That the prize winning papers for each year be printed in the yearly transactions of the Illinois Mining Institute, publication of the papers being subject to recommendation of the reviewing committee as being worthy of publication in the transactions.

Mr. President, I wish to recommend the adoption of this resolution by the Illinois Mining Institute membership.

* * *

Mr. William R. Chedsey (University of Illinois, Urbana, Ill.): Second the motion.

President Gerow: You have heard the report of the Scholarship Committee. I think there is a lot of food for thought in that report. He has called attention to a drop in the training of technical men for the mining industry, particularly in the Middle West.

The question that arises in my mind is this: Does it necessarily follow that this reduction should take place, when our production is still up, our mechanization is increasing and our various problems of washing, drying and fine coal recovery are still with us? I have heard more technical terms in the last three or four months than I ever thought could possibly be applied to coal. It takes trained young men to carry on that kind of work.

Professor Walker has given four points as possible reasons for this drop in training. I would probably be willing to accept the first three that he gave, personally; however, this "overcrowded" situation in the industry is quite a question mark to me. I wonder if those executives and the people running coal mining businesses who are here have taken full advantage of the training that is being put out by this Scholarship Committee and the efforts of the Institute? I think we can all search back and find that we are not making that kind of effort. Neither are we keeping up to date with the trend, (not only the miners but also the manufacturers) or with our many problems.

I think we are very deeply indebted to Professor Walker for his work on the Scholarship Committee.

You have all heard the resolution as presented by Dr. Walker, which has the approval of the Mining Advisory Committee; I believe I am correct in that. I think as long as it is a matter of so much interest to all of you, and affects every one of us who is here — regardless of what is your advisory capacity or technical capacity around the mines — I would like to take an actual vote on it. All in favor, signify by the usual sign of "aye." Opposed? It is carried, and you will so record the resolution, Mr. Secretary.

We have with us today Mr. M. D. Cooper, Manager of Vocational Training of the National Coal Association. I would like very much to have him step up to the platform and address a few words to the Illinois Mining Institute at this time.

Mr. M. D. Cooper (National Coal Assn., Pittsburgh, Pa.): As usual when Professor Walker speaks, he has something stimulating to suggest.

It happens to be my job to keep in touch with educational institutions throughout the country, both at the college and high school levels, and it is interesting to note that this year jobs have been plentiful for the graduates, but not so plentiful for undergraduates. There has been a feeling among students – and even, in some cases, among employers – that there may be too many men being given courses in mining engineering, beyond the capacity of the industry to absorb. That doesn't seem to be true.

Among the ten colleges that offer courses in mining engineering, and that pay some attention to coal, there were 280 graduates who received a Bachelor of Science or the equivalent degree in the class of 1950. One hundred and thirty of those men obtained jobs in the coal industry, the rest with other industries, in metal mining, or they returned for graduate work. Apparently they were readily absorbed into industry. That is, in itself, an indication of the need for such training.

The makeup of this program indicates that there is a demand for trained men. As you glance over the subjects in the program, you see that those subjects require the application of brains of trained men to carry out the research work that is already in progress, so there is a challenge for the young men who are coming along to get into the industry and to do the work that is necessary for them to do there.

In the future we hope that more of the coal companies will establish scholarships for the better public or industrial relations that will be built up. A scholarship needn't be an expensive thing. Five hundred dollars is ample for a year, plus a job during the summer, giving the holder of a scholarship a chance to earn additional money.

On the basis of what has been seen so far, we believe that if all of the larger coal companies will establish one scholarship and carry it through to the end of four years, and then appoint another son of an employee, it will do a great deal to stimulate good industrial relations at home, and to promote the good opinion of the public toward the coal industry throughout the country.

It is a good challenge, and not an expensive one to carry out, and we are hoping that in time, all of the coal companies will do something along that line.

President Gerow: Thank you very much, Mr. Cooper, for your remarks.

Is there any unfinished business to come before the meeting at this time? You have nothing else?

Secretary Schonthal: No, sir.

President Gerow: Is there any new business that anyone would like to bring up at this time?

Secretary Schonthal: I have none.

President Gerow: Gentlemen, we'll proceed now to mining coal. Jim Conway of Consolidated Coal Company is with us to ably direct the discussions and the papers of the morning session.

Jim is well qualified to carry on with the papers of this morning. Jim, will you take over?

(Mr. C. C. Conway, Consolidated Coal Co., St. Louis, Missouri, assumed the chair.)

Chairman Conway: The program of every group or gathering of coal mining men, for the last two years, has included a session or group of papers on roof bolting. These roof bolting sessions have always created interest and turned out to be a high-lighted portion of the program. I feel fortunate in that this session of the I. M. I. meeting has the roof bolting papers.

I think that all of you have had your ear to the ground and know how general the use of roof bolting is in this country, even though only a few years have elapsed since its introduction. There has never been an innovation in mining that has proved so useful or spread so rapidly in as little time. Roof bolting has really taken over and is becoming a huge factor in the mining of coal.

We have some very capable speakers on this program and I am sure that these points will be well emphasized. Since the program is long, I want to go directly to the first paper, which was to have been presented by Mr. J. J. Forbes, Chief of the Health and Safety Division of the Bureau of Mines. However, Mr. Forbes was unable to be with us today and Mr. S. H. Ash, who is Chief of the Safety Branch of the Health and Safety Division, will represent him.

Mr. Ash, will you please take over at this time.

Mr. S. H. Ash: Mr. Chairman, Members of the Institute: First, I would like to bring greetings from Dr. Boyd, Director of the Bureau of Mines, and Mr. Forbes, for the success not only of this meeting but also the Institute.

I also wish to state that this is the first time that I have had the pleasure of being before you, and, naturally, it is a great pleasure, but I do regret that Mr. Forbes could not be here to give his paper. On the other hand, the Roof Bolting Section is a part of the Safety Branch, so obviously, my interest in it, along with Mr. Thomas's is very great. I think we should be given full credit for selling an idea which, of course, I personally believe is going to help in reducing roof fall fatalities and certainly make for cheaper mining.

I would like to digress on that and say that in spite of all the good work that has been done in recent years, our severity still stands at the top, and I think all of us know why it is at the top. We just haven't found an answer to the preventing of deaths from falls of roofs in all branches of the industry, and until we do, we are not going to do too much to reduce our fatal accident experience, and that's where we are.

I believe that, as much as anything else, accounts for the widespread interest in – and certainly, now, the adoption of – roof bolting. It does offer a means of not only reducing injuries from falls of roofs but certainly reduces the cost of mining in many places.

It is not a cure-all for everything, certainly. We do find that there are places now having roofs supported that didn't have them supported before because there wasn't a chance to do that. Coal had to be loaded at the face, and the miner didn't set his props, and obviously we had faulty roofs.

I am not going to read the paper: You have copies of it, and you can read the paper.

When this program was drawn up, it wasn't contemplated that we would show this picture we have for you, which I know you will enjoy. It contains complete details of the technical matters I could mention.

I might say that today there are approximately 450 mining companies in this country that have adopted roof bolting, of which 350 are major coal producing companies. They are supporting somewhere in the neighborhood of 90 million square feet.

This program of activity has spread to Europe, too. There are several iron mines in the Lorraine district that are now roof bolted, as well as some potash mines in Alsace, so you see it's spreading quite rapidly, and there is considerable interest in it.

With that brief introduction I believe I have covered some of the highlights in this paper, and we'll go ahead and show this picture on roof bolting, after which I'll be glad to answer any questions that you may ask.

# PROGRESS IN ROOF BOLTING

By J. J. FORBES
Chief, Health and Safety Division, Bureau of Mines
Washington, D. C.

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*(We regret we are unable to reproduce the slides and motion picture presented in connection with this paper).*

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Progress in roof bolting to control roof in coal mines is probably one of the outstanding safety achievements in the history of mining. The Bureau of Mines originally became interested in roof bolting because it appeared to have possibilities in reducing the principal cause of mine accidents — roof falls. I believe that the results already obtained in safety and efficiency fully justify the efforts and funds that the Bureau of Mines has expended.

Much has been written about the origin of this method of roof control and also about the various materials and equipment for roof bolting and techniques of doing it. This paper, therefore, will be confined to some of the more important roof-bolting problems that have been solved and those for which solutions are being sought.

The progress made in developing and adapting roof-bolting techniques during the last 2 years, particularly in mechanized mines, is remarkable. This does not imply that roof bolting had not been applied previously in coal mines. Our records show that considerable pioneer work in securing coal-mine roof with bolts was done in 1947 in a mine in Illinois — No. 7 mine of the Consolidated Coal Co. at Staunton. According to reports, the use of roof bolts in the mine has contributed greatly to safety and efficiency.

Although the number of roof-bolting installations to control mine roof during 1947 was small, since then the widespread application of the method by the mining industry has been phenominal. In fact, within the last 2 years, roof bolts have been installed in over 350 mines to secure approximately 800 miles of mine roof. This certainly indicates excellent progress in such a short time in solving most of the problems concerning the use of roof bolts.

Regardless of the types of roof-bolting materials used and the variations in bolting patterns, the basic principle remains the same, namely, the reinforcement of thinly stratified rock to form strong, consolidated roof. It is true that in some instances the immediate roof can be secured by bolting it to a strong, massive, overlying rock, but this ideal condition is not common in mines. Under all roof conditions it is essential to minimize or eliminate the sag of roof rocks to prevent breaking of the roof.

To reinforce roof, steel bolts are inserted in boreholes and anchored therein. Wet percussion drilling of holes appeared to be the best method because of the hardness of the roof rocks and to minimize the dust hazard. Because of the annoyances of wet drilling, and because it was an uncommon practice in bituminous coal mines, in many instances the use of water during drilling was discontinued. In mechanized mining it is desirable to keep to a minimum the number of units at the working faces; consequently, at many mechanized mines electric rotary drills were adopted. Such drilling usually is done dry; therefore, without some means of controlling dust a health hazard is created while the attempt is being made to eliminate the hazard from falls of rock. Consequently, on January 17, 1950, representatives of machinery manufacturers, coal-mine operators, mine workers and representatives of the Bureau of Mines met in Washington to discuss dust-control measures in connection with roof bolting. Since then several types of dry dust collectors have been developed and are now available to the mining industry. Preliminary tests indicate that some of these collectors are effective if properly used and maintained.

The next problem requiring consideration was the type of steel best suited for making roof bolts. The need for establishing bolt specifications was emphasized when difficulties were encountered where slit-rod bolts of high-carbon steel were used. On May 22, 1950, a conference of representatives of bolt manufacturers, steel suppliers, and the Bureau of Mines was held in the Washington office of the Bureau to discuss roof-bolt specifications. It was decided that slotted-end bolts should be made of steel conforming to A.S.T.M. Specifications A131-49T, which establishes tolerances for tensile strength and elongation. Minimum requirements were agreed upon for alloy steels. Preliminary discussion of the possibility of standardizing roof-bolting materials was held. This problem involves establishment of minimum standards of safety but "leaves the door open" for new developments.

Corrosion of roof bolts, particularly in permanent openings, is a problem to be investigated and solved. In some mines, the high-acid content of mine water will require the use of corrosion-resistant metals, coatings, or sealing compounds.

How to obtain satisfactory anchorages in various strata with the many different types of anchoring devices now on the market is another problem to be solved. The wide range of physical properties of the roof rocks complicates the problem.

To obtain pertinent information on the unsolved problems relating to roof control, the Bureau of Mines has established field and laboratory research units. These units cooperate with various mining companies in solving their roof-control problems. For example, in making torquometer and pull tests on bolts, frequently the mining companies provide themselves with equipment to make these tests to be sure that bolting is effective under all of their roof conditions — particularly when installations are made in several sections of the mine under different conditions of bedding and composition of roof rocks.

To supplement these tests, work is being carried on to determine the physical properties of strata that comprise the mine roof. A centrifuge has been constructed at the Bureau's Eastern Experiment Station, College Park, Md., to carry on research on analysis of stresses that surround mine openings, particularly in bedded strata; virtually no scientific information on this subject is available. In this apparatus, the behavior of scale models of mine roof under stress will be studied. We expect to obtain data that will furnish information needed to determine and design safe, efficient roof-bolting patterns.

The Bureau participated in developing the stratascope, a device useful in roof-control investigations. This instrument permits the optical or photographic examination of boreholes 20 feet deep in mine roof to determine the extent of strata separation or sag. Roof-control studies in the past have disclosed that there is a definite relationship between the strata separation at bedding planes and the ability of the strata, acting as a beam across a mine opening, to resist the stresses that cause strata to separate. Information obtained with the stratascope is reliable in predicting failure of mine roof. Moreover, its use in connection with roof bolting will be of great value in determining the effectiveness of beams formed by bolting.

Roof rocks adversely affected by alternate wetting and drying due to changes in atmospheric conditions in a mine have created another problem in roof bolting. The use of Gunite or other substances to seal bolt holes and roof and sides of entries is being investigated. Two experiments are being observed closely, in which a vinyl resin base paint and a plastic material have been applied to the roof and sides of mine openings to prevent spalling. The plastic material, similar to that used by the military services to preserve and protect equipment, has been applied successfully to exposed surfaces in mine shops and battery-charging stations where the roof is subjected to above-normal mine temperatures. As the applications were made only a few months ago, it is too early to draw definite conclusions regarding the practicability of these materials.

Another program of investigation recently initiated is the use of electrical resistance-type strain gages to determine bolt tension. This phase of the work will supplement torque and pull test data that already have been collected. The information will be of great value in determining proper loading when the bolts are installed; similar tests, subsequently made, will disclose the effectiveness of the installation. It is believed that the information obtained will be valuable in determining the safety and efficiency of a roof-bolting installation to meet a specific condition.

The use of roof bolts to supplement conventional timbering in pillar work has been notably successful with respect to safety. The reports from four mines in which this method has been applied experimentally for more than a year indicate that the regular bolting program at each mine will be extended to all pillaring sections.

Until enough fundamental information on the problems mentioned, and others relating to roof bolting, is obtained, it is recommended that all experimental work be done under close control and supervision. During the experimental period, conventional timbers should be used to supplement roof bolting, and records show that experimenting can be done with minimum hazard. The Bureau continues to oppose recovery of bolts until methods are devised whereby it can be done without jeopardizing the lives of workman.

This slide illustrates the progress made during 1 year (show projection slide) in a Pennsylvania coal mine in which roof bolting has been adopted to supplement timbering. Roof bolts were applied to the area beyond the points indicated as falls. It is evident that conventional timbering did not provide adequate support for the roof conditions. Bolt failures have not occurred, and no roof failures have occurred since bolts were installed. Two areas, indicating by cross hatching, were drilled, but the bolts were not installed to determine whether roof stresses were relieved by drilling. The roof in these areas deteriorated rapidly. The total number of bolts installed was 13,671, each 1 inch in diameter and 6 feet long. Five hundred and twenty two channels were installed on haulageways. Other areas were secured with 3/8 - by - 8 - by 8-inch bearing plates. Approximately 14,720 linear feet of entries were secured by bolting. Ordinary mine timbers are still used, but the quantity has been reduced 50 percent. The average loading rate increased from 125 tons per machine shift to 270 tons. Both workman and officials consider roof bolting very satisfactory in securing roof at this mine.

Roof bolting has brought into sharp focus the problems of roof control and has stimulated thinking among mining men to a greater extent than any other recent innovation for coal mines. The progress has resulted from sincere cooperation of operating men at the mines where it has been applied successfully. Continued cooperation and research will provide the "know-how" for further improvement in roof-bolting techniques, which ultimately will result in greater safety and efficiency in underground mining.

* * *

Chairman Conway: We are already behind schedule and we must forego discussion of this paper at this time. Possibly, we can have some discussion following the completion of the Roof Bolting papers. I do, in behalf of this group and the Illinois Mining Institute, wish to thank Mr. Ash and the Bureau of Mines for the excellent picture.

And now I want to call upon a man who has become intimately familiar with the many problems of roof bolting and the advantages to be gained — Mr. John Williamson, Jr. of Peabody Coal Company — for some discussion of this subject. I hope that he can put across to you some of the enthusiasm that he has already expressed to me. I think that he has something of real interest to tell you — Mr. Williamson.

## DISCUSSION

Mr. John Williamson (Supt., Peabody Mine 40, Marion, Illinois): Thank you, Mr. Conway.

Gentlemen, I know that you probably all have seen quite a bit of roof bolting going on such as we saw in the picture, so I will more or less generalize on part of my experiences in Peabody Mine 40 in southern Illinois. Since it's getting close to lunch, too, and everyone is probably hungry, I'll give you the highlights of what we found there, as quickly as possible. I will be glad to answer any questions you may have after the program is over, and please feel free to visit us at any time in southern Illinois. We'll be more than glad to go over the roof bolting program that we have and show you what we have done so far. I personally think that we have done a remarkable job.

You all know that the principle of roof bolting is to do away with the falling of rock. Two weeks ago Saturday I had a very unfortunate accident happen. A man was killed at Mine 40, in the only section that was not roof bolted. The fall of rock was 29 feet long, 19 feet wide and 2 feet thick. It was one of those things – if that section of the mine had been roof bolted, that man would be alive today.

That is one instance which personally convinces me that roof bolting is here to stay, as far as low coal mining is concerned, and that is evidently true in high coal mining, according to the pictures which we just saw.

The bolting unit is part of the face operation. That is a necessary "must." In low coal we load from 16 to 22 places a shift. You know that in low coal operation everything must click to be efficient, and has to go along as quickly as possible. It takes us 15 to 20 minutes to load out a place 14 feet by 4 feet, with a cutter bar depth of 7½ to 8 feet. On that particular setup we utilize 5 or 6 roof bolts with plates. Our pattern that we utilize is 6 bolts north and south, with 5 east and west, this is because of the "cutting of the top" at the present time.

It was necessary for us to construct our own compressors for this work, and as quickly as possible, because of the urgent need of roof control. As there wasn't enough material or equipment on the market available soon enough for us to buy, it was necessary to use anything available at the time.

We utilize the stoper drill with the air impact wrench as you saw in the picture. We have approximately 150 to 200 pounds torque on each one. This is tested periodically, to keep the crew on its toes.

We have had trouble with our compressors, and as a result we lost our bridge of rock, which of course is the most essential or principle part of the face cycle of roof bolting. Any time you lose your face cycle of the bridge of rock, you have trouble on your next loading cycle, or on the cutting or drilling cycle. As a result, roof bolting must be kept up to the face as close as possible, which is as we can comprehend a necessary cycle to be included in the face operation.

We have standardized on a 30-inch roof bolt because of the gray shale formation we have. The laminations of the shale and it being from 6′ to 15′ in thickness makes it possible for us to standardize on the 30-inch bolt, whereas, in different parts of the country and different thickness of strata they need longer or possibly shorter bolts.

On our 30-inch bolt, we drill a hale 28½″ deep install a wedge-type bolt set plate and tighten the hut. It's a two-man operation, and takes from 1¾ to 2½ minutes to complete. That is the standard we have set up, of course the speed is necessary to keep up the bolting cycle of the face operation.

We use a dust collector which is very efficient. It is comparable to the one shown in the picture, only we have a dust box that the discharge air and dust goes through. If you ever use a dust box, it's a good thing to remember that the dust bag and dust box must be taken out periodically, dried, cleaned out, and then it can be used over again. It is understandable that dampness in the bag would tend to close the pores in the cloth and of course retard the efficiency of collecting the dust because of stopping the air from passing through the dust bag. This also utilizes more air from compressor and decreases the amount needed to run the stoper and impact wrench.

On each shift, and each unit we are, as mentioned before, loading from 16 to 22 places and it is necessary to install from 75 to 100 roof bolts per unit per shift. That's a lot of movement, and everything has to move like clockwork. So again we realize that to make roof bolting a success, speed, efficiency and superior workmanship in cooperation with the rest of the face cycle is needed.

It used to be that many times in the morning it was an hour and a half or two hours before we got the face operation going and started loading, and as a consequence we gave roof bolting a try. It proved so successful that we have utilized it in all of our sections, and will continue to do so. Our tonnage increase in one particular section, in a room territory, was very good. It was, previous to roof bolting, 125 tons, which, as you know, is very low. We increased it to approximately 350 or 400 tons, which is quite an increase for 12 men. That cuts down your cost which is the ultimate goal of efficient coal mining.

We tried timbering in 14-foot entries in low coal, and you can't do that; you can't crossbar and have clearance in 4′ of coal. That is even more of a hazard along that line than any possible protrusion of the bolt.

That brings another point to mind. When you're drilling a hole for a bolt, especially when using the wedge type, the length of your hole must be closely watched, as mentioned previously, we drill our holes 28½″ deep. If not, closely watched you'll have quite a few bolts protruding below the nut, which, of course, makes a hazard. Mr. Kelly will vouch for that.

Is there any question you'd like to have me answer, quickly, on roof bolting?

Once again I would like to extend any courtesies to any of you who would like to visit Peabody 40 and see our installation. It's a very efficient operation, the tonnage has increased greatly, and the safety factor is very high, and I think our operation on roof bolting is one of the best in Illinois.

Are there any questions you gentlemen would like to ask at this time? If not, thank you very much.

Chairman Conway: Thank you, Mr. Williamson, for your very graphic recital of the work that you have been doing at Peabody Mine No. 40. I see that you still have the enthusiasm expressed to me and that you certainly were able to put it across to this group.

We will now hear from another man, Mr. Leon Kelly, Assistant Mining Engineer of the Bureau of Mines, Terre Haute, who cannot be accused of lacking in enthusiasm. He has been following roof bolting for the Bureau since its start and has seen applications all over the country. We would like to have Mr. Kelly tell us of some of his experiences and thoughts on roof bolting. — Mr. Kelly.

Mr. Leon W. Kelly: Mr. Chairman, Members of the Institute: It's a hard job to follow a speaker like the one just up here, and the only way I can get by that is to leave out part of what I have written here. It won't affect the points that I'm trying to make.

## DISCUSSION

By LEON W. KELLY
Mining Engineer, U. S. Bureau of Mines
Vincennes, Indiana

Inasmuch as Mr. Forbes' paper states that in the United States approximately 800 miles of roof has been supported by roof bolts in 350 mines in the last two years, it is of interest to note the progress that has been made in Illinois, Indiana, and Western Kentucky in the last 18 months. With the exception of the Consolidated No. 7 mine in Stauton, where roof bolting has been in progress since 1947, there was exactly 22 feet of entry roof supported by roof bolts in 1 mine in the Middle West eighteen months ago. Today, there are more than 200,000 lineal feet of roof supported by roof bolts in 51 mines, or a total of more than 40 miles.

When roof bolting was first introduced in the Middle West it was thought that it would go through three phases viz: (1) experimental installations, (2) failures, and (3) permanent installations. It is beginning to appear as if we are entering phase 2.

For the past few weeks I have been devoting as much time as I could to investigating failures in wedge-type bolts in order to determine the cause and thereby gain knowledge that would help other companies to avoid the same mistakes. Although I feel sure that there are more wedge-type failures than I discovered, I was able to find and investigate three. A description of these three follows:

CASE 1. This is an ultra-modern trackless mine in which the coal is transported from the face regions to the surface preparation plant by means of belt conveyors. The coal bed averaged 6 feet in thickness and has a very peculiar roof. An ideal cross section of the roof would be 19 inches of hard black shale, overlain by 32 inches of limestone, which is overlain by another coal bed 5 feet in thickness. This was the condition of the roof when the original survey was made and 4-foot wedge-type bolts were recommended as they would be seated in the limestone. However, the roof begin to change. In some places the limestone thinned out and the black shale increased and the coal thickened. Then the limestone disappeared and was replaced by fire clay which apparently was the normal floor of the overlying coal bed. Several months had elapsed while these changes had been taking place and during this time the 4-foot bolts had been used and approximately 9,000 feet of entry roof had been supported. All of the employees and men had acquired unlimited confidence in roof bolts and when they found that their 4-foot drill holes were bottomed in fire clay, they continued to install the 4-foot bolts just as they had done previously in limestone and coal. When about 150 feet had been bolted the roof began to work. It worked for three days and then the entire 150 feet fell into the upper coal bed. The cause of this failure is the disregard of the well known fact that a hard stratum is necessary for the successful seating of the bolts.

Case 2. This mine is operated by means of shuttle cars dumping into mine cars which transport the coal to a slope belt conveyor.

The coal bed averages 58 inches in thickness and has one of the worst roofs in which I have seen roof bolts used. The immediate roof consists of 18 inches of hard black shale overlain by about 4 feet of gray shale which has very little inherent strength but which nevertheless is hard enough to form a good anchorage. Above this is from 6 to 9 feet of soft white shale with no strength at all and resembles the Illinois clod as much as anything.

When roof bolting was first considered in this mine it was as a last resort. The choice was either to support the roof with bolts or to shut it down as it was impossible to operate it with conventional timbers. Accordingly roof bolts were installed and the original recommendation was to use four, 5-foot wedge-type bolts every four feet along the entry. About 2,000 feet of roof was supported successfully in this way and then the owner decided to use four, 4-foot bolts every 4 feet along the entry. An additional 4,000 feet of entry was bolted but sections began to fall. These falls were calculated by the owner to comprise about 5 or 6 percent of the total length of the roadway bolted and were not taken seriously. Then it was decided to use three, 4-foot bolts every 4 feet and that was the situation at the time of my visit. Note that the beam-forming medium has been steadily decreased from four, 5-foot bolts to three, 4-foot bolts every 4 feet. It is the intention of the operator to decrease this medium still further by reducing the bolt length to 3½ feet.

At the time of my visit about 8,500 feet of roof has been supported and of this amount about 320 feet had caved. The failures average about 30 feet in length and when one is about to occur the roof starts to work and cut down one rib for from 12 to 48 hours before it falls. Then the whole mass falls to a height of 8 or 10 feet. The immediate area is barricaded during the period when it is working and before the cave occurs. The cause of these failures is obviously the failure to use enough bolts of sufficient length.

Case 3. This is a new modern trackless mine in which the coal is transported from the face regions to the surface by means of belt conveyors. The coal bed averaged 5 feet in thickness and was very easy to support if it were timbered properly. An average cross section of the immediate roof is as follows: Immediately on top of the coal there is a stratum of hard black shale 35 inches in thickness, and above this occur successively 28 inches of hard sandy shale which forms the main roof, and 84 inches of sandstone. The stratum of shale that lies directly on the coal separates from the overlying sand shale and falls if it is not timbered promptly.

At the present time there are about 29,000 feet of roof supported by roof bolts. Both entries and rooms are roof bolted and very little wood is used. Originally three, 3-foot bolts were installed every 4 feet and the roof was held successfully. Then it was decided to install two bolts every 4 feet instead of three. This was generally successful but falls started. As a rule they were small but one was 300 feet long. In addition to reducing the number of bolts from three to two, they sometimes omit the bolts for the distance of one cut and then start roof bolting in the next cut. Practically every time they do this the roof falls in the unsupported area. Every time the roof fails, it first starts to cut along one rib and then works about 24 hours before it falls. The reasons for these failures were obvious and when the superintendent was asked why these practices were allowed to continue, his answer was that in most cases the bolts held the roof long enough for them to work the place out and that he didn't feel justified in spending additional money. Furthermore, he stated that a place that was about to fall gave ample warning so that no one would be caught by a fall. However, this statement is open to a reasonable doubt.

The reasons why failures occurred in these three mines are perfectly obvious, and it is not necessary to spend time in detailing them. However, the important thing they show is the deliberate trend toward phase 2. In each case the sequence of events has been the same. When bolts were first used in a mine, everyone was more or less afraid of them and the pattern that was adopted was followed religiously. All of the work was done well and attention was paid to all details. The bolts were watched carefully day by day and when they didn't fall out the first week, a certain amount of confidence in them was felt. Great care was still exercised in the installation and, as time went on and none of the bolts fell out, they were taken for granted and it was assumed that bolts would hold the roof up as long as there were bolts in the roof. Slackness in seating the bolts and tightening the nuts developed. Small failures occurred.

This is thought to be the dangerous phase of roof bolting and it is due entirely to overconfidence. The mere fact that bolts are installed in the roof is no guarantee that the roof will be supported. The transition from fear to overconfidence is a natural human trait and can be explained by the old adage — familiarity breeds contempt. Some operators are beginning to tell me that we are all over bolting and naturally when they feel that way they will reduce either the number of bolts or the lengths of the bolts that they use. If this course is pursued indefinitely, and if failures are accepted as a calculated risk, it is only a question of time until a serious accident occurs and roof bolting will be set back for years.

* * *

Chairman Conway: Thank you very much, Mr. Kelly. The subject of roof bolting could well take up the remainder of the day, but unfortunately we are not allowed that much time for this session. In fact, we are behind our scheduled time and will not be able to enter into discussion of the papers that we have heard. Before leaving this subject, however, I would like to mention that it is my thought that within a few years, roof bolting will be so commonplace that it will scarcely be mentioned at these meetings and that it will be in use at every mine in the country where any type of timbering is indicated. The number of lives it will eventually save, I believe, is well nigh incalculable.

We have other interesting subjects on the program for this session and one of them which is of particular interest to everyone is the subject of Continuous Miners. There are about six different types of Continuous Miners operating, or about to operate, in this country. One of the successful machines is the Colmol and I am sure that you will enjoy this opportunity to learn more about the Colmol. We are fortunate to have Mr. W. S. Phillips, Assistant to the President of the Sunnyhill Coal Company, Pittsburgh, Pennsylvania, to tell us some of the details of its operation.

# "THE COLMOL"

By W. J. PHILLIPS
Assistant to the President, Sunnyhill Coal Company
Pittsburgh, Pennsylvania

*(We regret we are unable to reproduce the slides presented in connection with this paper).*

Let us first review the Colmol's method of functioning as well as some details of design and construction. The Colmol is one process machine, replacing the four conventional steps of undercutting, drilling, shooting and loading. The unit has best been described as a giant mole, being mounted on caterpillar tracks which move the machine forward into the solid and unshot seam of coal, simultaneously cutting and loading an area 9½ to 10 feet wide and the height of the seam being mined.

The Colmol is designed to have a series of rotary breaker heads mounted on heavy gear cases movably suspend from the main frame of the machine. These rotary breaker heads are positioned in horizontal rows (the lower and medium seam units employing two rows; the higher models, three rows) and are mounted on the aforementioned gear cases which can be raised or lowered in unison or expanded or contracted to regulate the cutting height of the machine to follow variation of coal seam thickness. The breaker heads are so designed that they may be stopped at a predetermined position where they are all within the dimension of the gear cases. Thus, the Colmol may move freely forward, backward or on an angle within the space it has cut. Half of the breaker heads turn clockwise and the other half counter-clockwise, all turning toward the center of the machine. They not only break the coal out of the solid, but also sweep the coal toward the conveyor in the center of the unit where it is picked up and carried to the rear of the machine and discharged into the intermediate and haulage medium.

*Slide 1. Front and Side View Showing Heads Turned Within Confines of Gear Cases*

The Colmol, while advancing the face at a mining rate of 15 to 24 inches per minute, leaves a floor which is clear and uniform, leaving less than one per cent of the total amount being mined along the rib.

*Slide 2. Showing Face and Clean Floor*

All functions of the Colmol are done with electric-hydraulic power. The caterpillar tracks on each side are driven independently with an infinite speed adjustment from minimum to maximum, either forward or reverse. This affords the operator accurate control of the machine under all mining conditions, permitting him to move the machine within a fraction of an inch of mine posts or crossbars repeatedly without disturbing them.

The functions of raising or lowering the front gear cases in unison, expanding or contracting the two, and tilting them forward or backward, to follow seam variations, are all done hydraulically, thus permitting the operator a quick and accurate way of making any of these adjustments while the machine is operating.

Now let us look at some of the pertinent points in the specifications of the low and intermediate model Colmols.

*Slide 3. Showing Low Model Colmol at Jeffrey Plant*

LOW MODEL COLMOL

*Power*—Three 50 horsepower continuous duty air cooled motors. One each driving the hydraulic pumps powering the upper and lower row of cutting heads, the third motor driving pumps for remaining hydraulic functions, tracks, conveyor, etc.

*Traction*—Hydraulically driven, giving a

*Mining Speed*—from 0 inches to 94 inches per minute

*Tramming Speed*—0 to 25 feet per minute.

*Width of cut*—9 feet 6 inches

*Height of cut*—32 inches to 51 inches (width change of upper gear case)

*Width of machine over gear cases*—(widest point of machine) — 8 feet 5 inches

*Width of machine over cats*—6 feet 1 inch

*Clearance between cats and rib*—20½ inches on each side.

*Length of machine (overall)*—23 feet 9 inches.

*Weight*—50,000 lbs. — 25 tons

*Slide 4. Showing Section of Main Frame with Recesses for Head Electric Motors and Pumps for Accessibility*

*Slide 5. Compactness of 50 Horsepower Air Cooled Motors*

*Slide 6. Showing Heavy Construction of Traction Gear Case*

INTERMEDIATE MODEL COLMOL

*Power*—3 70 horsepower continuous duty air cooled motors — same functions as low model

*Traction*—same as low model

*Width of cut*—9 feet 11 inches

*Height of cut*—45½ inches to 72 inches — (using various size cutting heads). Maximum spread with an given set varies from 10 to 15 inches.

*Width of machine over gear cases*—7 feet 10 inches

*Width of machine over cats*—6 feet 5 inches

*Clearance between cats and rib*—21 inches on either side

*Length overall*—24 feet 9 inches

*Weight*—70,000 lbs. — 35 tons

HIGH SEAM MODEL

A high seam model is now being engineered which will have a maxium cutting height of 88″ with substantially the same overall specifications as the intermediate model with the exception of the overall weight and the horsepower of the electric motors.

Low model units are now operating in West Virginia and Pennsylvania mines while intermediate models are nearing completion at the Jeffrey plant in Columbus.

Within the remaining allotted time let us quickly consider the problems encountered and the results obtained with the first experimental model and the low seam models now in operation.

Most of the time the experimental unit was mining in the Upper Freeport seam of coal, located in Preston County, West Virginia. The coal there is of a woody, fibrous structure with no natural cleavage lines. The seam varied in thickness from 48 to 51 inches, and lay between 14 inches of hard clay bottom and an overlaying 18 to 20 inches of bone coal, which was left up for roof support. Included in the 51 inches of coal mined was a 3 inch hard clay binder which the machine brought out in sizeable chunks with no apparent excessive damage to the carbide tip bits. Turnbuckle rib jacks supporting 5 by 7 inch gross timbers were used as temporary safety measures over the machine and operator to meet the requirements of the West Virginia mining law.

*Slides 7 and 8. Showing Use of Turnbuckle Roof Jacks. Noting Arch in Rib.*

This being a new mine only development work was done with this machine. The three entries were on 60 feet centers and were driven 12 feet wide. Cross cuts were staggered right and left off the belt heading every 70 feet. The Colmol turned these cross cuts off on 45 degrees from the 12 foot entry with surprising ease. Many operating men who watched the machine in operation commented on the minimum amount of maneuvering required to make such break throughs and remarked about the smooth, uniform rib left by the machine.

Our method of mining with the Colmol, we called the offset cut method. We first drive into the solid face approximately 20 feet so that the operator need not be under the newly exposed roof. The machine is then backed up the distance it had advanced and the lift cut of desired width is picked up to the full face and then continued on in a full cut for another 20 feet. The machine which has now moved forward a total of 40 feet is then backed up and swung to the opposite side and the process repeated. This method requires a back up of only half the distance moved forward.

With this system of driving, a 12 foot or greater width working place, brattice can be utilized to carry air forward to a point within 5 feet of the full face, at times only within 20 feet of the advanced single cut face, but always ahead of the operator.

*Slide 9. Showing Colmol Taking Offset Cut*

With this progressive offset method, any desired width entry greater than that produced by a single cut of the machine can be driven. This provides ample room for timbering and accessibility to the front of the machine for periodic bit inspection and lubrication.

Two five ton shuttle cars were used for intermediate haulage from the Colmol to a 30 inch main belt conveyor. At first the main belt was extended on off shift a distance of 150 to 200 feet. We soon found we could increase production by keeping shuttle car haulage to a minimum. We then began extending the belt 75 to 100 feet at a time but doing it more frequently. To gain head room in the belt entry, the Colmol was used to dig up and load the 12 to 14 inches of hard clay bottom. It did this job very effectively, saving both time and labor expense.

Our practice was to keep one shuttle car behind the Colmol, serving as a surge car, while the second car shuttled to and from the belt loading point. It was found advantageous when the hauling distance was over 200 feet to have the surge car leave the loading boom of the Colmol and transfer the load enroute to the other car.

Intermediate haulage has presented a real problem with the Colmol. Time studies showed the Colmol to be mining only about 33⅓ per cent of the actual 7 hour daily shift working face time. Since the machine normally loads the surge buggy with three tons or more in a minute to a minute and thirty seconds, the second buggy under favorable road and dumping conditions just can not return in time to permit the machine to operate continually.

Some better intermediate transportation system than any now available will have to be provided. We are presently working on a system which will soon be mine tested. We are of the opinion that when fully developed it will work successfully and carry coal from the Colmol to the main haulage system at the rate of 5 to 10 tons per minute without interruption. We know other manufacturers are also working on this problem and with the great amount of thought being given it by operating men, some practical way will surely be developed.

Our normal production for a seven hour shift at the working face was 225 tons. This average daily tonnage was maintained despite the fact that this was an experimental unit. Considerable productive time was taken up with development work on bits, taking hydraulic and electrical readings, and almost daily demonstrations to groups of coal operating men.

Our Colmol operating face crew consisted of five men: operator, utility man, two shuttle car operators and a timberman. The shuttle car operators and the other two crewmen teamed up to do timbering and cable moving when necessary. With production confined to one area, the foreman could spend a majority of his time at the face, giving him close supervision of the men and ample time to check sights. This being very important when you realize the machine may advance a 12 foot entry an average of 112 feet or more per shift.

The results obtained from the three low model Colmols operating in seams where the machines are mining from 38 to 45 inches of coal have definitely proven the production capabilities of these low units. One of these low machines operating in 38 inches of coal has produced in 5½ hour working shift 262 tons with a six man crew. Due to the low height of the seam it is impossible to use a surge buggy behind the Colmol resulting in more than 50% lost operating time every shift waiting for shuttle cars returning to the machine.

Since September 25, to date, while operating two and three shifts per day only two full shifts have been lost for repair work on this unit.

This loss occurred when a defective armature in one of the electric motors had to be replaced. The management of the mine where this machine is working tell us the average daily per man tonnage from the Colmol to date is more than double that produced at any face section of the mine, by other mechanical equipment.

Another low model machine at another mine in 44 inches of coal, produced 242 tons on the second shift after the machine had started to work. This was also on a 5½ hour working shift.

The many safety features of the Colmol should certainly not go unmentioned. Outstanding of these is the fact the operator is back 20 feet from the working face, and in a position where the machine would tend to protect him in the event of a roof fall. The machine itself, has an almost level top and is constructed rugged enough to take a fall without doing serious damage to working parts. Another feature is the ability of the Colmol to walk into a fall of bone coal or shale of large size, break it up and load it out at the rate of 5 tons or more per minute, leaving the floor perfectly clean and ready for further operations.

Visitors, mine inspectors and crew members have been high in their praise at the lack of dust produced by the machine when operating. A explanation of the Colmol's method of removing coal from the solid is important, I believe, since it is so closely related to the dust problem. You will recall that the breaker heads on the front gear cases are so designed that they employ a cooperative action of cutting wherein each step in the action provides a means for cutting toward the opening or relief provided by the previous step and beyond that where each step is correlated to other steps so that relief may be provided in the maximum number of directions.

*Slide 10. Showing Breaker Arms on Front Gear Cases*

As the machine advances into the solid seam of coal, the pilot bits in the lower row of breaker heads make first contact. Thus, the first opening or relief is provided by "drilling" five four inch diameter holes out of the solid. As the machine moves ahead the first radial bits breaks the coal toward the opening provided by the pilot bit and the second radial bit then breaks toward the opening provided by the first radial bit.

In addition to the aforementioned cooperative action of each bit providing relief for each progressively receeding bit, the overlapping action of the heads provides further relief. Each of these breaker heads turns within a substantial part of the area covered by the adjoining head, thus each radial bit is constantly intersecting the paths or relief provided by the radial bits on adjoining breaker heads. In addition to this relief the upper tier of heads are always breaking the coal out into the undercut provided by the advanced positioned lower tier. Thus, as the machine moves forward, the coal is not milled out by actual contact of the bits, but is chipped or broken out at cleavage points constantly toward relief, producing uniform size product with a minimum of fines. With this absence of milling, the Colmol just doesn't produce a great quantity of dust. What dust is produced is largely confined in front of the gear cases where a series of self cleaning water sprays are mounted.

These are augmented by two rows over the conveyor to allay dust which escapes through the opening. We are obtaining satisfactory results with this spraying system operating at approximately 100 lbs. pressure. Each nozzle delivering .41 gallons of water per minute or a total of 10 gallons per minute or approximately three gallons per ton of coal produced. With this kind of dust control the fire and explosion hazard is greatly reduced.

Profiting from our operating experience with the first experimental model the Jeffrey Colmols now in the field and those in production have considerably more weight built into them. This has been done by "beefing" up many of the steel components of the machine. They are designed with the thought in mind that a piece of equipment capable of producing 3 to 5 tons of coal per minute continually, must be ruggedly constructed. Design changes were made to place working parts of the machine in a position where they are easily accessible for repair and maintenance work. The present units have more flexibility of the front end, they are shorter in overall length which permits better maneuverability and provides more clearance.

We feel certain from the results obtained to date with the units now in operation and from the operation of additional Colmols under variable seam conditions that mining practices will develop to fully utilize the production capabilities of this piece of equipment. We are confident it is designed and built to stand up under the job required of it in the coal mines of our country and we are positive it is a forward step toward reducing coal production costs in our mines.

* * *

Mr. Phillips: I have a short motion picture showing the Colmol in operation underground which I am sure you will find most interesting.

It is very brief, and if you will take the slide off and put the motion picture on, we'll continue with that.

(Showing of motion picture of Colmol continuous miner.)

Mr. Phillips: If there are any questions, I'll be glad to try to answer them for you. Thank you very much.

Chairman Conway: Thank you, Mr. Phillips. Gentlemen, time is short and again we do not have a sufficient time for discussion.

We have another important subject on our program and that is safety. Safety, involving the preservation of life and limb, is of course important to all of us. There is no more important subject than safety and we have present to talk to us today, on this subject, Mr. Earl Maize, Executive Director of the Safety Division, National Coal Association. Mr. Maize's subject is in the form of a question, "IS SAFETY YOUR JOB?" – Mr. Maize.

Mr. Earl R. Maize: Mr. Conway, Members of the Illinois Mining Institute: I feel very proud and happy to be here. This is my first appearance out here with you all, and I am not going to keep you long.

The subject of this paper – copies of which have been passed around to you – is "Is Safety Your Job?"

Now, gentlemen, you have heard safety all through the papers that have been presented. They were very fine papers. The answer is almost obvious, so I'm going ahead and will not keep you away from your lunch any more than I can help.

# IS SAFETY YOUR JOB?

By EARL R. MAIZE
Director, Safety Division, National Coal Association
Washington, D. C.

Possibly you have asked yourself, is safety *my* job, and have come up with an answer that suits your particular needs. Stop just a moment now and reevaluate your answer, whether you are the crew foreman or the president of your company. Certainly Safety is your job and the job of every man working for or with you.

What does "Safety" mean? The dictionary simply states "freedom from injury or danger." Thus, the basic philosophy of safety is given. In prehistoric times families banded together became units or clans, erected thorn barricades about their dwelling places to achieve safety from prowling animals or other tribes. We erect cages around gears and flywheels to achieve the same results.

Industrial safety work is the modern outgrowth of our mechanized era. It really dates back to the days of the mastercraftsman, who took a personal interest in his apprentice. Why did the craftsman have this interest in the welfare and health of his apprentice? Simply because the apprentice was his most valued tool and injury to him meant a reduction in income. Are we in any way different from the mastercraftsman and the apprentice? I say no.

The coal miner is the common denominator in all mines. His well being — continued good health and freedom from injury — is our principle consideration. When the cost of safety work is considered, it is proving more profitable — in mine after mine after mine — to prevent accidents even to the extent of making large expenditures for accident prevention activities, production notwithstanding. The sincerity of this is exemplified in the slogan of one of the companies in your own state, which is: "Safety Even Before Production." Just recently in looking over the compensation charges of one of our coal states, I noticed the payroll charges ranged from 5 to 23 cents per ton. Why were the costs in some instances around 23 cents per ton? I believe they were high simply because some one didn't realize what it was costing to have an injury. Do you know what your costs are? If you don't, it would be well to find out because here is an opportunity to reduce costs through your own actions. You have the means within yourself, *it is in your attitude and habits.*

No matter what some people say or believe, safety cannot be legislated. Certainly there must be minimum laws as guides and these laws exist today in each state. Moving these minimum standards to another focal point will not accomplish savings in human injuries or suffering. It has been proved right within our coal industry that the question of individual action is what counts. The attitude of the workman is all important.

We have come a long way in accident prevention in the coal industry and your group is congratulated on the good work being accomplished. To date, 1950 is surpassing the best record we ever had; namely, that of 1949. Illinois ranks second only to Ohio in the present good record. It is nice to be able to tell you these facts and when men are doing a good job they should be told about it and encouraged to go on to better things. Thus, we revert to the theme of this paper, "Is Safety Your Job?" – and having answered it with an emphatic yes, let us briefly look into the attitude proposition.

You develop your attitude and influence the attitude of your men through your practices. If the attitude you have developed came through bad practices, your personal safety and that of your men is in jeopardy. And since safety is the job of each of you, you should pattern your actions and attitude so that they reflect for the good of the mine in which you work.

The ordinary man is normally careful but has lapses which at times verge on recklessness. It is in these lapses that accidents occur. You should be talking safety, as well as acting safety all during your working day and remind your men of the important things to do to prevent an injury. In talking safety you would probably not be correcting any defects in knowledge but would be reminding men of the things they know but are not using. We all know sincerity of purpose and constant application will do, but maybe we are all not practicing what we know. Someone has very aptly said "Safety talks and safety rules are signposts to prevent us from wandering unintentionally from the path of safety into the slippery detours of negligence and unsafe practices." So we must constantly apply the knowledge we have.

The country is again approaching, if we are not already in, a period when manpower will be short and the necessity to conserve it will be paramount. The reason for making safety the job of every man on the production line is obvious and must be done. The prevention of an injury means continued production, or conversely, each injury means curtailed production. Not only is production lost from the person injured but also from those necessary to aid the injured party. The transportation system underground is disrupted to move the injured man to the surface; if the injury is serious or fatal, the morale of the section or a whole mine is affected. Along with these man hours lost may be breakage of machinery, breakage to the extent of the complete stoppage of the crew using the equipment. And what about working short-handed or by moving a man less well-trained or less accustomed to the job into the place of the injured person; there is always the loss of production by a slowdown because of these factors. We have not fully evaluated all these losses, but nevertheless the costs are there. Possibly some day we will have the dollars and cents value of these costs for the coal industry.

Last year in an article prepared for the National Safety News, I made this observation, "Placing equipment and materials for enhancing health and safety is to small avail in bituminous coal mining unless safety-conscious workmen use it rightly throughout our mining labor force of some 400,000 men. In the final reckoning, the men working with machines and fast transport must think carefully and act carefully in the underground mass production factory which is the modern bituminous mine.

"The industry devotes a good $80,000,000 a year to mining safety, yet the basic problem is one of popular education in safety know-how at the 'grass roots' line, which is in the mine and its environs."

This statement is true today and is reiterated because of its basic truth.

There is very little question that anyone of this audience will seriously disagree with me that each of us has a job and a stake in the safety of the men working in the coal mines. Unfortunately we do not all work at the job as much as we should. Now if each of us would talk safety to at least one person a day and convince that person of the necessity of always acting safe, the coal mines would soon be the safest places in industry. The point of talking safety constantly has been stressed, but I want to drop a little cautionary word about talking safety. The point is to get the other fellow, the man working for you to talk safety. Get him to give you his ideas of the safe way to do a particular job, then quietly correct any wrong impressions. You will be surprised at the results that will come from all the little talks and the other fellows too. But keep in mind talk alone will not be successful if our actions and attitude are not in line. That little word "if" appears to be the stumbling block and our plight is well summed up by a little poem written by William Shepley in the Cement Bulletin, Canada Cement Company, Ltd., entitled – "If Everyone." . . .

## IF EVERYONE . . .

If everyone who does a job
Could lie a month in bed,
With broken bones and stitched-up wounds,
Or fractures of the head,
And there endure the agonies
That many people do,
They'd never need preach safety,
Any more to me or you.

If everyone could stand beside
The bed of some close friend
And hear the doctor say "No hope"
Before that fatal end,
And see him there unconscious
Never knowing what took place,
The laws and rules of safety,
I am sure we'd soon embrace.

If everyone could meet
The wife and children left behind
And step into the darkened home
Where once the sunlight shined,
And look upon "the vacant chair"
Where Daddy used to sit,
I am sure each reckless worker
Would be forced to think a bit.

If everyone who takes a job
Would say a little prayer,
And keep in mind those in the plant
Depending on his care,
And make a vow and pledge himself
To never take a chance,
The great crusade for safety
Would suddenly advance.

* * *

Chairman Conway: Thank you, Mr. Maize.

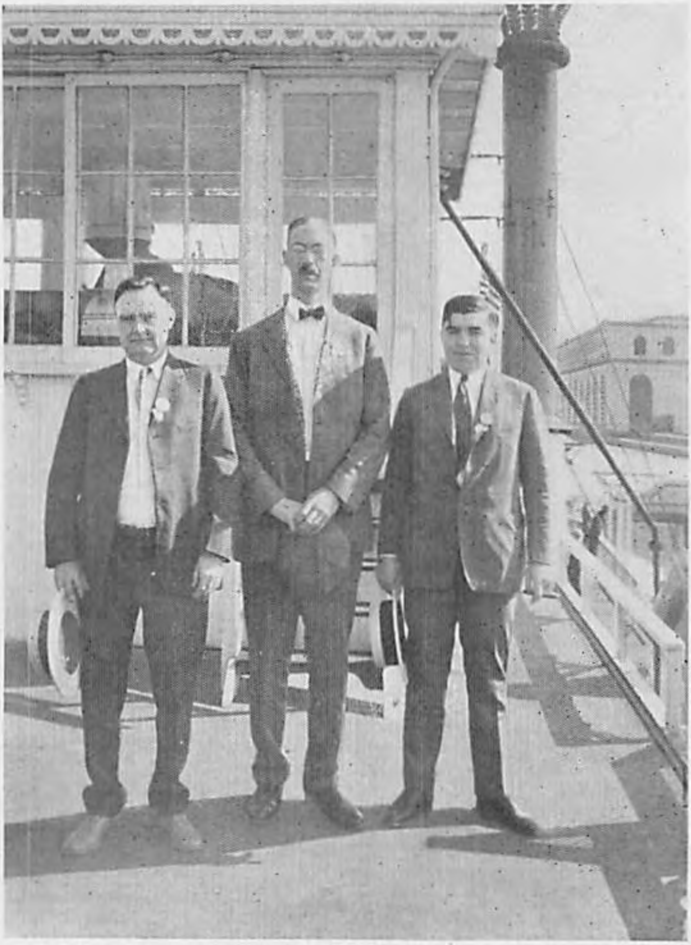
Now we are running very late, and I want to do three things, very briefly. First, on behalf of the Institute, I want to thank all of those who participated in this program. Second, I want to thank those who attended the meeting for their cooperation and attention. Third, I want to turn the meeting back to our President, Mr. Jerry Gerow.

(President Gerow resumed the chair.)

President Gerow: Jim has done the thanking of all the speakers. I want to thank Jim for carrying on with the program so well.

We have gone overtime, but I want to call your attention to the fact that the session will be resumed promptly at two o'clock. Also, don't forget the six-thirty date later this evening.

(The meeting recessed at twelve-forty o'clock.)



*REMEMBER?*

## FRIDAY AFTERNOON SESSION

November 17, 1950

The meeting reconvened at two-ten o'clock, President Gerow presiding.

President Gerow: Gentlemen, we're a little late in getting started. I'm going to ask the indulgence of the first speaker on interruptions of those in the rear as they come forward and are seated during his talk. I feel we should not delay any longer in calling the afternoon session to order.

As your Chairman of the afternoon I want to introduce Mr. Thomas L. Garwood, of C. W. & F., who is well known in the coal mining business, well versed in his subjects, and I'm sure he'll guide the afternoon session in the same splendid way that it was carried on this morning.

(Mr. Thomas L. Garwood, C. W. & F. Coal Co., West Frankfort, Illinois, assumed the chair.)

Chairman Garwood: Good afternoon! We want to hurry this thing through so we'll not be late as we were this morning, and without further ado we'll go into the first paper, which will be, "Electrical Sequence Control for Coal Preparation Plants," by George J. Reynolds, Morgan Mines, Incorporated, Herrin, Illinois.

Mr. George J. Reynolds: Members of the Illinois Mining Institute and Guests: It is a pleasure to be able to appear before you to present this paper on "Electrical Sequence Control for Coal Preparation Plants."

# ELECTRICAL SEQUENCE CONTROL FOR COAL PREPARATION PLANTS

By GEORGE J. REYNOLDS
Electrical & Preparation Engineer, Morgan Mines, Inc.
Herrin, Illinois

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We are operating a very efficient new Pittsburg McNally 350 ton/hr coal preparation plant at Herrin, Ill. At the time of its installation considerable thought was given to its electrical control and at that time we developed a modified interlocked control that we call Sequence Control.

Sequence Control as we know it is the interlocking of all units in successive operating order, or sequence, so that each unit can only be started in its order of sequence and only if its preceding unit has been started. Also when the plant operation is stopped, the units are stopped in the same order consecutively as that in which they were started.

It will be necessary at this point to define the terms "interlocking" and "preceding unit" as they are used here.

"Interlocking" means that the control or starting circuit of each unit is so arranged that the unit is locked in a specified starting order with respect to the other units.

"Preceding unit" as we use the term, is the unit that the coal is discharged into by the unit being referred to. It is started first electrically so that it takes the coal away from the unit being started. In other words, we consider the discharge conveyor the starting conveyor and each unit is started in order of sequence from the discharge conveyor toward the pan feeder at the truck hopper.

In our control scheme there are three positions of control for each conveyor unit, SEQUENCE, OFF, and MANUAL. The control is regulated by a simple three position selector switch for each unit and the selector switch is mounted on the Console Board just above each pushbutton station. The Console Board consists of a Start-Stop Pushbutton, Indicating Light, and Selector Switch for each unit in the plant.

In the SEQUENCE position the units are all interlocked in sequence and must be started and stopped in consecutive order. In the OFF position the unit is locked out and the pushbutton is dead. Sequence of all units is maintained by bypassing the locked-out unit through its selector switch. This will be explained in detail a little later. In the MANUAL position, individual control of the unit is obtained, regardless of the operation of the rest of the plant. Also in this position, Sequence Control is maintained for all the other units.

At the early stages of planning, all the operating features of control that were necessary and desirable to give the ultimate in operating control were listed. It had been found in past experiences that one plant manufacturer stressed one type of control and a second plant manufacturer stressed another, with actual practical operating personnel stressing a third or combination of features. Some operating men desire just groups of units interlocked, some desire all units interlocked for protection of plant operating time, some desire all units interlocked in some manner or other for mechanical and electrical protection of equipment, others recognize the need for interlocking but would not have the units interlocked at any cost because of the inability to take units out of interlock and thus being forced to run the whole plant when it was desired to run just one unit for a check or repair. There were ways developed of taking a unit out of interlock but often it necessitated the stopping of the entire plant and the operator going to the Starter Panel and snapping the necessary toggle switch or combinations of toggle switches. Quite often the Starter Panel is quite a distance from the Console Board and at times even on a different floor level. This involves considerable lost time, and a five minute delay repeated several times a day represents a large percent of loss of production time in our 7 hr. and 15 min. working day. It is also not just the five minutes of actual down time, it is the time of slowing down and bringing to a stop and the starting again of the numerous units of a large plant with the necessity of alerting all involved personnel, the attendant disturbance of the wash boxes, disturbances of the blends, and the percentage of risk of one unit or the other flooding due to stopping or starting of the combinations of units. Thus our control was developed to eliminate many of the above disadvantages and to take full advantage of the interlocked system.

The success of our control scheme is achieved through the application of a simple three position selector switch, containing variable cams, allowing almost any number of variations of circuit combinations. This is the

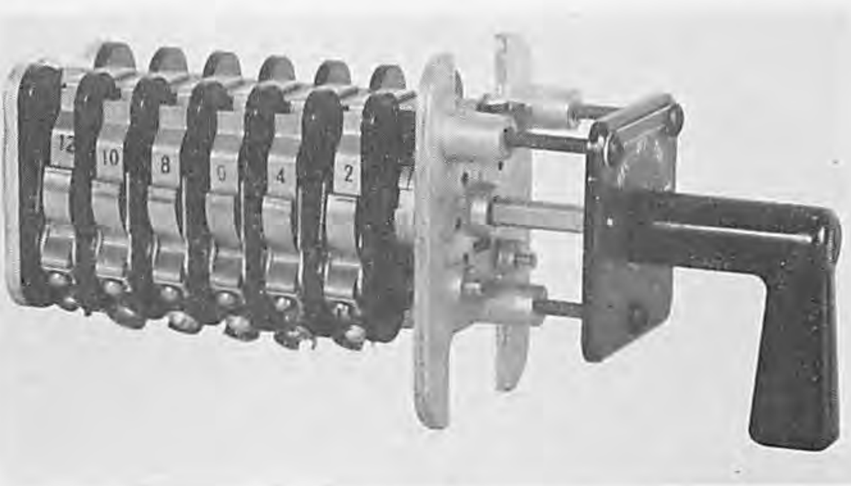
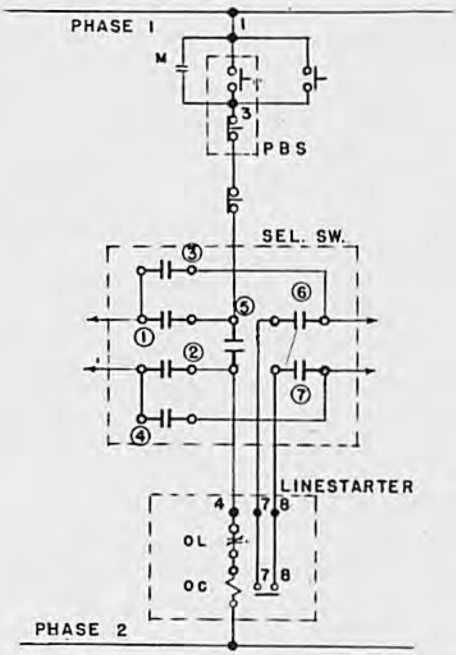



Figure 1




ARRANGEMENT

| CONTACT | SEQ. | OFF | MAN. |
|---|---|---|---|
| 1 | X | | |
| 2 | X | | |
| 3 | | X | X |
| 4 | | X | X |
| 5 | | | X |
| 6 | X | | |
| 7 | X | | |

Figure 2

General Electric SB-1 Selector Switch as shown in Figure 1. This view shows twelve simultaneous circuits that are available, though we use but seven in our control scheme. The switch may be specified with just the required number of cammed circuits to set up the predetermined number of electrical connections for each position.

The Selector Switch is inserted in the Start-Stop control circuit of each individual motor starter as shown in Figure 2. The seven contacts of the selector switch are shown in Figure 2. The seven contacts of the selector switch are shown, and their predetermined electrical connection for each position is given by the contact arrangement form at the side of the selector switch. In the SEQUENCE position, contacts 1, 2, 6, and 7 are closed while the rest remain open. In the OFF position, contacts 3 and 4 only are closed. In the MANUAL position, contacts 3, 4, and 5 are closed.

In the SEQUENCE position the circuit may be clearly seen by referring to Figure 3. Here the interlocked control circuits of three successive units are shown. The path of current, drawn in heavy lines, of one unit with the selector switch in SEQUENCE position is shown. This modifies the conventional pushbutton control by routing the control power back through the normally open interlock 7-8 of the starter of the preceding unit so that the preceding unit must be operating and the interlock closed before power is available to the desired unit. This places the unit in sequence, or in successive order in respect to its proper unit. With all units interlocked in successive order each unit must positively be started in consecutive order as each unit obtains its control power through the preceding unit. If it is attempted to start a conveyor out of sequence, the unit will not start until its proper preceding unit has started. This eliminates much lost time due to flooding or stalling of conveyors due to the operator having inadvertantly pushed the wrong button.

With units interlocked in Sequence Control, of course, it follows that if the final discharge conveyor should stop accidentally due to either mechanical or electrical failure, all units would automatically come to a stop consecutively and practically instantly, thus preventing an overflow of coal at this point and also possible damage to other units.

The Flow Sheet of our plant is shown by Figure 4. Following the simple flow of coal from where the coal is dumped by trucks into the hopper it may be seen where the coal is carried by a belt conveyor to a 6″ shaker screen and across a picking table. The 6″ plus is separated, crushed to 6″ minus size and the flow combined and discharged into the washbox. The coal is discharged from the washbox, or washboxes, onto the classifier shaker screen where it is sized and discharged into the distributing, or fine coal conveyor as we call it. This conveyor distributes the coal onto the various loading booms where it is conveyed into the cars. We are loading on five tracks at the present time. ¾ x $\frac{3}{16}$ on track

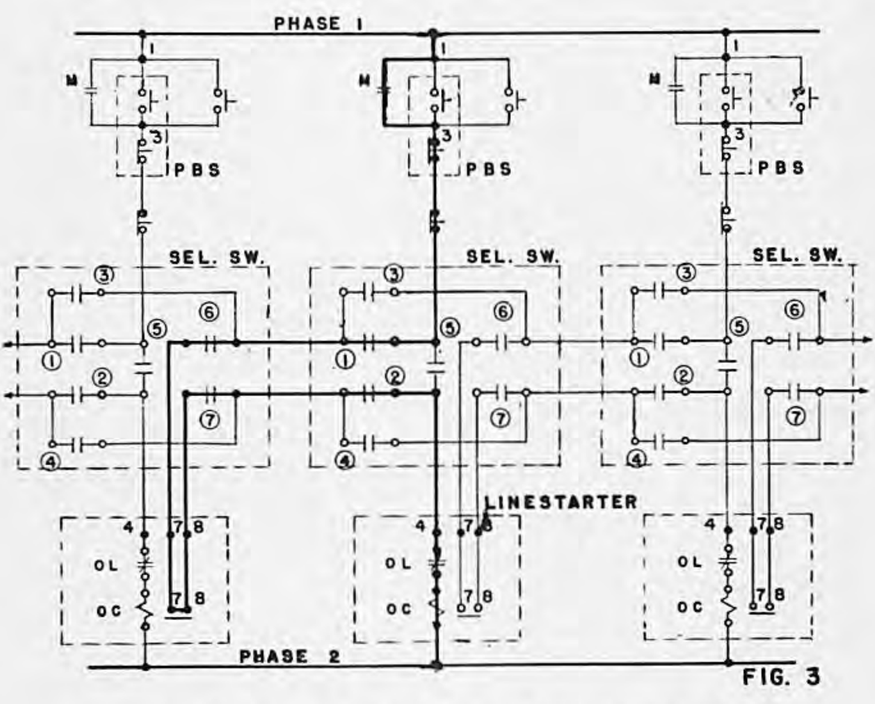
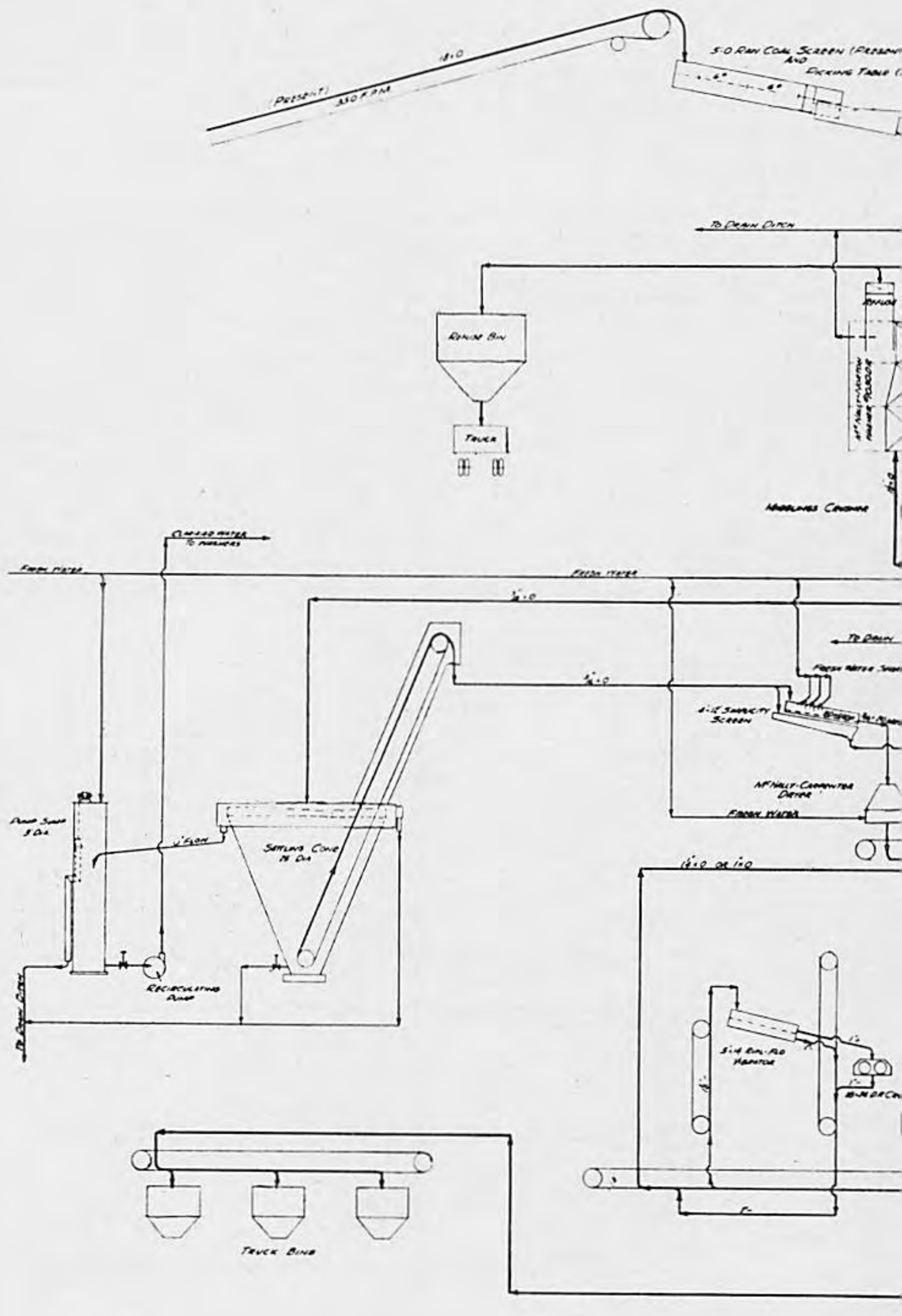



FIG. 3


(Present)
350 F.P.M.
To Drain Ditch
Refuse Bin
Truck
Middlings Crusher
Fresh Water
Clarified Water
To Washers
Pump Sump
Settling Cone
Recirculating Pump
Fresh Water
Truck Bins

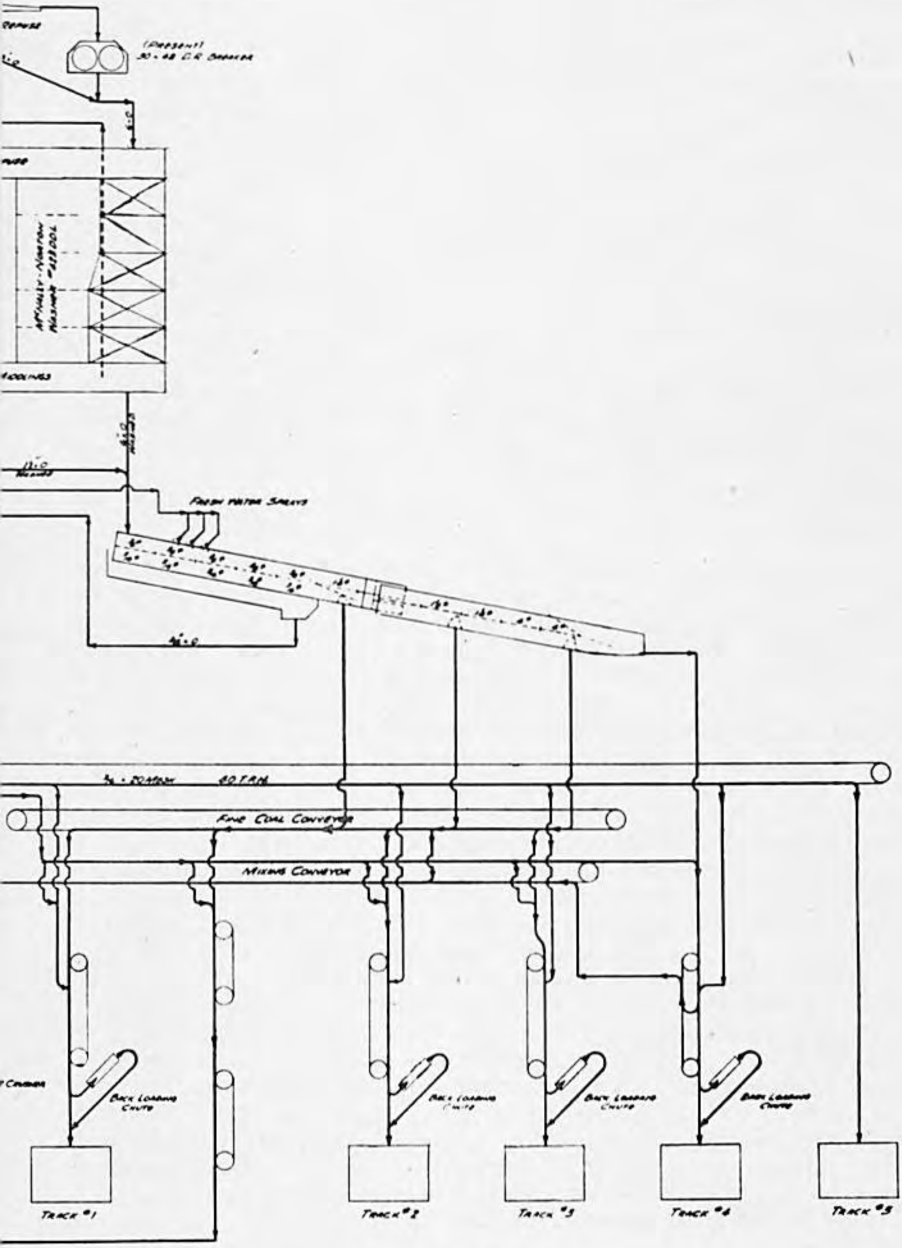

(PRESENT)
30 x 48 C.R. BREAKER
FRESH WATER SPRAYS
FINE COAL CONVEYOR
MIXING CONVEYOR
BACK LOADING CHUTE
BACK LOADING CHUTE
BACK LOADING CHUTE
BACK LOADING CHUTE
TRACK #1
TRACK #2
TRACK #3
TRACK #4
TRACK #5

Figure 4

No. 1, $1\frac{1}{2}$ x $\frac{3}{4}$ on track No. 2, $1\frac{1}{2}$ x 20 mesh on either track No. 1 or No. 2 in place of either one or the other, 3 x $1\frac{1}{2}$ track No. 3, 6 x 3 track No. 4 and $\frac{3}{16}$ x 20 mesh carbon on track No. 5. Of course, any number of combinations can be made and loaded on almost any track.

Before getting back into Sequence Control, I feel that it is well to explain that the flow of coal is not entirely controlled by electrical control. The flow is diverted by means of mechanical gates after the required conveyors have been set in motion. The gate usually consists of a sliding door in the bottom of a conveyor and is operated usually with pinion and racking. The gates are opened to allow coal to drop through the conveyor into another conveyor and closed to pass the coal further along the conveyor to another transfer point.

Sequence Control allows centralized control of the plant. The entire plant is operated by one man who starts and stops all units, with the exception of the loading booms, from a single pushbutton board or Console Board. The exceptional advantage of centralized control is that the plant operator has the whole operating story of the plant before him at all times as given by the indicating lights. He knows whether the unit started or not when he first pressed the Start button, and at times of the accidental stoppage of a unit, he can immediately locate the source of trouble. The indicating light of that unit and the lights of all succeeding units feeding that unit will be out, showing that the flow has stopped at that point. All preceding units taking the coal away from the damaged unit will continue to flow and thus clear themselves.

The Console Board is located beside the washboxes and the main plant operator is also the washbox operator. The loading booms are operated by a boom operator who loads the cars and starts and stops the booms on horn signal from the main plant operator. The boom operator is in direct contact at all times with the main plant operator both by horn signal and FEMCO Audio Phone.

At the time a change in flow is required, the boom operator informs the main plant operator as to the coal circuit desired to suit the car orders and the plant operator sets up the sequence to maintain all units in interlock.

For an example and again referring to the flow sheet, if the coal is being run in natural sizes and it is desired to add crushed coal sizes it is necessary to start up the crushed coal section. This consists of the mixing conveyor, the $1\frac{1}{2}''$ stoker crusher and the stoker coal conveyor. It is necessary to insert the crushed coal section ahead of the fine coal conveyor in sequence because of its being closer to the discharge end of the flow. This is done practically instantaneously by the operator turning the selector switches of the three additional units from OFF to SEQUENCE and pressing the Start button of all the units that have stopped in sequence. This is a two-handed operation for the operator all the way, and with the proper selector switches set in SEQUENCE position, the operator cannot make a mistake by pushing the wrong button. This allows great speed in the change and the boom operator is often quite unaware that the change has been made until it has been confirmed by the plant operator over the Audio Phone.

Often we have to break into our day's run to make 1″ stoker coal. That means the addition of four more units in addition to the crushed coal section. These units are inserted in the sequence ahead of the crushed coal section as the 1″ stoker section is fed from the 1½″ stoker crusher. The four selector switches are turned to SEQUENCE from the OFF position and the Start buttons pressed again. Here again it is scarcely noticeable when the plant hesitates and starts again. The ease and rapidity with which such sections may be inserted or removed from the flow circuits allows great flexibility in the operation of the plant with but the minimum of down time. In the above cases, none.

At the time of an instantaneous stop, the high $wr^2$ units such as crushers and centrifugal dryers must not be stopped or they would immediately be jammed. This problem is solved as shown by the electrical circuits in Figure 5. The unit is maintained in interlock but the sequence is bypassed from the preceding unit through the crusher unit and to the succeeding unit. A selector switch with a different cam arrangement is used, and in the SEQUENCE position contacts 1, 6, and 7 are closed with contact 2 open. Contact 1 sets up the crusher circuits for manual operation and contacts 6-7 bypass the sequence circuit of the succeeding unit C back through the interlock 7-8 of the preceding unit A. If the preceding unit A should accidentally stop, it breaks the sequence circuits at 7-8 and all units interlocked in sequence automatically drop out. In this particular circuit the crusher unit does not

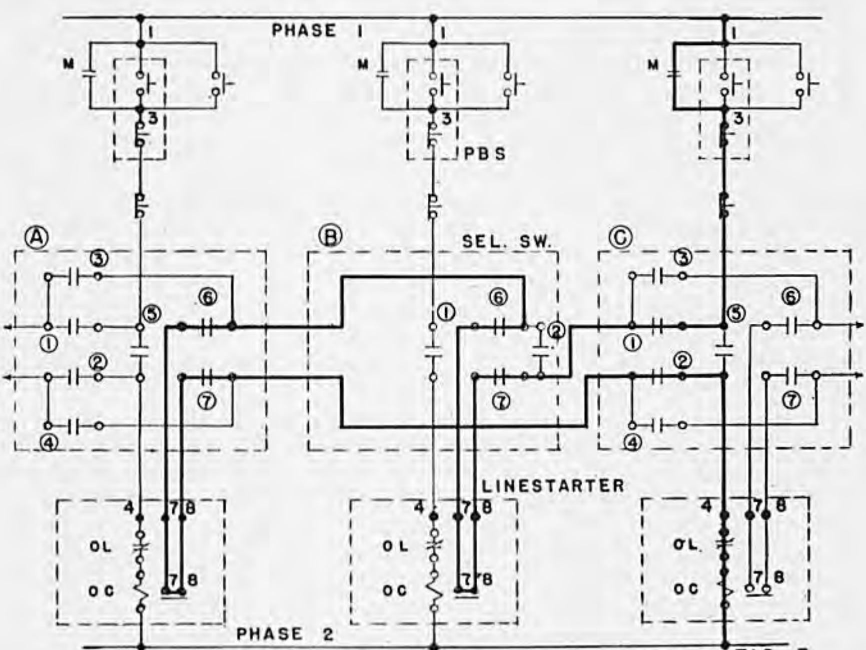


FIG. 5

drop out, and thus cannot be jammed by coal remaining in the rolls. Each crusher or dryer unit must be stopped manually. If the crusher unit B should accidentally drop out however, it breaks the sequence circuit at its interlock 7-8 and all the succeeding units are dropped out with the preceding units continuing to flow and thus clearing themselves.

If unit B happened to be the centrifugal dryer and it were possible to bypass the flow of coal, the unit can be shut off and the sequence bypassed by turning the selector switch to the OFF position. In this position contacts 1, 6, and 7 are open thus locking the unit out safely, and contact 2 is closed thus bypassing the sequence.

The crushers and dryer are started first when starting the plant up from a dead stop. After they have come up to running speed, the fresh water pump is started which is the first unit in the starting sequence, and with all selector switches in SEQUENCE position, it sets up the Sequence Control for the plant. When the plant is stopped in Sequence Control, the crushers and dryer continue to run until they are shut off individually.

At this point one disadvantage of the interlocked conveyors would appear to be the lack of individual control of the conveyors. It is very necessary at times when the plant is shut down to move one or more of the conveyors when making repairs. If this conveyor was interlocked in the middle of a series of conveyors, it would be necessary to run half the plant in order to start this one particular interlocked conveyor. This would be exceedingly dangerous with other repair crews working throughout the plant, or else result in enormous amounts of lost man hours with other crews standing by while the unit is being tested. This possible disadvantage is overcome by having a third position of the Selector Switch, MANUAL Control, as shown by Figure 6. In the MANUAL position contacts 3, 4, and 5 are closed and contacts 1, 2, 6, and 7 are open. Individual control of the unit is obtained through contact 5, and the sequence is bypassed to the succeeding units through the contacts 3 and 4. Thus control of any one unit or units is possible as individual control. A further feature is that the unit may be operated in MANUAL control and still maintain the sequence of all units while operating. This maintains the sequence by bypassing itself, though this unit itself is not in sequence or protected by sequence. Thus it is necessary that we have a standing rule that all units must be operated in the SEQUENCE position unless for a specific reason and then returned to SEQUENCE as soon as possible.

Any unit or combination of units can be locked out and the sequence bypassed by turning the individual selector switch or switches to the OFF position. Figure 6 also shows the path of the control power with the selector switch of a single unit in the OFF position. Contacts 1, 2, 5, 6, and 7 are open and contacts 3 and 4 are closed. The power of the operating unit is routed through the 3-4 contacts of the OFF selector switch, through the SEQUENCE selector switch and the 7-8 interlock of the next operating starter. Thus the sequence of all units are maintained in interlock by bypassing the control power through the shut off unit. In the OFF position the unit is definitely locked out as contact 5 is open

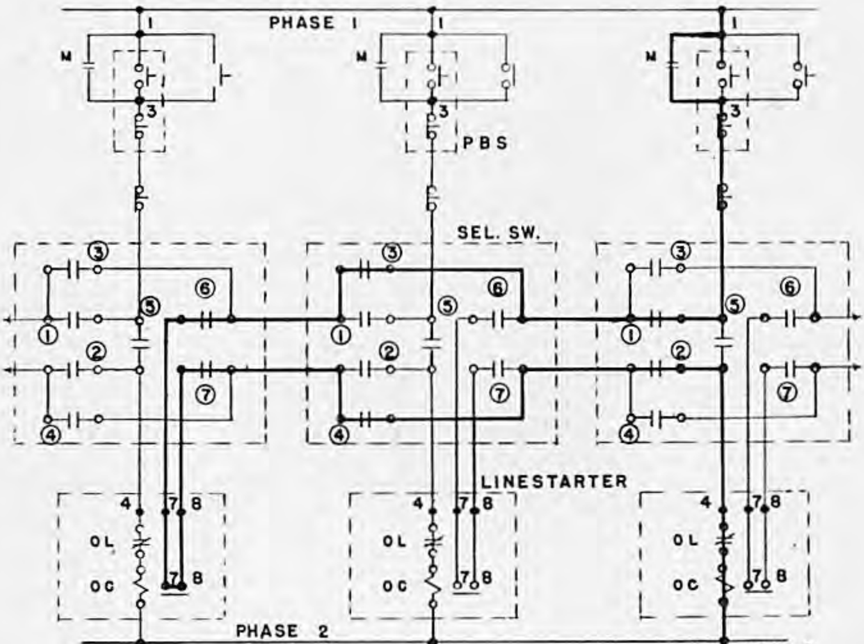



FIG. 6

and it is not possible to start the unit by either the pushbutton at the motor or the pushbutton on the Console Board.

If a unit should be bypassed and the selector switch turned to the MANUAL position where the unit is locked out at the Console Board, it is possible to run the motor independent of the Console Board by the use of a Start and Lockout Stop Button mounted at the motor. Thus the maintenance man can "jog" the motor as desired to locate the trouble, or to try out the repaired conveyor, without disturbing the sequence control of the other units while they are operating. After having located the trouble, the workman knows that the conveyor can be locked out on the Board with the selector switch in the OFF position but he also knows that there is nothing to keep the operator from turning the selector switch to SEQUENCE or MANUAL position while making changes in flows of coal and starting the conveyor with possibly him in it. This possibility is eliminated by the locking out of the pushbutton at the motor by the workman. The Lockout pushbutton at the motor supersedes all control at the Board so it is impossible to start the conveyor, regardless whether the selector switch of the Console Board is turned to SEQUENCE or MANUAL position. The control of this motor can only be released by the removal of the workman's lock from the pushbutton and the release of the Stop button. The motor can then be started by either the Start button at the Console Board, or the Start button at the motor.

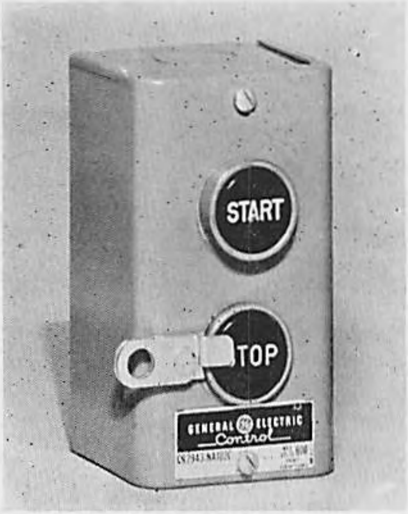



Figure 7

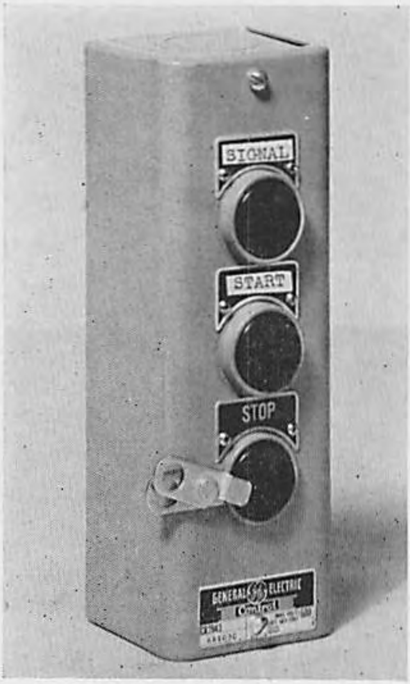



Figure 8

The Lockout Start-Stop pushbutton is shown in Figure 7.

The Lockout Start-Stop Signal pushbutton is shown in Figure 8.

Emergency Stop Stations are included in the overall scheme and are located in various strategic locations about the plant. The emergency stop stations are in series with each other as shown by Figure 9, and with the control circuit of the first operating unit, such as conveyor, fresh water pump, whichever it may happen to be. In our case our Sequence Control starts with the fresh water pump unit as that unit which must be running before we can operate the plant. At the time of an emergency or when there is not time to wait for a signaled stop, an instantaneous stop of all units can be made by tripping one of the emergency units. This is usually followed by a horn signal, giving the cause of the stop. A signal button is mounted close to each emergency stop station.

An now for the benefit of the men who foot the bills. Sequence Control is an extremely simple control scheme which has a material cost but slightly higher than any standard pushbutton control; yet, it is actually cheaper in the fabrication of the Starter Panel, installation wiring of the control scheme, and ease of trouble shooting and maintenance. We have already proved the point where it makes money in the reduction of daily down time.

We use the G. E. Cabinetrol Unit where each magnetic starter is in a separate compartment. The simplified fabrication of this unit is in that each unit is wired exactly alike and to its individual terminal board as shown by Figure 10. There is no complicated internal wiring from

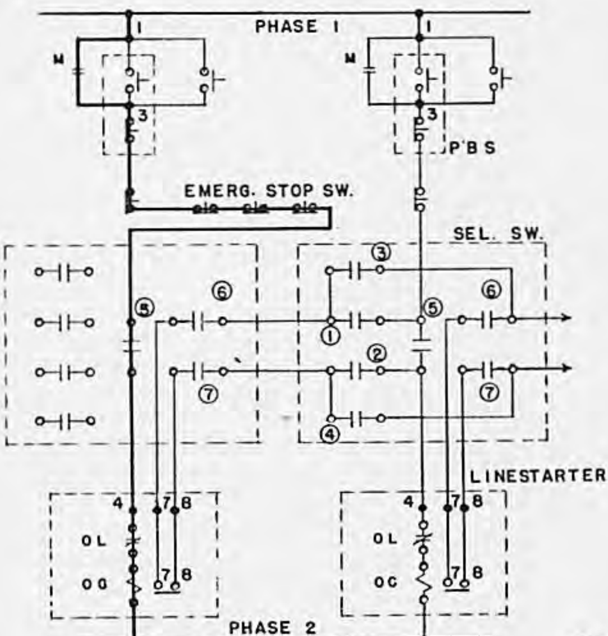



FIG. 9

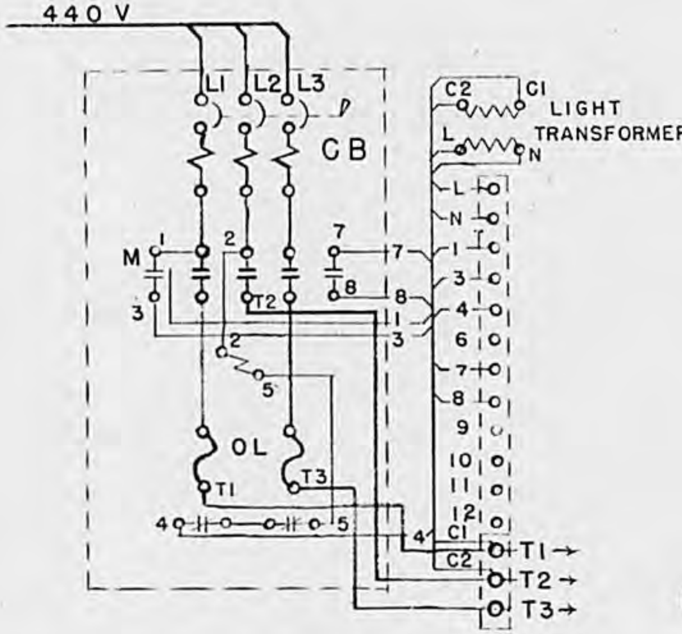



FIG. 10

one starter to another to provide the interlocking. All interlocking circuits are set up by the selector switches at the Console Board. One normally open interlock 7-8 is added to each starter and wired to the terminal board.

Sequence Control uses but two more No. 14 wires from the Cabinetrol to the Console Board than the standard pushbutton control which requires five. Referring to Figure 10 again, number 1, 3, and 4 are for the Start-Stop button and L-N for the Indicating Light. Sequence Control adds but the two wires 7-8 from the interlock.

Installation wiring is greatly simplified due to the duplication of each unit. A color code is used and each of the seven wires assigned a separate color. The wiring consists of sorting the wires into bundles of seven wires each, assigning a bundle to each starter and the connecting of each colored wire to its numbered terminal on the terminal boards at the Cabinetrol and the Console Board. In fact, when we did the job, we were pressed for installation time and we used every man we could spare on the control wiring. The wiring was done by tipple day men, pit men, and shovel operators under the supervision of our one electrician. When we tested the control, it went off without a hitch the first day, which is an achievement that speaks for the simplicity of the control.

The additional material required consists of the Selector Switch, one extra normally open starter interlock, and the two additional short lengths of No. 14 wire, per units. An inexpensive installation.

Therefore taking all the above details into consideration, the outstanding features of Sequence Control for a coal preparation plant are as follows:

1. Centralized Control.
   a. One man has complete control of starting and stopping a large plant of numerous units and has the entire operating story before him at all times as given by the indicating lights.
   b. All controls are grouped so he has absolute control grouped right at the Console Board, instead of divided between Console Board and Cabinetrol, wherever it may be located.
   c. Speed and simplicity of starting a large plant of numerous units.
2. Flexibility and Versatility of Control.
   This allows various units or combination of units to be stopped or started at will without interrupting the flow of coal and still maintaining plant protection.
3. Protection of Plant Production.
   a. The possibility of flooding conveyors with coal due to the accidental stoppage of one unit is eliminated.
   b. The possibility of mechanical or electrical damage to succeeding conveyors or conveyor due to the accidental stoppage of the one unit is eliminated.
4. Safety for Maintenance Personnel.
   a. It is possible for the plant operator to lock out the unit so it cannot be accidentally started by himself or anyone else.
   b. The maintenance man can lock out the unit himself at the unit so it positively cannot be started by anyone other than himself.
5. Ease of Maintenance of Tipple Conveyor Units.
   a. By bypassing the Sequence Control of the damaged unit, the unit can be shut off and worked on safely during the shift.
   b. The unit can be run and tested by the mechanics without disturbing the Sequence Control of the rest of the units.
6. Simplicity of Control Scheme.
   a. Requires little or no maintenance.
   b. Does not require skilled help to install.
   c. Trouble shooting is simplified as but one basic circuit is used for all units.
   d. Low first cost.
   e. Low installation cost.

The above operating features of Sequence Control have proven themselves sound in over one and one-half years of operation, and no unforeseen "bugs" have appeared. We can safely say that Sequence Control is an invaluable asset to our plant and has increased the efficiency of our plant many times over.

* * *

Chairman Garwood: Thank you very much, Mr. Reynolds, for your fine paper on "Sequence Control."

Are there any questions at this time? If you have any questions, ask George. He is expert enough to answer them.

If not, we'll pass on to the next paper, and you will note in front of each of you some three-by-five cards, so, as Mr. Purnell reads his paper and a question comes to you, you can write your question on the card. If you would like any literature, put your address on the back of that card. They will be picked up at the end of his paper, and the literature will be sent to you. If the literature doesn't carry the information you want, then a letter will get it for you.

The next paper, or group of papers, will be read by Mr. Charles G. Purnell, Development Representative, Market Development Division, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania. He has three experts with him — Mr. R. C. Altman, Alloy Metallurgist of Carnegie-Illinois Steel Corporation at Pittsburgh, Mr. R. M. Stodgell, Product Representative, Stainless Division of Carnegie-Illinois, and Mr. C. H. Jackman, Senior Service Metallurgist, Structural, Plate and High Strength Steels, Carnegie-Illinois, Chicago. These gentlemen should be able to answer any questions you have on the paper.

Mr. Charles G. Purnell: Mr. Chairman and gentlemen, as you have seen on your program for this meeting, the discussion on steel under the subject "Alloy, Stainless, and High-Strength, Steel in the Coal Industry" is a new venture at these meetings.

We are all very glad and appreciate the opportunity of presenting this paper on these specialty steels, because we know that proper applications of these steels to your equipment will have an important effect on your operations, maintenance, production costs, and the resultant dollar sign that shows up with your profits or losses.

None of us are pretending to be coal industry experts, but we are cognizant of what has been going on in the coal industry. However, we feel that new demands on the coal industry mean that mechanical processes, mechanized equipment, and a more rapid trend toward more and better coal-preparation plants will require more thought to steel applications in this equipment and primarily in subsequent maintenance and repairs.

Competition by oil and gas with coal for all kinds of fuel applications is demanding more economy and efficiency in coal production and improved quality along with maintaining your markets.

More and better coal preparation will be demanded for old and new coal markets, and particularly those markets which lend themselves to invasion by oil and gas.

Knowing that the coal industry has plans for extensive research and development that will keep coal very much in the picture, we feel that the paper we are presenting is timely in view of the oncoming mechanization of the coal industry.

With these facts in mind, you will be interested in steels or anything else that will reduce failures and down time. Therefore, we feel sure that you will b interested in the steels we are to discuss.

All of these steels have definite applications and specific uses that have an important part in resisting corrosion, abrasion, and providing high-strength factors that will resist fatigue failures.

We must mention that toughness and strength of steels are increased by heat treatment, but the best piece of carbon or alloy steel will fail in service unless the part is properly designed with optimum fillets and devoid of sharp corners and radial tool marks.

We desire to make this new venture interesting; hence, we will welcome any questions on these steels regardless of how simple or how technical the questions may be.

We want you to feel that you know us, and we hope that you will ask plenty of questions. Therefore, will you please make notes of your questions and have them ready to submit to us for answering at the conclusion of the papers.

At this point, I would like to introduce to you the men who have composed these papers and who will answer your questions i.e., and give you any information you desire.

Mr. R. C. Altman, Alloy Metallurgical Department, Carnegie-Illinois.

Mr. R. M. Stodgell, Stainless Product Sales, Carnegie-Illinois.

Mr. C. H. Jackson, Senior Service Metallurgist, Chicago, Structural, Plate and High Strength, Carnegie-Illinois.

Gentlemen, we are going to tell our story with slides. I want to point out that we are going to discuss three different types of steel. Each has its own specific characteristic.

TYPICAL MECHANICAL PROPERTIES

| | AISI-1040 | | | AISI-4140 | | | AISI-4340 | | |
|---|---|---|---|---|---|---|---|---|---|
| Composition | C .37/.44, Mn .60/.90, Si .15/.30 | | | C .38/.43, Nn .75/1.00, Si .20/.35, Cr .80/1.10, Mo. .15/.25 | | | C .38/.43, Mn .60/.80, Si .20/.35, Ni 1.65/2.00, Cr .70/.90, Mo .20/.30 | | |
| Heat Treatment | Water Quench Draw 1000°F | | | Oil Quench Draw 1200°F | | | Oil Quench Draw 1200°F | | |
| Size | 1″ rd. | 3″ rd.* | 6″ rd.* | 1″ rd. | 3″ rd.* | 6″ rd.* | 1″ rd. | 3″ rd.* | 6″ rd.* |
| Yield Point (psi) | 78000 | 60000 | 54000 | 105000 | 96000 | 91000 | 119000 | 100000 | 99000 |
| Tensile Strength (psi) | 110000 | 92000 | 89000 | 128000 | 117000 | 113000 | 148000 | 131000 | 129000 |
| Elong., in 2″ % | 16 | 24 | 25 | 25 | 27 | 21 | 20 | 20 | 20 |
| Red. of Area % | 58 | 47 | 46 | 68 | 69 | 62 | 58 | 54 | 46 |

* Sample taken half-way from center to edge.

# ALLOY STEEL IN THE COAL MINING INDUSTRY ALLOY, STAINLESS, AND HIGH-STRENGTH, LOW-

By P. R. WRAY, R. M. STODGELL and C. H. JACKMAN
Carnegie-Illinois Steel Corporation
Pittsburgh, Pa.

*(We regret the slides accompanying this presentation are not available for reprint.)*

## PART I—ALLOY STEEL

The alloy steels referred to here are that group of constructional steels defined by the American Iron and Steel Insitute as follows:

By common custom steel is considered to be alloy steel when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: Manganese, 1.65%; Silicon, .60%; Copper, .60%; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, boron, chromium up to 3.99%, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying element added to obtain a desired alloying effect.

The commonest reason for using alloy steels is to obtain higher mechanical properties than are available in carbon steel. Nearly always such mechanical properties can only be fully realized after heat treatment. In fact, except in the cases of certain special purpose alloy steels, it is conceded that the alloy steels cannot be economically justified unless they are heat treated.

To illustrate the benefits that may be obtained from using alloy steel, we have prepared slides which compare typical mechanical properties obtained by heat treating one carbon steel and two common grades of alloy steel.

Before discussing mechanical properties we want you to see the differences in chemical composition of these steels as shown on the next slide.

The advantage to be gained by using the alloy steels is obvious. Much higher tensile properties are obtained without sacrificing ductility.

The principal uses in mining equipment for the two alloy grades shown have been in shafting, pinions and axles.

A new alloy steel named Carilloy T-1 Steel has recently been developed by our company and should find many uses in the mining field. It has been successfully used for buckets, bucket lips, bails and dipper handles of large coal stripping shovels.

For wear or abrasive applications requiring high hardness and toughness plus good weldability, Carilloy T Steel may be furnished heat treated to 321 minimum Brinell. It has been demonstrated that even at this high level of hardness, adequate toughness is maintained. Forming and machining will, of course, be more difficult than when this steel is in its normal condition. It may not be practicable to meet standard flatness tolerances in all gauges and sizes of T Steel treated to this high hardness level.

Carilloy T Steel combines extremely high strength with excellent ductility and toughness, even at subzero temperatures.

The composition of Carilloy T Steel is designed to provide atmospheric corrosion resistance at least two to three times that of Carbon Steel.

This steel is especially designed for fabrication where welding or gas cutting is involved and requires no special preheating or postheating treatments beyond those normally used with ordinary structural steels. These unique properties are obtained by the judicious addition of several alloying elements coupled with a precision heat treatment. The carbon content has been restricted to .18% maximum to promote ease of welding and gas cutting.

Carilloy T Steel plates can be furnished to the following mechanical properties:

| | Gauge 1/4" to 2" incl. | Gauge Over 2" to 4" incl. | Gauge Over 4" to 6" incl. |
|---|---|---|---|
| Yield Strength, .2% offset (min.) | 100,000 psi | 90,000 psi | 90,000 psi |
| Tensile Strength (min.) | 115,000 psi | 105,000 psi | 105,000 psi |
| Elongation in 2", % (min.) | 18 | 17 | 16 |
| Reduction of Area, % (min.) | 55 | 50 | 45 |

| | Gauge 1/4" to 1/2" incl. | Gauge Over 1/2" to 1" incl. | Gauge Over 1" to 2" incl. |
|---|---|---|---|
| Cold Bend | 180°D = 1t | 180°D = 2t | 180°D = 3t |

(Tested in accord with A.S.T.M. recommended practices.)

Various tests have been run to determine the manual metal-arc weldability of this steel. This steel is not susceptible to under-bead cracking if low hydrogen type electrodes are used. Electrodes that will develop the full strength of the base metal are available today, and should be used if 100% joint efficiency is needed.

Normal plate fabricating procedures may be used with this steel. In gas cutting, no special treatments are necessary beyond those observed with ordinary structural steels. Bending or forming may be accomplished cold if sufficient power is available to overcome the high yield strength of this steel. Liberal bending radii are recommended. For those fabricators whose equipment is too light to form heavy plates of this material, we are prepared to do simple cold forming in our own press shops where very heavy equipment is available. Ordinary machining operations may be readily carried out, but it should be borne in mind that the nominal hardness of the steel is about 250 Brinell which is well above the usual hardness of mild steel plates. In the event of user wishes to hot form, it will be necessary for him to carry out the heat treatment which involves liquid quenching and tempering after the hot forming operation. Our Service Metallurgists will provide the necessary heat treatment information to enable the user to properly carry out this work. The Service Metallurgists can also provide fabricating data and detailed information on the engineering weld tests we have performed.

Carilloy T Steel is basically a plate steel and is produced over a wide range of sizes. It may also be furnished as bars or semifinished material in the untreated form.

## PART II—STAINLESS STEEL

Most of you have had experience with stainless in your plants and are aware of its advantages and limitations. This talk will review in general the several uses of stainless in coal preparation plants.

### General Mechanical Properties and Special Characteristics Compared to Carbon Steel

The great majority of stainless tonnage used in the coal mining industry is in the form of coal screens. Two grades of stainless steel are commonly used for this purpose – Type 302 (18 Cr - 8 Ni) and Type 410 (12 Cr), having the mechanical properties. Cold rolled carbon steel is included for general comparative purposes.

| | *Type 302* | *Type 410* | *Cold Rolled Carbon Steel* |
|---|---|---|---|
| Tensile Strength ............ | 80-95000 psi | 65-80000 psi | 40-50,000 psi |
| Yield Strength .............. | 35-45000 psi | 35-45000 psi | 25-30,000 psi |

(Note that tensile strength for cold rolled carbon steel is considerably less than for stainless)

The Corrosion resisting properties of stainless steel are primarily due to the chromium content. Corrosion resistance is believed to be due to the presence of a very thin, continuous, transparent layer or film which forms naturally on clean surfaces when exposed to the atmosphere or to certain oxidizing agents. It does not peel and repairs itself once when broken.

### Welding

Stainless steel may be welded satisfactorily by the following methods.

(a) Arch Welding – fusion welding by metallic-arc. (This method is preferred because it is more rapid; electrode positive – work negative)
(b) Insert gas shielded electric arc welding
(c) Acetylene (gas welding)
(d) Atomic hydrogen
(e) Spot welding
(f) Flash welding

In either arc or gas welding, electrodes or filler rods should have alloy content slightly higher than that of the metal to be welded, since some of the alloy is lost in passing through the arc and it is desirable to maintain the composition of the weld metal similar to that of the parent metal.

### Formability

Stainless steel may be deep drawn, bent, and cold formed. Greater power and reduced speeds are required on account of its higher mechanical properties to form and draw stainless steel than for carbon steel. Increased springback must be compensated for in design of the tools.

### Punching

Chromium-Nickel steels will require at least 30-40% more power for punching than similar thicknesses of mild steel because of its higher mechanical properties. The straight chromium steels are intermediate in the lower requirement. The hole diameter should be at least twice the thickness of the steel being perforated.

### Abrasion

We have stated that types 302 and 410 are the grades of stainless usually selected for perforated coal screens. These grades have been selected because of their ability to resist corrosion and abrasion.

For corrosion and abrasion normally encountered in coal screen applications, USS 12-Type 410 is satisfactory. This grade has the proper degree of toughness and hardness to resist normal abrasion in the hot rolled, annealed and pickled (No. 1) finish.

The other grade of stainless steel often used in coal screens is 18-8 Type 302. Type 302 is suggested for use where abrasion and extremely corrosive conditions are encountered.

This stainless steel is generally furnished in a cold rolled (No. 2B finish) so as to present initially a dense, slick surface.

### Economics in Selecting Proper Grades

Selecting the proper grade of stainless steel will depend to some extent on the following factors:

1. Corrosiveness of the mine water.
2. Type of coal being mined.

We have described Type 302 as the more corrosion and abrasion resisting stainless; however, satisfactory results have been obtained with the use of Type 410. In a recent study of the stainless steel requirements of one of the major perforators during 1949, it was interesting to note that 64% of the total tonnage (for perforating coal screens) was Type 410 and 36% was Type 302.

### Perforated Shaker Screens for Sizing, Dewatering, Desanding, and Refuse

Perforated shaker screens are specified in terms of thickness, perforation diameter (or slot size), and pattern, depending on size of coal to be screened. Stainless steel is generally used economically in screens having ½″ - 9/16″ diameter perforations (10 gauge thickness) down to approximately $\frac{3}{64}$″ diameter perforation perforations (22 gauge thickness). There are exceptions to this rule. These exceptions may result from the different sizing arrangements in the anthracite and bituminous industries. A report from the southern Illinois area states that stainless steel is an economical material for screens having perforated hole sizes from ⅜″ to 1¼″ or possibly 2″.

It is generally recognized that stainless is usually specified two gauges lighter than carbon in the same perforation size. This fact offers a two-fold advantage: One, lighter gauge reduces the weight; two, lighter gauge reduces the tendency to blind.

For perforations larger than 9/16″ diameter, blinding is not a serious problem and carbon steel is considered satisfactory from this standpoint.

The finer perforated screens for sizing anthracite, also for dewatering and desanding, offer an excellent application for stainless. With their abrasion and corrosion resistance plus lighter weight, these screens stand up well and give a good account as far as wear is concerned. By resisting corrosion, stainless screens are less likely to blind under intermittent operation.

The perisertread screen, or step screen has risers which serve to stiffen the screen and lengthen the life over the normal flat screen.

A report from midwestern bituminous mines indicates that for minus ⅜″ coal, stainless woven wire and wedge wire screens are proving most satisfactory. For dewatering, the wedge wire screen with ½ mm openings is most effective. Bone (refuse) shakers are another application for stainless.

In the anthracite field the sizes of coal are well defined and in many instances the grades of steel, thicknesses and perforation size used are standardized.

Apparently a similar situation does not exist in the bituminous industry.

## Linings, Hoppers, and Chutes

Information on this subject has been obtained from several preparation plants. The results obtained by using stainless in sluices and chutes are similar to the results obtained by using stainless for perforated coal screens.

The following reports will give some idea of the use of stainless for these applications.

1. Chutes emptying minus 3/8" coal into the Carpenter dryers are lined with 1/8" thick 18-8 Type 302. It is reported that one piece of 1/8" thick stainless out-wears two pieces of 3/8" thick abrasion resisting steel.

2. For all future construction one company intends specifying stainless steel for sluiceways and chutes. Their new sluiceway specifications call for 1/4" thick Man-Ten steel bottoms and side plates, and all wearing surfaces (lining) shall be stainless steel 1/4" thick — stainless linings shall extend full length along the bottom and the sides. The new chute specifications calls for 1/4" thick stainless steel liner plates for all wearing surfaces. Stainless liners shall extend full length along the bottom and a minimum of 12" high along the length of the sides. Sluices will convey 15-30% solids and the coal is minus 1/4" x 0.

3. Another plant uses stainless Type 302 chutes 10 ga. to 1/4" thick for conveying 3/8" x 0 coal with 60-70% solid content.

4. And still another company's plants is using Abrasion Resistant (AR) steel sluiceways and some stainless 1/4" and 3/8" thick sluiceways. Solid content conveyed is approximately 25%.

5. In a fourth installation, the chutes running from the blending bins to the primary launderer were lined with 5/8" Abrasion Resisting steel. Near the bottom of this chute a section of stainless Type 302 3/16" thick lining had been installed. The stainless lining was butt-welded to the AR lining at 3 or 4 spots. The AR steel bottom lining was rather deeply grooved at a point several inches above the adjoining stainless. The stainless lining by comparison was smooth and bright and no coal fines were observed hanging to its surface. According to the foreman this was the second installation of AR steel to be replaced. The stainless chute lining was the original installation.

The lining for blending bins and hoppers is also an excellent application for stainless steel.

The use of stainless steel for sluices and chute linings may be economically advisable depending on the type of coal mined, mine water and regularity of operation.

## Carpenter Dryer Screens

The Carpenter Dryer normally is used for drying coal 3/8" and finer. Stainless steel screen sections are used extensively for this application. In many cases Type 410 is used in Carpenter Dryers. One producer of dryer screens specifies 16 gauge stainless with $\frac{3}{32}''$ perforations on $\frac{5}{32}''$ centers with 33% open area. Other size screens are also used such as 18 gauge with $\frac{1}{16}''$ perforations. We have reports of stainless screens lasting anywhere from 7 days to 6 months in this application.

For the Carpenter Dryer top section screens it may be necessary to use heavier gauge stainless — possibly 14 gauge.

From several sources we have obtained data indicating that the Carpenter Dryer screens wear out usually along the impact plate at junction of vertical rib and impact plate. The impact plate may be fabricated from AR steel and we believe should be at least ¼″ thick and protrude at least ½″ to ⅝″ from the screen surface.

### Stainless Steel for Continuous Conveyor Belts and Status of Tests

One of the problems continuously facing the coal industry is the conveying of coal from the mine and through the preparation plant operation. Today there appear to be numerous advantages in transporting by conveyor belt.

Much progress has been made since this time last year when Mr. A. B. Crichton, Jr., discussed the use of stainless steel for conveyor belts before this group.

Within the past year we have observed a stainless steel conveyor belt operating above ground. This belt was made of 18-8 Type 302 stainless steel in half hard condition. It is .035″ thick, 29½″ wide and about 200′ long. It operated on 95′ centers over a 24″ diameter drive pulley and an 18″ diameter tail pulley. The belt operated at a speed of 284′ per minute.

Run-of-mine was conveyed up a 16° slope. Very little slippage was noted even when wet coal and huge lumps were encountered. Coal moved up the belt extremely well and no movement was observed as the coal moved over the idlers. The owner stated that there was less movement of the coal on the stainless belt than on rubber belts.

Troughing action was excellent, and no side spillage was observed. The idler interval near the feeder was 8 feet: However, the greater portion of the belt was supported by idlers at intervals of 4 feet. We believe an 8′ interval between idlers will be entirely satisfactory. Instead of the conventional arrangement of three idlers per stand, only the two edge idlers were employed. Results were entirely satisfactory.

The ends of the belt were drilled and spliced with a stainless steel wire spiral fastener. This splice proved satisfactory and was easy to install in a short period of time. Future tests will also include butt welded splices.

A new self aligning pulley designed recently is expected to solve the alignment problem with respect to steel belts, which has been encountered in earlier operations.

This project is developing satisfactorily, and the results so far appear quite encouraging.

## PART III—HIGH-STRENGTH, LOW-ALLOY STEEL

Any discussion of the importance of steel to the Coal Mining Industry would be imcomplete without mention of the High-Strength, Low-Alloy steels. In order that there may be a clear understanding of what is meant by the term "High-Strength, Low-Alloy Steels," we quote the following definition proposed by the American Iron and Steel Institute:

> "High-Strength, Low-Alloy Steels are a specific class of steels, in which enhanced mechanical properties, and, in most cases, good resistance to atmospheric corrosion, are obtained by the intentional incorporation of moderate proportions of one or more alloying elements, other than carbon.
>
> "These steels are generally intended for applications where savings in weight can be effected by reason of their greater strength, atmospheric corrosion resistance, and where better durability is obtained because of their other desirable characteristics.
>
> "These steels are supplied to minimum mechanical properties and are normally furnished in the hot rolled (as rolled) or cold rolled, annealed or normalized condition, and are intended for use without further heat treatment, particularly not by quenching and tempering.
>
> "These steels are readily adaptable to fabrication by forming, riveting and welding; in the latter case, no preheat or postheat is required. In certain complex structures stress relieving may be desirable."

Of the more than a dozen High-Strength steels produced by the major steel companies of the United States, the subsidiaries of the United States Steel Corporation produce two of the true High-Strength, Low-Alloy type, namely, USS Cor-Ten and USS Tri-Ten. In addition, they produce a third High-Strength Steel, USS Man-Ten, which belongs to the intermediate manganese classification, and USS Abrasion Resisting steel, having higher carbon and higher manganese than Man-Ten for applications where the resistance to abrasive wear, coupled with moderate cost, is desired in a hot rolled steel capable of being moderately cold formed and metal-arc welded by using proper precautions.

The mechanical properties of most of the High-Strength, Low-Alloy steels produced in this country are generally similar, and in the limited time, we will not attempt to give you all their names, as you probably are familiar with most of them anyway, but will confine our remarks to those four which we have mentioned and with those characteristics we are most familiar.

While the true alloy steels date back to the early 1900's and received terrific impetus during and immediately after World War I, it was not until 1933, when an increasing need for the economics made possible by weight reduction in the Transportation Industry of the United States, that the High-Strength, Low-Alloy steels, as we know them today, were brought forth. In your dealings with the nation's railroad industry, you are probably aware that many thousands of railroad cars have been constructed wholly or in their more vital parts of these High-Strength, Low-Alloy steels. You have probably seen on many of our city streets how these steels have been utilized in both street cars and busses to obtain reduced weight and longer life, but as users of coal mining equipment, you are naturally more interested in the utilization of these steels within your industry. Up to the present time, more than 25,000 mine cars have been constructed of Cor-Ten alone, and it is safe to say that the major portion of these cars are still in service in the Coal Mining Industry. Another remarkable fact is that over half of the coal mining cars built of Cor-Ten have been repeat orders from original purchasers.

We do not wish to create the impression that this High-Strength, Low-Alloy steel can be of value to you only in your mine cars, as its greater strength, corrosion resistance, and resistance to abrasive wear make it ideally suited for chutes, conveyors, hoppers, mine skips, screens and trucks. Perhaps it would be well at this point to tell you that a typical chemical composition of Cor-Ten would be .09 carbon, .38 manganese, .09 phosphorus, .033 sulphur, .48 silicon, .41 copper, .84 chromium and .47 nickel. The combination of these elements makes possible a steel which, in hot rolled ½" plate, will have a yield point of at least 50,000 pound per square inch and a minimum tensile strength of 70,000 pound per square inch, with a minimum elongation in two inches of 22 per cent.

Cor-Ten is a steel of relatively high ductility in view of its higher strength than ordinary structural steel. As you are aware, ASTM A-7 steel has a yield point of 33,000 pounds per square inch. Furthermore, based on experience of over 17 years, it has been found that Cor-Ten steel has an atmospheric corrosion resistance of four to six times that of ordinary carbon steel. This means a lot of weight due to atmosperic corrosion of between ¼ and 1/6 that of ordinary carbon steel, not four to six times the life of a structure. In designing, you can, by increasing thickness sufficiently to provide for corrosion loss, insure proper strength over a period of years and approximate the potential life which you desire. In further connection with designing, you may, if weight reduction is desirable, reduce the section thicknesses in High-Strength Steel, in some cases as much as 25 per cent, and still maintain strength more than equivalent to that of a structure built of structural carbon steel, with a potential serviceability life approximately the same as the structure being replaced. If greater strength and longer life are desired, it is the practice of many fabricators to retain the same sections as were previously used in ordinary steel construction, thus assuring maximum life and resistance to abuse.

While Cor-Ten, due to the characteristics which we have enumerated, is pre-eminently suited for the Coal Mining Industry; Tri-Ten, although having somewhat less atmospheric corrosion resistance than Cor-Ten, has even better weldability than Cor-Ten in heavy sections, and its shock resistance at low temperatures has been demonstrated through service performance in such applications as shovels, booms, buckets, dippers and dipper sticks, particularly where this type of equipment is subjected to hard abuse during winter months. The toughness of this grade of steel has been proven by our own mining subsidiaries in the stripping operations necessary to remove overburden during the severely cold Minnesota winters. This steel, in thickness up to ½ inch, has the same mechanical properties as Cor-Ten. Whereas Cor-Ten is supplied for welded structures only up to and including ½ inch thick and for riveted structures up to three inches thick, Tri-Ten may be used where good weldability is required up to thicknesses of four inches. The yield points and tensile strengths of both steels are reduced 3,000 pounds per square inch for thickness between ½ inch and 1½ inch. For thicknesses over 1½ inch (up to the maximum thicknesses) these properties are further reduced 4,000 pounds per square inch. While Tri-Ten has not been subjected to atmospheric corrosion tests for as long a period as has the older Cor-Ten, sufficient evidence has been accumulated to establish that the atmospheric corrosion resistance of Tri-Ten is three times that of ordinary carbon steel.

At this time it may be of interest to mention that the Bailey bridges used by our Armed Forces in World War II were constructed of this steel, and we have no record of any weld failure ever having occurred. As you are aware, these Bailey bridges were of the portable, quickly erectible type used not only during military advances, but also allowed to remain in place of bombed bridges until they could be replaced by permanent structures. A typical composition of Tri-Ten would be .19 carbon, 1.15 manganese, .021 phosphorus, .031 sulphur, .21 silicon, .40 copper and .80 nickel, from which those of you versed in welding will realize that this is a suitable steel for metal-arc welding.

The third steel we mentioned, Man-Ten, is a high strength manganese copper steel depending for its strength on carbon, manganese and copper. It is considered a weldable grade, provided mild steel electrodes are used, as well as good welding technique and workmanship. This steel, due to its high strength and an atmospheric corrosion resistance of approximately twice that of ordinary carbon steel, is a good steel where strength is desired at a minimum increase in cost. It is a steel that is ideally suited to the construction of dirt handling equipment where lessened corrosion resistance and somewhat less toughness is necessary than may be obtained with the two High-Strength, Low-Alloy steels which we have previously described. Briefly this steel, in thicknesses ½ inch and under, has a minimum yield point of 50,000 pounds per square inch and a minimum tensile strength of 75,000 pounds per square inch, with an elongation in two inches of 20 per cent, and approximately the same elongation in eight inches as Cor-Ten and Tri-Ten. In thicknesses over ½ inch to 1½ inch, the yield point and tensile strength values are reduced 5,000 pounds per square inch, respectively, while from 1½ inch to 3 inches another 5,000 pounds per square inch reduction is made in both values. From this it can readily be seen that, in heavy structures where corrosion is of minor importance and cost becomes an increasingly important factor, this steel fills a very definite need. A typical composition of Man-Ten would be .22 carbon, 1.40 manganese, .020 phosphorus, .030 sulphur, .07 silicon and .27 copper.

The fourth steel we mentioned, Abrasion Resisting Steel, is produced, not to any specified mechanical properties, but to specified chemical composition ranges and is intended for use where resistance to abrasive wear is most important. Due to the considerable amounts of carbon, manganese and silicon in the steel, it does have high strength and relatively high hardness, so that the ease of fabrication, such as shearing, punching and cold forming, is, of course, reduced. Due to its wear resistance, Abrasion resisting steel serves well in conveyors, chutes, spouts, screens, and as wear plates between moving parts. Abrasion Resisting steel also lends itself well to the construction of dredge pipe, as the amount of cold forming necessary to make pipe of relatively large diameters can be performed successfully. When Abrasion Resisting steel is to be gas cut or welded, conventional preheating and postheating practices should be observed. As this steel is produced with carbon of .35/.50; manganese, 1.50/2.00; phosphorus, .05 maximum; sulphur, .055 maximum; and silicon .15/.30, it can readily be seen where the foregoing characteristics are obtained. Furthermore, as the steel is an air-hardening material, the surface hardness will approximate 200 to 250 Brinell in the hot rolled condition.

While limited time has permitted only a very brief mention of those characteristics peculiar to these four steels, we hope that we have mentioned enough to arouse your interest in the wide possibilities of their applications. Whether higher strength, longer life, or increased efficiency of mobile structures is your problem, you can, after a further investigation of the desirable characteristics of the High Strength steel family, find the type that will best suit your particular purpose.

In conclusion we want to point out that economics should govern the selection of the proper grade of steel. Any one of these three steels, Alloy, Stainless or High Strength, may give different results under the varying conditions found in different mines.

* * *

Mr. Purnell: Are there any questions? If you have the cards, will you kindly pass them toward the center of the hall, and we'll be very glad to gather them up.

Mr. Stodgell, here's one for you. They would like you to comment on the flexing properties of 18-8 302 stainless.

Mr. R. M. Stodgell: Regarding the question of the flexing of 18-8 Type 302 stainless, first of all, I'd like to ask a question about the question. Will you further describe what you mean by flexing, and identify the operation you are referring to?

Chairman Garwood: I had reference to the use of stainless steel plates in screens, allowing the deck to vibrate while in action.

Mr. Stodgell: That's a very good question. I might say that in some of these stainless perforated screens — I'm thinking primarily now of screens of a thickness of $\frac{3}{64}$th, also the finer meshes — when you get down to that thickness or mesh it is a good idea to have a framework under the screens.

In some of the heavier screens, you will find that – depending on the width of the screen and the amount of coal going over it – there will be no necessity for a frame.

I want to make sure that you understand what I said about the width of the screen, because when you get wide widths of 40 or 60 inches, it may be necessary to have a frame under the screen.

Does that answer your question, sir?

Chairman Garwood: Yes, sir.

Mr. Stodgell: Any other questions that anybody would care to ask at this time, either on stainless or any of the other grades?

Chairman Garwood: Any other questions? The paper was rather thorough, and it covered most subjects you might question about.

Mr. Purnell: Another one for you, Bob: How do stainless steel conveyor belts compare in cost, maintenance, and so forth, with rubber belts?

Mr. Stodgell: If I had the answer to that question, I'd really be an expert.

Well, I might say this: As to cost, from the figures we have available now, stainless belt might run two dollars or two and one-quarter per lineal foot – maybe a little less or a little more, but something around that general figure.

As far as maintenance is concerned, I think we have something to talk about. I might go on to say a little about stainless results at this time.

I have observed a stainless belt in operation within the past two weeks, and from looking at that operation – which was 29½ inch wide belt on a 16 degree slope – I thought it was doing a very fine job of conveying the coal. It had the 2B finish, which was identified here as a slick, dense surface. Many people thought the coal would slide, and although it poured rain that particular day the coal was conveyed up and it did a very fine job.

As far as maintenance is concerned, with the 18-8 type 302, with the very fine corrosion resistance we have with that grade, I don't anticipate that there would be much of a maintenance problem except – and, again, you're in a deep subject now – with alignment. There will have to be some corrections made so that we keep the edges of the belt in good condition.

There is one thing to consider in stainless – you do have to keep a smooth edge; at least we have found that indication so far in our development work.

I think I have covered cost. Are there any other questions on conveyor belts?

Mr. Edwin H. Johnson: I'd like to ask a question about the conveyor belt. How does your butt welding compare in performance with the spiral joint that you mentioned?

Mr. Stodgell: The question is "How does the butt-welded splice compare with the spiral?"

The butt-welded splices have been used on small prototype test installations. According to theory, of course, everyone I know would say that the butt-welded splice would be the most perfect arrangement under which a belt could operate. However, there are such things to consider as the practicability of welding in the mine, and you may have a rupture in your belt, or want to add a section, and there may be some difficulty there.

I can't honestly answer your question directly, because I have not at this time seen a belt with a butt-welded splice in full operation. The belt that we did see in operation had $1/8$-inch-diameter spiral wire on the joint, just like the spiral bindings you see on some notebooks. The belt ends were drilled and the wire simply run through. I went up to the head pulley and watched the belt revolve, and when that splice came up, it went over the pulley perfectly. There wasn't any flexing or snapping of the belt. It was just as though a solid section of the belt was rotating right around the head pulley.

That's about the only information I can give you on that subject.

Mr. Purnell: Were wipers used on the belt?

Mr. Stodgell: No. No wipers were used.

Mr. John J. Huey (United Electric Coal Companies, Chicago, Ill.): I wish you'd elaborate on that edge condition — why you need a very good edge.

Mr. Stodgell: First of all, with continuous cold-rolled stainless steel you must have a straight belt, and there are two or three methods of obtaining a straight belt.

First of all, you might obtain it satisfactorily rolled in the mill, but you do have some difficulty there, and I might outline on the blackboard what I mean at this point.

(Draws two parallel curved lines on blackboard.)

Here I have slightly exaggerated this condition. Seeing the direction in which I have made the lines, you will note that we have a condition which, in the steel industry, we call "camber." In other words, that means "out of straightness." Now, with the belt that is not straight, you will have a difficulty in alignment.

We have mentioned the Lorig pulley which is self-aligning, and we believe it will do a very fine job, even with a belt which is out-of-straight.

To get back to your question, you may roll out this particular section of steel and, if it is not straight, you may — by scribing a line down the center and measuring equal distance from that line, trim the edges smoothly and obtain a straight belt. That is one method.

In slitting the edges of cold steel you sometimes encounter a condition known as shear burr and simply by filing or preparing the edges you can usually remove it, so that when the belt revolves, the condition will not be aggravated.

Does that explain it to you?

Mr. Huey: Does the burr cause a cracking to develop?

Mr. Stodgell: A burr, because it is a stress raiser, would in the long run cause cracking, in the continual flexing and revolving, with the tension over the pulley. However, if you file the edges smooth, they will remain that way and you will have a good condition.

Does that answer your question, sir?

Chairman Garwood: Is there anything further? If not, we'll turn the meeting back to President Gerow.

(President Gerow resumed the chair.)

President Gerow: I certainly want to thank all participants in the afternoon's session. Chairman Garwood, we thank you very much for carrying on the program in such fine shape. We also want to thank George Reynolds on his splendid paper, and Charles Purnell and his Development Representative associates who so kindly answered the questions.

Bela, have you any announcements to make?

Be sure to be here promptly at six-thirty, when we will reassemble for dinner, with the introduction of your new officers, and so on. We'd like to assemble as promptly as possible. We have a very interesting speaker this evening, whom I know you will all enjoy. Some of you have heard the chap before, and those who haven't are in for a treat. I'm sure.

We'll adjourn the afternoon session until six-thirty this evening.

(The meeting recessed at three forty-five o'clock.)

## FRIDAY EVENING SESSION

November 17, 1950

The meeting reconvened at seven forty-five o'clock, President Gerow presiding.

President Gerow: Gentlemen, may I have your attention, please?

Members of the I. M. I., Students, and Guests: Once again we welcome you to Springfield and the Illinois Mining Institute's Fifty-Eighth Annual Convention.

At this time I wish to express my appreciation for your confidence in me last year by electing me your President. I have thoroughly enjoyed the term of office, and have felt highly honored. I wish to express my thanks to the other officers, the entire membership, the Executive Board and the various committee members, and, in particular, the backbone and the sparkplug of the I. M. I., your Secretary-Treasurer, Bale Schonthal, for carrying on the work of this organization so splendidly in this past year.

At this time the I. M. I. also wishes to express its thanks to all who participated in today's program. The sessions were very well attended, the speakers excellent, and the session leaders are to be congratulated on the way in which they carried on their individual sessions.

I have two points that may be of interest to you people who are attending this meeting with us tonight. There are 127 new members this year. Are they in attendance?

Secretary Schonthal: Yes.

President Gerow: About 725 registered in at the headquarters downstairs. I believe there are about 500 attending this banquet.

Your Secretary has received the following radiogram from Zonguldak, Turkey, via RCA Radio, addressed to B. E. Schonthal, Illinois Mining Institute, Hotel Abraham Lincoln, Springfield, Illinois: "Greetings from Turkey to our friends of the Institute on the beginning of another successful year. Paul Weir Company, by Lee Richards."

That's a greeting from a long way off.

We have a number of officers, incoming officers and guests at the table this evening, and I should like to briefly introduce them to you.

At my left, and your right, Mr. William Ginder, of Coal Age.

Mr. George Lindsay, of Mechanization Magazine.

Professor Harold L. Walker, Head of the Department of Mining and Metallurgical Engineering, University of Illinois, Urbana, Illinois. He is also Chairman of our Scholarship Committee. I very much urge what he had to say in this morning's session.

Mr. F. E. Weissenborn, Illinois Coal Operators Association. He is an Honorary Life Member, and the oldest living member of the I. M. I.

Mr. W. J. Jenkins, Consolidated Coal Company. He is the head of three generations in the coal mining industry, in the same company. He is a past President of I. M. I. and an Honorary Life Member.

Mr. H. A. Treadwell, Vice President in charge of operations, the C. W. & F. Coal Company. He is President of the Illinois Coal Operators Association, a past President of I. M. I., and also a Life Member.

Mr. M. D. Cooper, Manager of Vocational Training, the National Coal Association, at Pittsburgh, Pennsylvania. He spoke to us this morning.

Intentionally passing over the next two at the table, and starting from my right, your left, we have Mr. Walter Eadie, Director of the Department of Mines and Minerals, a new member of the Executive Board of the I. M. I.

Mr. William Bolt, Superintendent of the Freeman Coal Mining Corporation, Farmersville, Illinois, a new member of the Executive Board.

Mr. H. H. Taylor, President of the Franklin County Coal Corporation, now serving on the Executive Board. He is a past President of the I. M. I., and is also a Life Member.

Mr. D. W. Buchanan, Jr., President of the Old Ben Coal Corporation, now serving on the Executive Board of I. M. I., and also a Life Member.

Mr. C. C. Conway, Chief Engineer, Consolidated Coal Company, St. Louis, now serving on the Executive Board.

Mr. A. G. Gossard, General Superintendent of the Union Colliery Company, DuQuoin, Illinois, now serving on the Executive Board.

Mr. F. Earle Snarr, General Superintendent, C. W. & F. Coal Company, new member of the Executive Board.

The next gentleman is B. E. Schonthal, Secretary-Treasurer. Enough said. You all know him well.

Mr. Clayton G. Ball, Vice President, Paul Weir Company, and incoming Vice President of I. M. I., elected this morning. He is a Life Member.

I'm going to skip over the next gentleman. I'll be after him a little later.

We have special guests in the audience tonight – two groups of young fellows interested in our industry. I wish I had time to introduce each one individually and give you a little history, and so on, but I'm afraid we'll have to pass that up. However, I will ask the groups to stand as a group when I call them.

There are three instructors and six students from the University of Missouri School of Mines at Rolla, Missouri. I'd like to have those gentlemen stand so that we can all see them. Thank you very much.

In addition, we have Professor Clark, Professor Chedsey and thirty-six mining students from the University of Illinois at Urbana. Will you please rise? Thank you very much.

I hope that all of you have had an opportunity to listen to some of the remarks at the morning's session. At that time someone said that it had been indicated that the indusry was overcrowded with technical men. I take serious objection to that. I am sure there is a lot of room in the industry for those men. I have personally heard nothing but the technical side of coal mining – coal washeries, sizing, size consists, washabilities and all that sort of thing – for the last several months, and I know there is a lot of opportunity for all you fellows, and I'm sure that you're going to get as much of a bang out of it as all these gentlemen who are in attendance here tonight, five hundred strong. We had seven hundred strong attending this meeting. I wish you all the best of luck.

I should take notice of five members of our Executive Board who are not in attendance tonight; I'll just review them briefly so that you will be brought up to date. They are: Frank L. White, of Peabody Coal Company, Henry C. Woods of the Sahara Coal Company, F. S. Pfahler, of the Superior Coal Company, H. A. Reid, The United Electric Coal Companies, and G. Don Sullivan, Fairview Collieries Corporation. Unfortunately, they could not be with us this evening.

It is now my pleasure to introduce to you the speaker of the evening, whom I had the pleasure of introducing several years ago at the American Mining Congress. I feel that he is an old friend; however, I think you should know a little more about him.

He is a native of southern Mississippi and Collins, Missouri. He has been editor and publisher of the Collins News-Commercial for 19 years, and his editorial comments have gained his newspaper a reputation of being Mississippi's most quoted newspaper.

In addition, this is his seventh term as Mayor of his home town of Collins, Missouri. I asked Mr. Arrington just before the meeting if he was usually addressed as "Honorable." He said he guessed that might be a proper way, but he doubted that many in Collins would call him "Honorable."

In addition to all that, he runs a law business there, on his own, and takes care of all the legal affairs in Collins and the surrounding vicinity. Therefore, you have a mayor, an editor who can write you up afterward, and a lawyer who can get after you in many ways – all rolled up in one.

His subject is "Yesterday, Today and Tomorrow." I'm sure it is going to be of interest to all of you, as I think he is well grounded legally, politically and editorially to dwell on this very important subject.

I give you, at this time, Mr. James D. Arrington, of Collins, Missouri.

Mr. James D. Arrington: Thank you, President Gerow.

Members of the Illinois Mining Institute and Guests: I tell you I certainly do appreciate the kind invitation that was extended to me which has culminated in you good people having the opportunity of hearing me here tonight.

For goodness' sake, don't let it get back down to Mississippi that I'm living in *Missouri* now. It's a good state, it certainly is, but I don't live there.

*(The following is a condensed version of Mr. Arrington's address. We wish — we certainly do — that we could recapture his deep southern drawl, his deliberate deadpan delivery, his perfect sense of timing.)*

# "YESTERDAY, TODAY, AND TOMORROW"

By JAMES D. ARRINGTON
Mayor, Collins, Mississippi

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Mr. Chairman, members of the Illinois Mining Institute and friends; I certainly do appreciate the kind invitation extended to me to come here and speak to you fine people.

You know when my friend and your efficient secretary, B. E. Schonthal, called me upon the telephone a few weeks ago and when the fellow that has got the telephone down there at Collins where I live, came over to my house and told me that Chicago was calling me, I couldn't imagine who it was, I certainly could not.

When I got to the phone and found out that it was Schonthal wanting to know if I would be kind enough to come up here to Springfield and bring a message of inspiration, encouragement and enlightenment to the members of the Illinois Mining Institute, I couldn't say no, as I could not think of then nor can I think of now, any group that would be in need of encouragement and enlightenment more, than people who are engaged in the mining business, I certainly could not.

So I told him I would come and I feel like I am qualified for the job because I can't think of anybody that knows less about the mining business than I do unless it is you people that are engaged in the business. Therefore not knowing anything about your business, I can speak here as an expert, I certainly can.

However you are a fortunate group here tonight as I spoke two days ago in Birmingham, Alabama and used the subject, "The Possibilities of Atomic Energy in the Industrialization of the Orient." Now if you can think of a more nauseating subject than that for a man to speak on — even to the people of Alabama, I wish you would advise me.

I am not going to use that subject here tonight, I certainly am not, but in case somebody tomorrow wants to know what my subject was, you can tell them it was "Yesterday, Today and Tomorrow." Now that is a good subject and I assure you I will try to stay just as far away from it as I possibly can.

I feel that I should first give you the source of the inspiration for such a subject. Like all great men I have a motto that hangs on my office wall and on it is this inscription, "Today Is the Tomorrow That You Worried About Yesterday." Now that motto has meant a lot to me personally. It has really brought warmth into my life. Not so much because of the great truth contained in the inscription but because of the fact that the motto is the exact size of a window pane that is broken out in my office window and when the wintry winds starts blowing, that motto fits over the hole in the window pane and keeps me warm, it certainly does, and I have grown attached to it and am using it as the subject for my addresses over the nation.

We look out tonight on a nation and world of unrest, uncertainty and confusion. Everywhere you go in this great nation you find our people are worried and they all feel like they are justified in worrying.

The American people have worried so much in the past 20 years that America is on the verge of a national nervous breakdown.

I believe that the greatest contribution that any individual can make to his nation in these trying times, is to resolve in his heart and mind that he will eliminate out of his life this promiscuous worry. And get me straight — there is a vast difference between thinking seriously and just worrying about things.

What the average American has been doing is not thinking seriously about his problems but has merely been worrying about them. Most of us when faced with a problem, let our hair down, if we are fortunate enough to have any hair of which most of us are not, and wring our hands in despair and despondency.

I am speaking to you people tonight not as an amateur in the field of worry but I am an expert, I certainly am. For many years I was the champion and undisputed worrier of the south. You know I live in a section of the nation where quite frequently, too frequently that is, we have cyclonic disturbances. I don't know whether you folks have tornadoes in your part of the country or not but they are awful things.

I will never forget the time when my town was hit by a tornado back in 1924. One night about eleven o'clock a twister came out of the north and descended on my town and in its wake it left seventeen wrecked homes.

The next morning as my people looked out upon the devastation they said with one accord that nothing could ever happen to Collins that would be worse than that. Well, a few weeks later a carnival company came to town and a twister came out of a sideshow and she wrecked 32 homes. I tell you this not only to wake you up but to impress upon you the fact that things can be worse. They certainly can be, and every time I hear somebody gripe and complain, I am reminded of a great Chinese philosopher whose name I don't recall at the present time, and if I could remember it I could not pronounce it as I do not speak Chinese very fluently, and if I could pronounce it, you could never repeat it, so it doesn't make any difference what the man's name was; but what he said was this, "I felt sorry for myself because I had no shoes until one day I met a man who had no feet." How true that is, and when we in this great nation start feeling sorry for ourselves we should but raise our eyes and look across the ocean at millions of people who are suffering trial and tribulation we cannot even conceive of.

A few months ago the man who is president of this great nation, of which at the present time Mississippi is enjoying the status of a colonial possession, found it necessary to use 30,000 words in telling our people the state of the union. I can tell it to you in four words – It's in a mess.

With the national debt having reached a figure so big that the majority of people cannot read it, let alone pay it, we are learning the hard way that we cannot get something for nothing.

The constitution sets forth that the government shall have power to levy taxes in order to meet the necessary expenses of the government. The original intent of the framers of the Constitution was that taxes were to be used as a source of revenue only. We find today a philosophy of taxation that considers it as an instrument to equalize income, prevent inflation, maintain full employment and to control the business cycle.

This new philosophy will not work in this country, as America became great because its people had the same right to go into bankruptcy as they did to become millionaires.

We are hearing a lot about strife and discord between management and labor but I think the real trouble is that everybody wants to manage and nobody wants to labor.

We take pride in all the great assets that this nation has, but the greatest asset of this nation is its people. Today it is tragic to find the virtue and strength of the American people has been quick-frozen into indolence and dependence upon government. The only way to defrost these frozen assets is get the people to do for themselves the things they can and should do and quit depending upon their government to do it for them.

We have been a fortunate people and have been blessed far beyond our deserts and the least we can do is to become people of more faith – a people that has more faith in our own ability to do things – more faith in our fellowmen and above all more faith in this great American way of life that we are hearing about. I want to digress for a few minutes and talk about the American way of life. Every speaker that gets up on his hind legs has to say something about it and I am no different, I certainly am not, except I want to confine my observations to giving you a definition. There have been a lot of definitions written as to the true meaning, but in all modesty I contend that the best one that ever has or ever will be written is the one I wrote myself a few weeks ago when I said, "The American Way of Life is a way of life that most folks won't appreciate until it is either gone or is about to go."

Did you know that some of the most precious things in this life we do not appreciate until we have either lost them or are about to lose them?

However, I am more optimistic than the average run of men, for as I travel around the nation I find that our people are beginning to think seriously upon the question of our way of life being in danger, and when the American people start thinking seriously and then acting postively – as the voters in Ohio did a few days ago – then I have no fear as to the consequences.

Yes, I commend to you the philosophy that it doesn't pay to worry. I learned my lesson from that carnival company I mentioned a few minutes ago, for when it came to town they had with it a game of chance. They called it "Bingo." I don't know whether you folks have ever seen the game or not, but it was new to us and it attracted people by great number and I was no exception, I certainly was not. I was right on the front row and wanted to play but I remembered the official position I held as mayor of my town and I couldn't afford to engage in such games of chance (I thought about resigning but I needed the five dollars every month) so I remained a spectator.

A lovable couple was playing the game – that is the woman was sitting down playing and her husband was waiting for her. He was holding the baby of the household, who was about five months old and very hungry and restless. The baby had already chewed all the starch out of the old man's collar without any satisfaction to either party and he was getting after his wife to hurry up and come go home but she replied, "I ain't going to budge till I bingo." "You have been down there an hour and have given no indications of bingoing" her husband said. "I don't care, I still ain't budging till I bingo," said his wife.

Well, when that couple started to arguing I found myself getting worried about them arguing out in the public with the window shades up and was being worked up into a state of nervous prostration. Finally the man told his wife to get up and hold the baby and let him sit down and see if he could bingo. Well they exchanged places but he had no better success, he certainly did not, and then his wife started getting after him to go home and that was really when the arguing started and it looked like I would see a good fight before I got home. I knew I would see one when I got home.

There they were arguing back and forth and there I was, just worried to death, wondering what was going to happen, and then the baby "bingoed" and everybody went home.

I wish I could stand up here longer and talk to you but I was injured several years ago playing football and can't stand on my feet long at a time. I played back during the time when we had in this nation a federal agency known as the Works Progress Administration. I don't know whether you had the WPA in Illinois or not but that was the only industry we had in Mississippi for five years. It was about this time when all the bowl games started up over the nation. My people took the matter up and decided to have a Relief Bowl game. One team to be made up of WPA players and the other of non-WPA men. The only trouble we had was that we couldn't find eleven men for the non-WPA team but we ran in a couple of Republican ringers from Louisana and got the game started.

The first half went off with no trouble except a WPA saw some sweat and fainted and had to call time out. The half ended with no score. I didn't play the first half but at the beginning of the second half the coach called me and said "Zumanski" – that's my football name – go in and see what the trouble is. I went in and found the WPA using a tricky formation on us, they called it the New Deal formation – that is where the quarterback ran around in a circle and both ends drug the ground.

We couldn't score until the fourth quarter when I interrupted one of those shovel passes that the WPA team had been leaning on and started out for paydirt but felt my suspenders let loose their responsibility.

I don't know whether any of you have ever tried running down a football field with a football in one hand and your pants in the other or not, but it's hard to do, but it proves what I have been trying to say, and that is that it doesn't pay to worry, because everytime one of the WPA players would start to tackle me, I would let go my suspenders and turn around and say, "You wouldn't hit a man with his pants down, would you," and I got by.

Believe me when I say that it has been a real pleasure to meet with you and may this association continue to enjoy success.

I am through.

* * *

President Gerow: I know we are all deeply indebted to Jimmie Arrington for turning that man loose here tonight. I think you can see why I enjoyed introducing him the second time, and I know he has given you all some good, sound, basic philosophy to take home with you. We are deeply indebted to you, and thank you so much.

We are coming to the conclusion of our Fifty-Eighth Annual Meeting. My last duty of this year's meeting, which is a pleasure, is to introduce your new President. G. Stuart Jenkins, Vice President in charge of operations, Consolidated Coal Company. He is known familiarly as Stuart. I think most of you know him. You certainly know of his activities around Illinois. Although he is a St. Louis man, he is far more familiar with the state of Illinois, I think, than his own home state of Missouri, and is really at home when in the Illinois coal fields.

Stuart is a graduate mechanical engineer from Washington University. He follows in the footsteps of his father, Bill Jenkins, whom I had the pleasure of introducing a little while ago, and, in turn, has two sons, one a mechanical engineer from the University of Illinois and another an electrical engineer from Washington University, who are making fine progress in following coal mining and keeping the name of Jenkins prominent in the Illinois coal fields.

Stuart started in the coal business just in time to catch the mechanization era, the beginning of mechanical loading, and I believe he is credited with being one of the main cogs in the mechanization of Consolidated's Number 15 Mine, which I believe was the first mine in this country or any other that saw a hundred per cent mechanization.

Stuart is a man who is always looking for new methods to improve his mechanization. He often concocts his own devices and methods, involving radical departures from previous practice, and they always seem to click. I'm sure that Stuart is going to make the Illinois Mining Institute click this coming year.

Stuart Jenkins!

(President-Elect Jenkins assumed the chair.)

President-Elect Jenkins: Members of the I. M. I. and Guests: Jerry left me some awfully tough footsteps to follow, but I appreciate very deeply the privilege of heading the organization this coming year, and with the help of my fellow officers I am sure that we will keep the I. M. I. advancing along the same plane it has been progressing these many years.

And now I will take the privilege of the incoming President and announce that the meeting is adjourned.

Thank you.

(The meeting adjourned at eight-fifty o'clock.)

General view of hydrogenation demonstration plant, Louisiana, Mo.

*Reprinted from July, 1950 issue of "Mining Congress Journal" by permission of the author and the American Mining Congress.*

# COAL PREPARATION FOR HYDROGENATION

By RALPH J. LOFQUIST
Contracting Engineer, Roberts & Schaefer Co.
Chicago, Ill.

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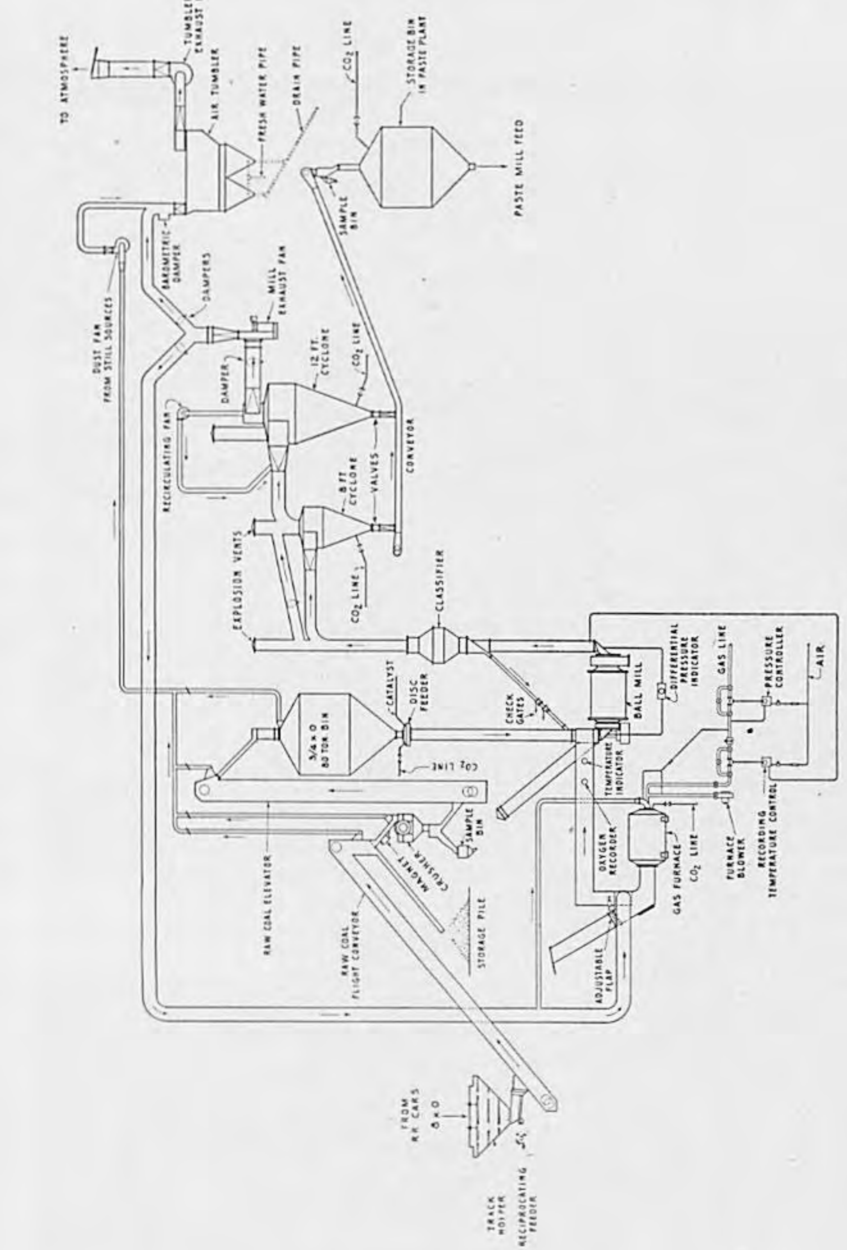
Highly automatic methods are used in the preparation of coal for hydrogenation to convert Wyoming coal to gasoline and other liquid fuels at Louisiana, Mo. The pioneer pilot preparation plant uses full sized equipment so that the results of railroad unloading and crushing at the rate of 70 tons per hour and the milling and drying of 13.5 tons per hour will be representative of those anticipated from the operation of a full-scale plant. The new installation, located on the banks of the Mississippi River, has as its purpose the preparation of dried, pulverized coal. This product is supplied to the coal paste plant for subsequent hydrogenation to produce high octane motor fuel in another section of the demonstration plant. The coal preparation plant also provides facilities for unloading and movement of the coal to the storage pile or through the plant on into the 60-ton coal bins in the paste plant where the dried-pulverized coal is stored until used.

Bituminous, sub-bituminous and lignite coals of varying preparation characteristics can be handled in the versatile plant. The railroad car unloading section has been designed to handle 8-in. R.O.M. at 70 tons per hour to the storage area or to the crusher where the coal is reduced to ¾ in. top size. The pulverizing and drying stages have been designed to process 13.5 tons per hour at the ¾-in. crushed coal when this section draws speed from the 80-ton bin, the coal contains up to 30 per cent total moisture. The total moisture is reduced to two per cent and the coal is pulverized to 99.5 per cent minus 60 mesh with a minimum amount of minus 200 mesh material.

Raw coal is delivered in hopper-bottom railroad cars and unloaded through removable breaker bars with 8 by 10-in. openings into a track hopper. The reciprocating plant feeder feeds the coal to an inclined scraper conveyor which discharges the 8 by 10-in. raw coal to a rolling ring crusher. Tramp iron is removed when the coal passes over a magnetic chute. The raw coal is reduced to a minus ¾ in. and then passes over an automatic sampler, where the raw coal samples are taken to the foot of a bucket elevator.

Crushed coal is elevated to an 80-ton storage bin equipped with indicators to show high and low levels of the minus ¾ in. coal content. When the bin is full, the coal normally feeding the primary crusher can be run back to the storage pile for subsequent processing.



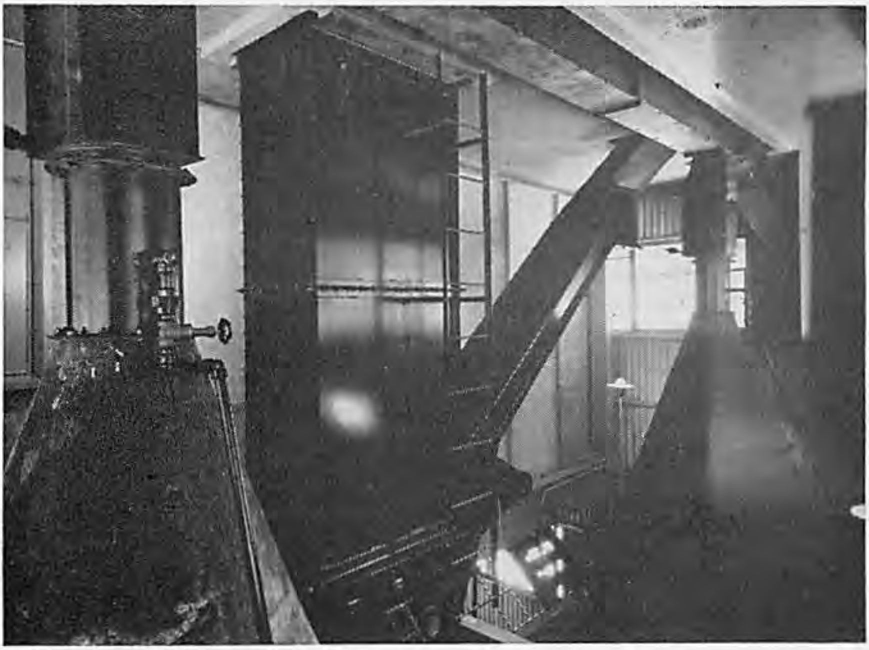

**Flowsheet of plant that prepares the coal for hydrogenation**

### Processing Plant

A disc feeder draws coal from the 80-ton bin for delivery to the pulverizing stage. The enclosed worm drive of this feeder can be adjusted to deliver raw coal to the ball mill at different rates. A variable speed motor which drives the feeder is controlled by an electric eye mill level control. Also, at the feed point, provision has been made to spray dissolved catalysts on the raw coal prior to pulverizing and drying.

Raw coal is fed to a Kennedy van Saun integral gear driven, inert-gas-swept ball mill where the coal is pulverized and dried in a single stage. The ball mill load normally consists of ten tons of 3-in. balls. The ball charge is maintained at the proper level by adding balls when an ammeter indicator on the bench board shows that the charge has fallen below the ten-ton level. A special baffle plate at the mill trunnion insures that the incoming gases correctly sweep the mill.

Inert gas for drying and conveying the pulverized coal product is natural gas with a rating of 1000 Btu per cu ft. For raising to the proper operating temperatures, the gas is passed through a steel shell furnace adjusted for pressure with an indicating controller and with temperature regulated by a proportionalizing controller. A combustion safeguard system insures proper ignition, burning and shutting down of the gas furnace with a minimum danger of explosion. To make certain that the oxygen content of flue gas remains below lower explosive limits, an oxygen recorder automatically analyzes and constantly records and is set to give an alarm when safe limits are exceeded.



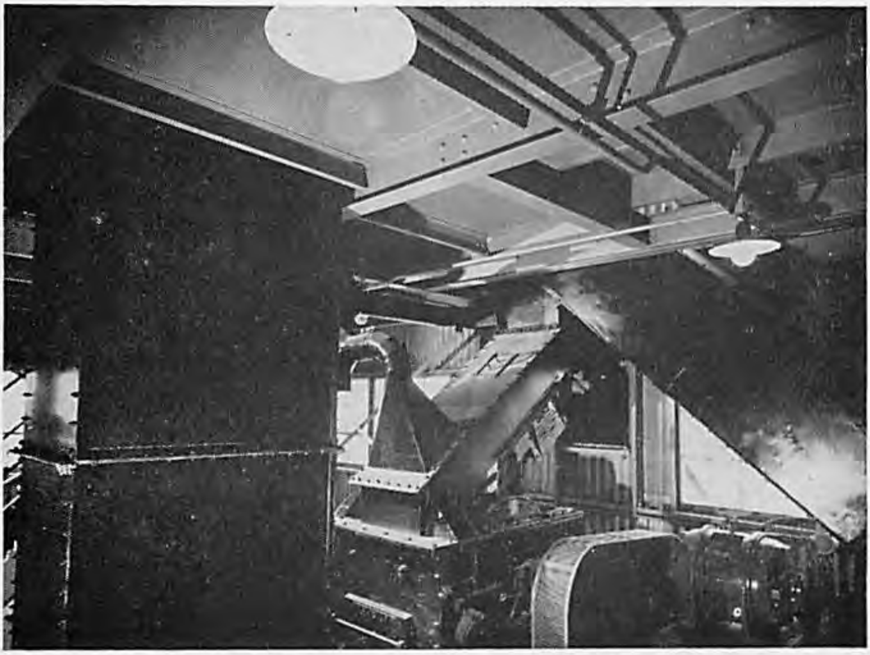
Product collector and cyclone collectors operate in inert gas

Furnace flue gas is tempered with recycled flue gas to build up the proper temperature and volume of hot drying medium to convey the 60-mesh coal product to the product collector cyclone via an expansion type classifier. In this latter unit, oversized particles are removed and returned by gravity through air locks to the ball mill for further grinding.

Intricate piping system handles various materials and products

The product collector cyclone is of standard construction with the product discharged through a double discharge valve air lock. The flue gas from the product collector passes to the dust collector cyclone for reclamation of the finer sizes of product, thence, a part of this flue gas is recycled back to the inlet duct to the ball mill for tempering hot gases from the furnace. The balance, after passing through the mill fan, goes to a wet-type air scrubber where the cleaned gas is exhausted into the atmosphere by a fan.

A specially constructed dust collector cyclone is equipped with a re-circulating fan. The dust is discharged through a double discharge valve air lock. The mill fan exhausts inert gas from the furnace through the ball mill, classifier and cyclones. The damper at the fan inlet is remotely controlled for starting up the plant. The dampers at the mill fan exhaust "Y" are actuated by a piston-operated control drive that is controlled by a selector valve at the bench board to suit the amount of recycled tempering gases.



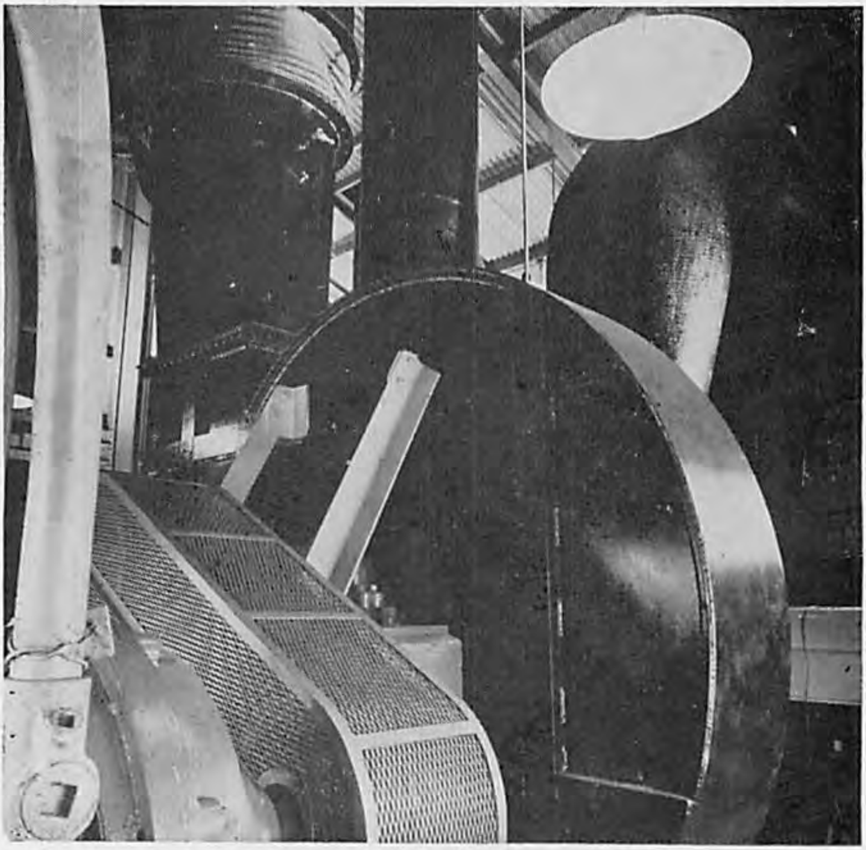
Primary crusher reduces R.O.M. to minus ¾-in.

Dust laden air from still sources is collected by a tumbler exhaust fan. In addition to the air diverted to it from the "Y" branch at the mill fan exhaust, this air is passed through a horizontal type wet air scrubber. The fan runs at a fixed capacity with the variations of gas volumes from the mill fan compensated for by a barometric damper at the tumbler inlet.

### Coal-Oil Paste Feeds Hydrogenation Unit

The collected 60-mesh coal from the product collector cyclone mixes with the coal from the dust collector cyclone on a Redler conveyor. Both products are carried to the paste plant and discharged to the 60-ton pulverized coal bin for storage over an automatic sampler where the finished product samples are taken. The dried pulverized coal is drawn from the bin at a low rate for mixture with a catalyst and with heavy oil obtained from the liquid-phase process. These ingredients form a viscous, 47-percent solids paste with which the hydrogenation process is started.

Piping to handle both air and dust is of standard round section. This piping collects and eliminates dust, supplies recycled flue gas to the furnace, gas-conveys pulverized coal from ball mill to collectors and serves as venting to minimize effects of explosion in the pulverizer-classifier-collector system. All ducts carrying hot gas are heavily insulated as are the

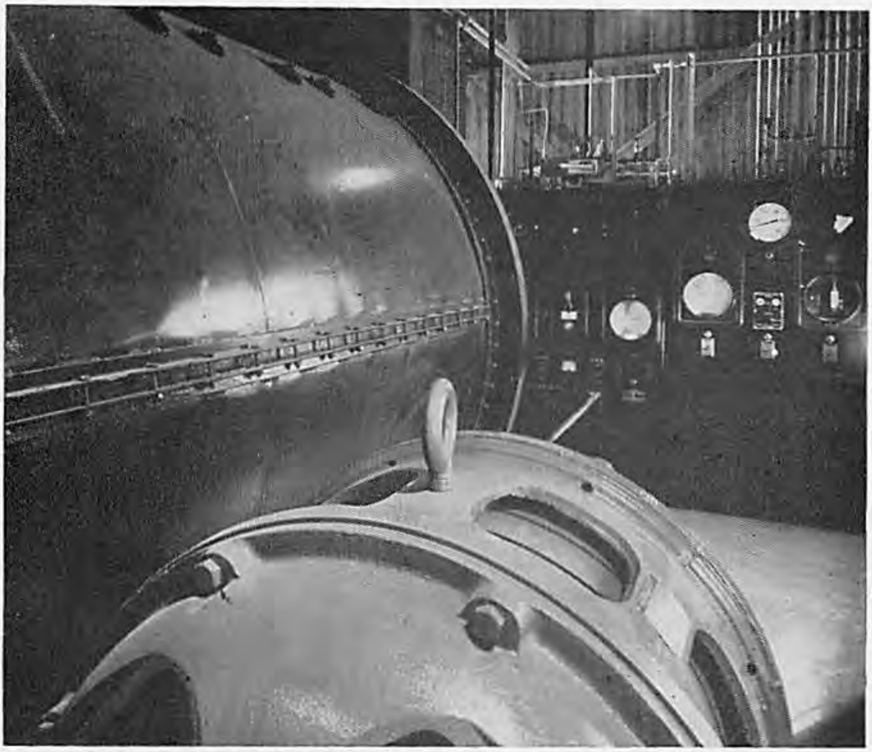


Mill fan pushes gas through wet-type air scrubber

furnace, mill, classifier and cyclones. This insulation reduces the temperature drop in the recirculating system.

Precautions have been taken to minimize the danger of explosions from the heat-dried coal, air and gas mixtures. Safety devices and explosion vents are used throughout. Low-pressure nitrogen is used for blanketing the coal storage bin in the paste plant and at various points in the mill and drying circuit.

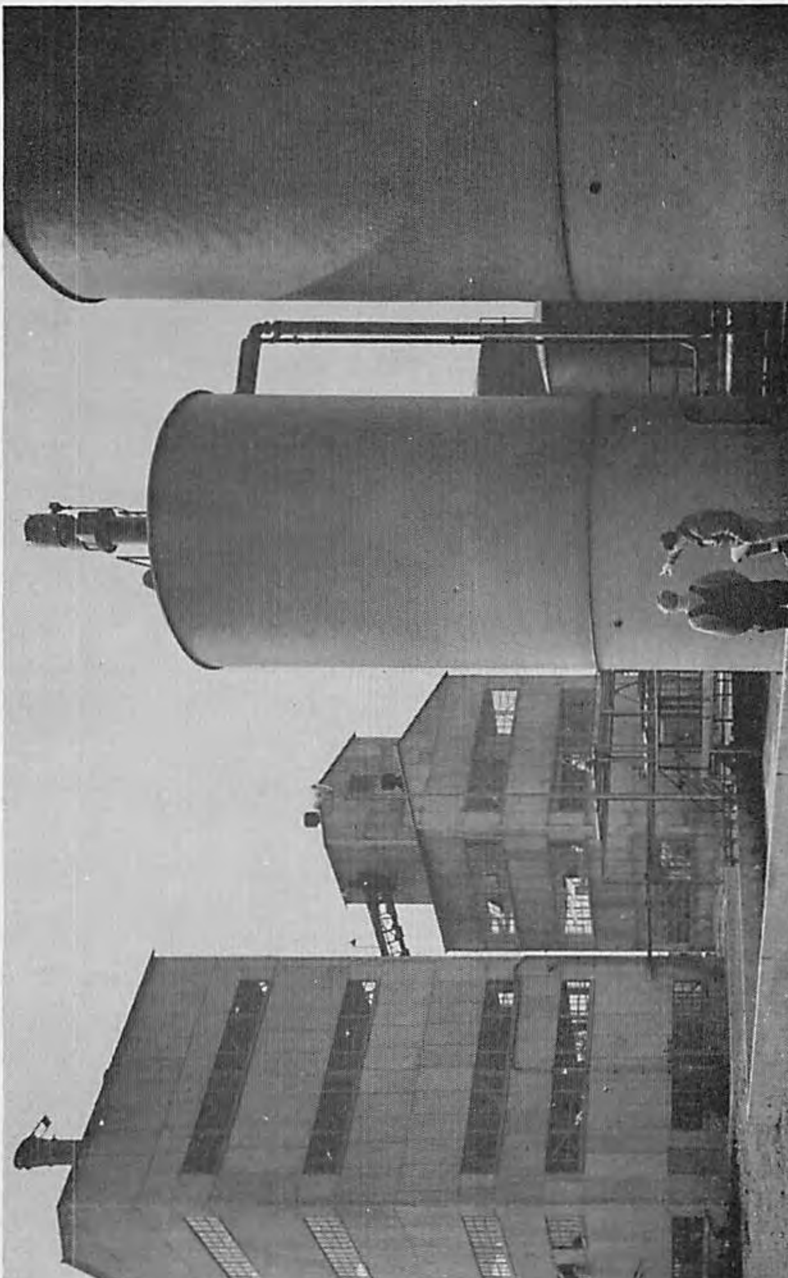
All motor starters are identified and mounted into a cubicle control center with sequence interlocking to insure starting the plant in proper order. If for any reason a motor driving a piece of apparatus should stop, the interlocking system will prevent spills by automatically stopping all motors driving units feeding coal to the shutdown apparatus. Push-but-



Ball mill and other equipment feature maximum of automatic control

ton stations for all motors, temperature indicators, recording controls, manually-operated controls and instruments are mounted on a vertical-type bench board. Once started, the plant works automatically. This extensive use of automatic controls and instrumentation makes it possible to operate the plant with a small crew. Equipment for coal preparation and handling is housed in a 32 by 32 by 79-ft. structural steel and corrugated cement-asbestos building with concrete floors and fireproof construction.

Although preliminary investigations indicate that high volatile, low ash coals are the most suitable for hydrogenation, the U. S. Bureau of Mines plan to test all types of American bituminous, sub-bituminous coals and lignite to determine their suitability for the hydrogenation process. The construction and operation of this unusual coal preparation plant marks the successful completion of one of the most important phases in the development of a process to produce liquid fuels from our extensive reserves of coal.



Coal preparation plant to the left and paste plate in center

*Reprinted from July, 1950 issue of "Mining Congress Journal" by permission of the authors and the American Mining Journal.*

*Note: In securing the permission of the authors for reprinting the following article we have been requested to call your attention to the following statement by G. B. Southward, Mechanization Engineer of the American Mining Congress:*

*The following report of the Haulage Committee is to show the possibilities for reducing costs through the use of prefabricated material in coal mine tracks. Factory turn-outs, rails cut to the desired length and pre-bent to the proper curvature, save time and labor underground.*

*In presenting this report, the Committee wishes to emphasize that the tabulations given here are designed to show the items which should be included in making comparative estimates; in such estimates local quantities, prices and labor rates should, of course, be used.*

# PREFABRICATED TRACK CUTS HAULAGE COSTS

By J. B. HASKELL
West Va. Steel & Mfg. Co., Huntington, W. Va.
and
J. R. ULRICH
Bethlehem Steel Co., Bethlehem, Penn.

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Track haulage has been used in coal mining since the early beginnings of the industry and today it is still the standby method, dependable and economical. The haulage system is the main artery of a coal mine. However, in the transition from hand to mechanical methods, the other operations—loading, cutting and drilling—received major attention. Improvements in haulageroad construction came last on the list and only in recent years have new methods and equipment been given the attention they deserve. A number of progressive companies, both operating and manufacturing, realized the need for a track system that would meet the requirements of high speed and heavy equipment. They led the way and railroad specifications for track construction are now being generally accepted by the industry, particularly in those mines that have completely modernized their operations.

Main line and intermediate haulageroads can be considered as more or less permanent installations. But in the working panels, the track is temporary. In a room it may be only a month or two from the time that a switch is laid in the neck until the place has been driven up, completed and the track taken out. In a panel of this nature considerable track work is needed and, using conventional methods, much labor is involved. In these days of rising wage scales, it has become essential to effect economies wherever possible. Prefabricated material has proved its worth in reducing track labor in a working panel.

## MINE NO. 1—ROOMS WITHOUT PILLAR RECOVERY

### CLASS 1—TRACK WITH RANDOM STOCK MATERIAL

Using steel room ties—wooden ties in entry and turnouts; 18' 0" rails in both entry and room track, standard joints, all cutting and curving of rail done by track laying crew.

| Material Used in Panel | Amount Material Used | Unit Material Cost | Purchase Cost of Material | Deprecia-tion Rate —Uses | Material Charged to Panel | Labor to Install— Move |
|---|---|---|---|---|---|---|
| Room Track | | | | | | |
| 3900 ft @ 40 lb....... | 54.9 N.T. | $78.00 | $4,280.64 | 13%— 7.6 | $557.00 | |
| Steel ties............ | 1,570 | 1.72 | 2,700.00 | 23%— 4.3 | 621.00 | $3,760.00 |
| Joints and bolts....... | 433 | 1.16 | 500.12 | 26%— 3.8 | 130.00 | |
| Entry Track | | | | | | |
| 144 ft curved<br>445 ft straight ...... | 8.18 N.T. | 78.00 | 638.00 | 13%— 7.6 | 83.00 | |
| Steel ties............ | 115 | 1.72 | 197.80 | 23%— 4.3 | 46.00 | |
| Wood ties............ | 1244 | .70 | 870.80 | 33%— 3.0 | 290.00 | 6,192.00 |
| Joints and bolts....... | 57 | 1.16 | 65.84 | 26%— 3.8 | 17.00 | |
| Turnouts—No. 2½........ | 26 | 115.00 | 2,990.00 | 8%—12.5 | 239.00 | 1,320.00 |
| Total............... | | | $12,243.64 | | $1,983.00 | $11,272.00 |

Total Labor and Material Charged to Panel, $13,255.00

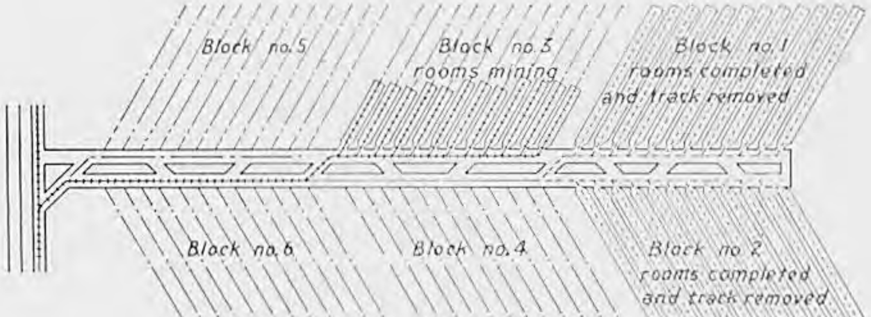
### CLASS 2—TRACK WITH RAILS PRECUT AND PRECURVED

Using steel ties in rooms and entry—steel switch ties with interlaced standard ties, standard turnouts knocked down with closure rail cut and curved. Stock rail precurved and all straight rails cut to predetermined lengths.

| Material Used in Panel | Amount Material Used | Unit Material Cost | Purchase Cost of Material | Deprecia-tion Rate —Uses | Material Charged to Panel | Labor to Install— Move |
|---|---|---|---|---|---|---|
| Room Track | | | | | | |
| 3900 ft @ 40 lb....... | 54.9 N.T. | $78.00 | $4,280,64 | 13%— 7.6 | $557.00 | |
| Steel ties............ | 1,570 | 1.72 | 2,700.00 | 23%— 4.3 | 621.00 | $3,760.00 |
| Joints and bolts....... | 433 | 1.16 | 500.12 | 26%— 3.8 | 130.00 | |
| Entry Track | | | | | | |
| 261 ft curved<br>562 ft straight ...... | | | 1,229.70 | 13%— 7.6 | 163.00 | |
| Steel ties............ | 1,359 | 1.72 | 2,337.48 | 23%— 4.3 | 544.00 | |
| Joints and bolts....... | 261 | 1.16 | 301.45 | 26%— 3.8 | 79.00 | 4,632.00 |
| Extra bolts........... | | | 25.00 | 100%— 1.0 | 25.00 | |
| Turnouts—Steel Ties...... | 26 | 132.00 | 3,432.00 | 7%—14.3 | 245.00 | 1,086.00 |
| Total............... | | | $14,806.79 | | $2,364.00 | $9,478.00 |

Total Labor and Material Charged to Panel, $11,842.00

Submitted by J. R. Ulrich.




Mine No. 1. Rooms without pillar recovery

## MINE NO. 2—ROOMS WITH PILLAR RECOVERY

### CLASS 1—TRACK WITH RANDOM STOCK MATERIAL

Using steel room ties; wood ties on the switches and turnouts; random length stock rails for straight and curved track and closure rails; standard purchased joints; all bonding, cutting and curving of rail done by tracklaying crew.

| Material Used in Panel | Amount Material Used | Unit Material Cost | Purchase Cost of Material | Depreciation Rate —Uses | Material Charged To Panel | Labor to Install—Remove. Labor estimated at $1.50 per hr |
|---|---|---|---|---|---|---|
| Straight Track: | | | | | | |
| 6004 ft @ 40 lb...... | 80 N.T. | $71.00 | $5,680.00 | 5%—20 | $284.00 | $2,332.50 |
| Joints and bolts...... | 600 pr | .855 | 513.00 | 12%— 8 | 61.56 | |
| Steel ties—No. 4. | 2000 | 1.35 | 2,700.00 | 10%—10 | 270.00 | |
| Curved Track: | | | | | | |
| 1594 ft @ 40 lb... | 21.3 N.T. | 71.00 | 1,512.30 | 5%—20 | 75.60 | 813.00 |
| Joints and bolts...... | 160 pr | .855 | 136.80 | 12%— 8 | 16.32 | |
| Steel ties—No. 4. ... | 530 | 1.35 | 715.50 | 10%—10 | 71.55 | |
| Turnouts—No. 2½....... | 42 | 82.00 | 3,444.00 | 5%—20 | 172.20 | 3,967.50* |
| Total...... .... | | | $14,701.60 | | $951.23 | $7,113.00 |

Total Labor and Material Charged to Panel, $8,064.23.

### CLASS 2—TRACK WITH RAILS PRECUT AND PRECURVED

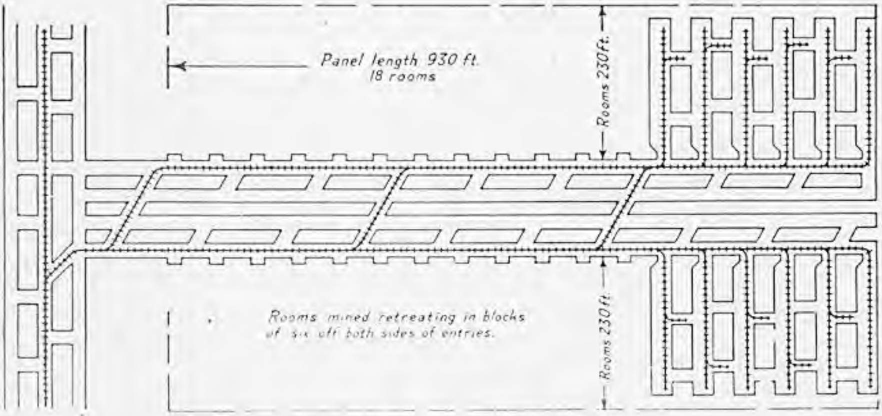
Using steel ties, steel switch ties with standard steel ties interlaced; standard purchased turnouts knocked down, but with closure rails cut and curved; stock rails precurved and all straight rails cut to predetermined lengths.

| | | | | | | |
|---|---|---|---|---|---|---|
| Straight Track: | | | | | | |
| 6004 ft @ 40 lb...... | 80 N.T. | $71.00 | $5,680.00 | 5%—20 | $284.00 | $2,332 50 |
| Joints and bolts...... | 600 pr | .855 | 513.00 | 12%— 8 | 61.56 | |
| Steel ties............ | 2000 | 1.35 | 2,700.00 | 10%—10 | 270.00 | |
| Curved Track: | | | | | | |
| 1594 ft @ 40 lb...... | 21.3 N.T. | ** | 1,894.86 | 5%—20 | 94.70 | 609.40 |
| Joints and bolts...... | 160 pr | .855 | 136.80 | 12%— 8 | 16.32 | |
| Steel ties............ | 530 | 1.35 | 715.50 | 10%—10 | 71.55 | |
| Turnouts—No. 2½........ | 42 | 98.00 | 4,116.00 | 5%—20 | 205.80 | 3,331.70 |
| Total............. | | | $15,756.16 | | $1,003.93 | $6,273.60 |

Total Labor and Material Charged to Panel, $7,277.53.

* Lay and remove 92 turnouts at 27 hours each.
** $71 per net ton plus 24c per lineal ft of track.

Submitted by J. B. Haskell.




Mine No. 2. Rooms and pillar recovery

Good track quickly installed is essential for mechanical loading

Prefabricated track, or a track system made up largely of parts machined, bent and curved at the factory, can be used to construct a good mine track system adaptable to all needs. Such a system is designed to fit a particular mine layout and all rails, both curved and straight, turnouts and other track material are so made that they may be used throughout that mine interchangeably with no bending, cutting or curving. The turnouts, with special switch ties, etc., are designed to be quickly laid and as quickly removed.

Rails are furnished in standard lengths having a direct relationship to the cutter bar being used and the clean-up distance in a working place. Certain other rails are also furnished in related lengths, such as 8, 12 and 16 ft., so that changes in room neck locations may be made without departing from the interchangeability of the system when the mining conditions dictate such changes. The turnout length is also made with a direct relationship to rail length so that when a turnout is picked up, standard rails may be used to fill the gap. It has been found that inaccuracies in turning the rooms do not adversely affect the laying of prefabricated track as many of these errors are cancelled out. In other words, a room spacing is just as liable to be slightly over the required distance as slightly under.

Estimated costs of labor and material are shown for completely mining a panel as applied to two conventional mining systems—rooms without pillar recovery and rooms with pillar recovery. In the tables, the track systems are shown as Class I and Class II; Class I is where the material is purchased on the market in random lengths and Class II is where the rails are pre-cut to correct length and pre-bent to proper curvature before going underground. In this estimate, Class II shows a considerable saving over Class I. Comparisons, however, should not be made between the two mining systems. The total costs for labor and material charged to the panel is given in a lump sum, and the per ton cost in each case would of course depend on factors outside of the track work, such as width of working places, height of seam and percentage of coal recovered from the panel.

There are several reasons for the cost savings in Class II. To begin with, in using prefabricated track there is no wastage from cutting and bending rails and, as a corollary, the rails have a longer life because cutting, rebending, etc., is eliminated. Steel ties can have many applications before renewals are needed and their installation and removal is easy and fast. With completely prefabricated material it is generally found that the rail may be laid in about one-third the time it formerly took under the old methods and this labor does not require experienced crews. Further labor is saved by the elimination of cutting, bending and drilling rails. Finally, through true gauge of track and proper alignment of turnouts and curves, there is less track maintenance as well as less wear and tear on mine cars and locomotives.

### Permanent Track

The foregoing deals principally with prefabricated track as applied to the working section of a mine. It is also well established that track for permanent locations may be prefabricated, and made ready to install, with a resultant saving in time and labor to the coal company. This especially may be the case where a complicated track arrangement is required, as for example where crossings, double crossovers, etc., are involved. The principal idea and purpose of prefabricated material is to save time and labor in the installation and removal of track in the mines, and at the same time permit better haulage and operating conditions with their resultant cost savings.

*Reprinted from July, 1950 issue of "Mining Congress Journal" by permission of the author and the American Mining Congress.*

# A PREFABRICATED TRACK OPERATION

By J. N. CRICHTON
General Superintendent, Johnstown Coal & Coke Co.
Beaverdale, Penn.

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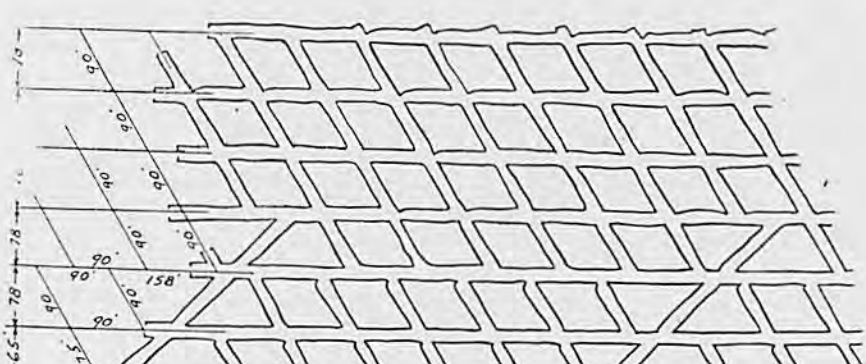
Prefabricated track is comparatively new to our company but certain advantages have been found in the short time it has been in use. Our experience has been in the Upper Kittanning or C prime seam where the seam height gives headroom to work efficiently. We have not used this system in low coal as yet.

Track haulage is employed throughout—from the tipple to the working faces where the coal is loaded mechanically directly into mine cars. In this system the time for the car change at the working face is the main factor that determines cost and production. Since it takes as much time to shift a one-ton car as an eight-ton car, as large a capacity car as can be handled is used. This reduces operating delays. Then, as a means to reduce the track work, the prefabricated method was adopted.

Experience has taught a great deal about how such track should be installed. First, the haulage layout must be coordinated with the mining system and the advance plan must consider all track details such as rail lengths, location of curves, switches and turnouts. Blueprints must show by identifying numbers where each straight rail, curved rail, frog, switch, etc., is to be located. The surveyors and trackmen must be thoroughly familiar with these details so that proper sight lines can be set and the layout plans followed. Then there must be periodic checks by surveys and



**Plan of a typical panel using prefabricated track with mechanical loading into mine cars**

measurements to see that no errors have accumulated. The foregoing may sound involved but it is comparatively simple in actual practice.

The track laying does not necessarily require highly skilled labor, as the blueprints are easily understood. Also, the work goes much faster with a consequent saving in labor cost. For example, two men can lay a room switch with steel ties in approximately two hours. After the track crews have learned the mining plan and have become accustomed to using the prefabricated material, there is no need for the detailed supervision required in conventional track work where all rails are cut, bent and fitted underground.

The supervisor or his assistant lays out the work, of course, but does not have to stay with the crew continually as the men can usually make the installation without constant bossing. The prefabricated material costs somewhat more than stock material but the additional expense is more than offset by the resulting economy in labor.

Prefabricated turnout reduces track labor

*Reprinted from 1950 "Coal Mine Modernization" Yearbook through courtesy of The American Mining Congress, papers presented at the American Mining Congress, Cleveland, Ohio, April 24, 25 and 26, 1950.*

# TRAINING HIGH SCHOOL AND ENGINEERING GRADUATES

By H. C. LIVINGSTON
Vice President, The Union Pacific Coal Company
Rock Springs, Wyoming

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Each and every coal mine operation is an individual problem which must be solved by giving due consideration to natural conditions in mine layout and planning, proper application of equipment and machinery and organization of cycle of operation from the working face to the preparation plant. Likewise, the training of supervisory personnel is an individual problem, depending somewhat on geographical location and the attendant available training facilities, but much more important, the selection of individuals to be trained for supervisory positions.

## High School Graduates

The influx of high school graduates into the mining industry has slowed greatly during the war and post-war years with a very recent indication of greater numbers desirous of gaining mine employment possibly due to increasing unemployment experience.

We believe there are few high schools offering any specific courses applicable to mining with the exception of mathematics, science and manual arts. We therefore accept the high school graduate realizing he has no knowledge of mining as such and start his embryonic career with the thought of accelerating his absorption of the subject by supplementing "on the job training" with regularly scheduled evening class room work under the direction of qualified engineering and operating personnel. We also encourage extension course work.

The mining laws of the State of Wyoming require a period of five years' practical mine experience and a minimum age of 23 years before examination for certification of gas watchman, unit foreman (face boss) or mine foreman. Our district wage agreement provides full direction of the working force and assignment of duties without regard to seniority. This allows the assigning of high school graduates to all phases of mechanical preparation and loading, haulage, timbering and mechanical and electrical maintenance. This is considered to be the five-year absorption or "on the job training" period.

Following two or three years of service in and around the mines, giving indication of the individual's desire to remain in the industry and expression of ambition for better things, together with an appraisal of his "individual thinking," he is encouraged to enter training classes for certification to supervisory capacity. The classes are conducted over a six months' period on Monday, Wednesday and Friday evenings from 7:00 to 9:00 p.m. under the supervision of the resident mining engineer, chief electrician, mine foreman and mine superintendent, with occasional discussions led by the safety engineer, general superintendent and general manager.

Classes in algebra, geometry, trigonometry, primary physics and chemistry, mine ventilation and hydraulics are conducted by the resident mining engineer. Practical and applied electricity, both a-c and d-c is disseminated by the chief electrician. Discussions in practical mining are led by the mine foreman with problems in labor relations and prompt handling of labor grievances outlined in detail by the resident mine superintendent. General officers instruct in the art of "human engineering" and "what it takes to make a good supervisor."

### Engineering Graduates

The qualifying period for engineering graduates from standpoint of practical mining experience differs from that of high school graduates under the mining laws of the State of Wyoming. The rules governing the Examining Board makes allowances in the amount of three years' practical mining experience for completion of engineering training and securement of degree. They also consider the duties of the graduate in his activity of mine surveying and general engineering in and around the mines over a two-year period to be equal to two years' practical mine experience. It therefore is possible for a graduate engineer to be eligible for examination and certification as gas watchman, unit foreman or mine foreman after two years' work in and around the mines.

We encourage all graduates to be examined for both gas watchman and mine foreman certification after two years' service. These men also enhance their training by acting as instructors in regularly scheduled classes for the non-engineering graduates.

The first assignment of the graduate engineer is usually as assistant resident engineer at one of the mining districts, his duties consisting of mine surveying, ventilation surveys, including testing for noxious and explosive gases, time studies and detailed monthly reports of inspection of conditions in and around the mine from an operating and safety viewpoint. Generally speaking, we await a spontaneous expression of engineers of their desire to leave straight engineering work and enter operations. At this time they are usually assigned the position of unit foreman or assistant mine foreman and encouraged to find their way through the ranks of mine foreman, assistant mine superintendent and mine superintendent to the upper level of management.

It has been our experience that although engineering graduates require a shorter period of time in which to absorb practical mining and develop "mining sense," it is necessary that they be completely exposed to all of the many problems of mine operation and have sufficient time to absorb same. There is a general tendency among engineering graduates to neglect the small details so necessary to maintaining cycles of an efficient operation and by the same token stress generalities and the over-all picture. Needless to say, this tendency requires correction. This problem, in what we might term "human engineering," is handled by the immediate supervisors, namely the mine foreman, mine superintendent and general officers.

The training of the individual supervisor at the lower level is a day-to-day problem and a definite part of the work of his immediate supervisor. Although a general plan of procedure is mapped out, we do not feel that there is any blueprint or stereotyped plan applicable to this problem. However, close contact and association with experienced and competent superiors concentrating attention on the initiate is the most successful approach.

General staff meetings are held at each district weekly and it is mandatory that all supervisory personnel attend, including the unit foremen (face bosses), assistant mine foreman, mine foreman, master mechanic, chief electrician, outside foreman, resident engineer and the mine superintendent. One of the general officers attends each staff meeting and current problems are thoroughly discussed.

The staff meeting conforms to that of an open forum discussion with top level supervisors lending direction to organized thought and the art of "human engineering." We find that weekly staff meetings encourage "individual thinking" and resolving of problems within the compliance of general policy and contribute greatly to the training of both high school and engineering graduates.

## Selection of Trainees

Selection of potential supervisors is just as important as the training after selection. Unfortunately, there are as many degrees of natural ability as there are supervisors and trainers. Regardless of whether or not the individual is a high school or engineering graduate, an inventory must be made of his aptitude and "individual thinking" revealing his attitude and qualifications of leadership previous to selection as trainee.

The demands of the industry require a good sound body and a mind not susceptible to emotional upset. Good character with the inherent quality of truthfulness regardless of consequence is mandatory. Intestinal fortitude and the ability to combat the desired inroads of labor is required. General scholastic background and formal training are much desired but not altogether necessary.

Finally, it is our opinion that *ATTITUDE* allowing decisive action demonstrating the individual's prerogative to be a definite part of management is the deciding factor in selection of a trainee for supervisory activity. Regardless of the individual's background and aptitude, his attitude and desire to be loyal to the organization and management he represents is the most important fact to be determined before selecting supervisory talent. An individual having the philosophy of "riding the fence" and not displaying loyalty to either labor or management is hopeless from the standpoint of developing to the stature of supervisory capacity.

*Reprinted through courtesy of the Illinois Society of Coal Preparation Engineers and Chemists. Summary of a speech delivered on May 19, 1950.*

# UNDERGROUND GASIFICATION OF COAL

By E. SARAPUU
Consulting Engineer, Sinclair Coal Co.; Graduate Student
Missouri School of Mines & Metallurgy

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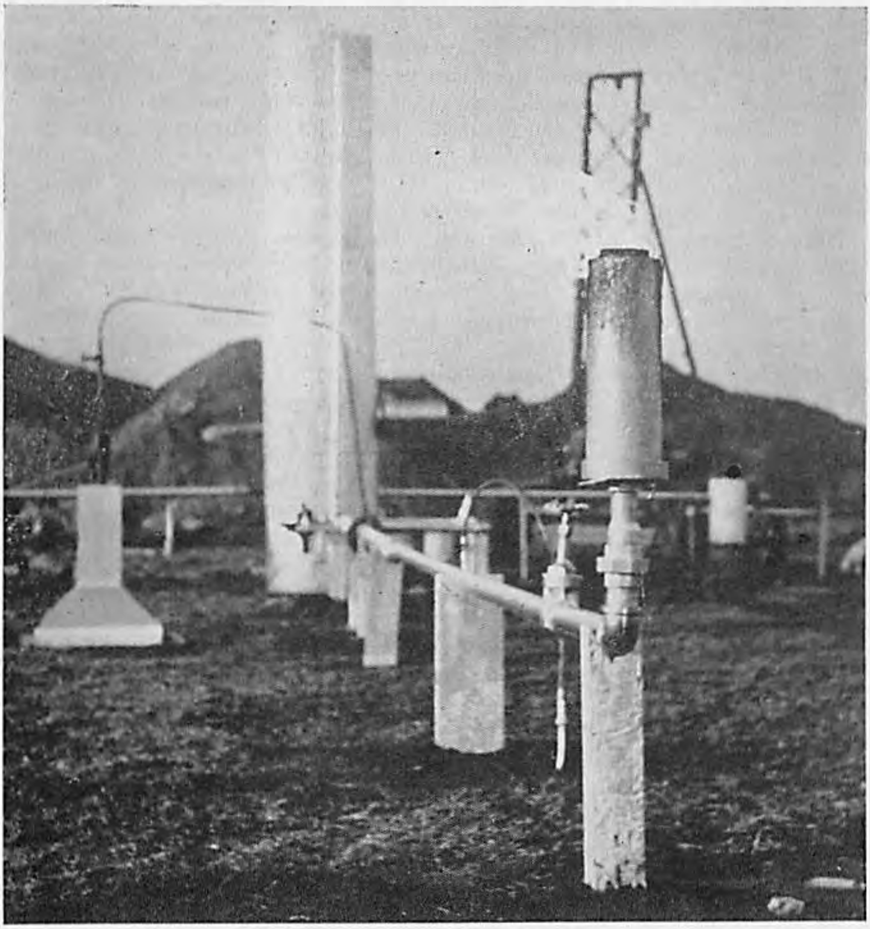
The extensive exploitation of our national reserves of liquid hydrocarbons has considerably increased the necessity of a new source and



**Underground Electrocarbonization Pilot-Plant in Operation**

technique for supplying our future requirements of liquid and gaseous fuels.

In this aspect, the tremendous reserves of coal deposits provide enough raw materials to supply our national demand for liquid and gaseous fuels for several hundred years.

The conversion of solid hydrocarbons into oil and gas is a well established technique by means of the hydrogenation process, or by means of gasification in retorts. However, the economical conditions vary from country to country, and therefore the application of new methods can be accomplished after economical results have been proved to be visible.

The underground gasification method can be considered as an integral part of modern fuel technology. Its aim is the duplication of results of the gasification processes so far obtainable only in the surface gasification plants.

It may be of interest to mention that producer gas, water gas, coke-furnace gas, and synthesis gas, have been actually produced by underground gasification. Briefly, the scientific foundation for underground gasification is well verified, but the further development deals with the technical and industrial phase of knowledge.

Visualizing the practical application of underground gasification in this country, I believe that the first economical result can be obtained by a combination of electric power plant and underground gasification unit. It is expected that the power plant will be close to the coal field, in order to eliminate a long piping system. This principle applies to the coal mines as well, which produce their own power.

The development of gas turbines opens a new possibility for producing electric current by means of underground gas. The actual economic data are very limited, due to the novelty of the underground gasification idea itself. In accordance with the Russian information, the generating cost of electric current by underground gas has been reduced about 25%.*

In Belgium, Professor Demart has published a figure indicating that underground gasification by a unit in Belgium can produce electric power with the price only 17.6% of the production cost by steam-operated power plant.†

In future progress, it can be expected that a synthetic fuel plant can be operated by means of underground gasification. Utilization of the Fischer-Tropsch method in connection with gasification in situ, should improve the economics of synthetic fuels, which at the present time are still too expensive to be produced commercially in this country. An additional possibility of the utilization of underground gas, is the use of the gas as domestic fuel. This surely can be accomplished only at places where no natural gas is available.

The newly developed shaftless underground method of "Electrocarbonization in situ" also helps to exploit the high-grade hydrocarbons deposits for oil production, like the boghead coal. For instance, a bog-

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* G. O. Nussinov: Underground Gasification, Moskau.

† P. Demart: World Power Conference. Transactions of the Fuel Economy Conference, The Hague, 1947. Band II, Sect A, No. 5. "Comment et pourquoi la gazeific tion souterraine tion souterraine peut ameliorer le prix du kWH." Page 654/661.

head coal in Brazil known as "Turfa de Marahu" yields up to 42% oil (by weight) by the carbonization process.

The production of smokeless fuel by underground "Electrocarbonization" can be technically performed after the economical problems are solved.

In summarizing the aims of underground gasification, it may be said that the gasification process in situ should supplement the total production of coal, but will not by any means replace the coal mining overnight. However, we can keep the idea in our mind that one of these days the coal miner will not need to go underground, but will execute his duties in surface plants using the underground gas.

Speaking about underground gasification, generally several grades of coal are considered as the raw material. In fact, all kinds of hydrocarbons can be subjected to the process of gasification in situ. The oil industry, as the closest competitor of the coal industry, has been investigating the problem for several years. The gasification of tar sand deposits and depleted oil fields can be classified as the thermal recovery of crude oil (secondary recovery). At the present time the experiments are still more or less on a laboratory scale, but the oil industry can expect much from this new trend in technique.

However, the underground gasification of coal has been considered of prime importance for our future fuel supply, and this problem should be investigated with adequate manpower and financial support.

Transferring the discussion to the chemical nature of underground gasification, one can say that the chemical reactions in situ are similar to the processes in gasification retorts. The difference exists in distribution of reaction zones, which spread essentially in horizontal directions instead of vertical as in the retorts.

The proper layout of an underground gasification unit has been under investigation by many researchers. At the present time, the problem of the size of cross-section per length of fire-drift is still unsolved. Our present knowledge depends more on experience than upon a sound scientific foundation.

The numerous gasification tests performed have proved a few principles, which should be considered when a new experiment is started.

The underground fire-drift should be layed out completely in coal. The exposure of rock in the fire-drift will consume considerable heat and reduce the gasification efficiency. The problem is slightly different when a deeply dipping seam is gasified. It is essential that the cross-section of a fire-drift not be over-dimensioned. The low gasification efficiency of operation is the first indication of improper dimensions of the underground unit. Secondarily, the amount of air introduced into the fire-drift has created a difference of opinion among the scientists, where the gasification efficiency was lower than expected. As underground gasification is performed by remote control, it is obvious that the whole problem is extremely difficult to handle.

It would be logical to use the computation made for designing a surface retort as a base for estimating the proper size of fire-drift. The deviations of the actual conditions should be correlated with base estimation and the limit of correction factors found.

The development of a shaftless underground gasification unit requires a quite different approach of investigation. The openings in the seam made by shaftless gasification are small in dimension, and therefore the gasification temperature is reached quickly. The composition of gas can be controlled directly with the input of air. The response of the gasification reaction is rapid, and from the gas composition, a proper conclusion can be made.

In spite of several theories of underground gasification, no single method has been found to be adequate for the varying geological conditions of coal. Therefore, the progress of underground gasification ideas can be illustrated by the development of underground gasification methods.

The Soviet Russia was the first country to start underground gasification tests with the aim of industrial application in the future. The problem has been under investigation for about 20 years in the U.S.S.R., and has found semi-industrial application. In further research, the Russians hope to build a full-scale underground gasification industry.

The history of Russian work may be divided into three different periods. At first the novel problem was approached with the idea of duplicating the conditions in the surface retorts. A method was developed for disintegrating the coal by means of explosives. Another method, "Chamber Method," was developed by an engineer, A. S. Kuznetzov. In accordance with his idea, special chambers were built directly into the seam and filled later with broken coal. The results of these tests were negative, and the Russians soon realized that this kind of gasification did not represent the true idea of underground gasification.

The second period of Russian work is characterized by the gasification of bulk coal. The "Stream Method" was successfully applied to deep dipping seams. This method is suitable for gasification of inclined panels of coal, which are opened on the bottom of the seam by a fire-drift. The "Stream Method" has been widely used in Russia, and could be considered as one of the best underground gasification methods in the U.S.S.R.

The third period of Russian work is represented by the development of shaftless gasification methods. This idea represents the true idea of gasification in situ.

A shaftless gasification method does not need underground openings, but the preparation is made through the bore holes from the surface. The shaftless underground gasification method can be prepared by several means, which create an induced permeability for gasification of the bulk material in the coal seam. The following ways have been developed in the U.S.S.R. and other parts of the world, for making an opening in the seam between the bore holes:

Filtrational Linking
Hydrolinking with solvents
Electrolinking
Electrocarbonization

It is expected that the modern research of underground gasification will utilize more and more of these new ideas. The results obtained in

Russia and the post-war conditions, created a tremendous interest in underground gasification outside the Soviet Union.

Several countries in Europe, like Belgium, France, Italy, and England, have started the investigation of these problems. At present, extensive research is continuing in Europe, and several tests have been performed. The first gasification test was started in Belgium (Bois la Dame). The idea of gasification of a depleted coal mine was successfully started, and a panel of 17,000 tons of coal set on fire. The second test was made in Italy (Valdarno), whereby the lignite was gasified.

The research in Europe is still in the preliminary stage, and no far-reaching conclusion can be made.

In accordance with the problem, a large-sized organization has been formed in Belgium and France.

In Belgium alone, a syndicate of 35 companies was formed, and the scientific problems divided among:

Mining and Geology
Gas Chemistry
Chemical Utilization of Gas
Thermic Utilization of Gas
Purification and Distribution of Gas
Experimental work — Material and Control

These committees held regular monthly meetings, at which time each person received specific assignments.

It is told that in France about 200 research men are involved in the development of underground gasification methods.

In this country the idea of underground gasification has found much discussion, and three actual field tests have been performed.

The new method of "Electrocarbonization" in situ was developed in the Missouri School of Mines. Dean Curtis L. Wilson and Dr. J. D. Forrester, Chairman of the Mining Department, have extensively supported the work done by the School of Mines. The field experiment of "Electrocarbonization" was arranged by the Missouri School of Mines, and by Mr. L. Russell Kelce, President, and Mr. Thos. C. Cheasley, Assistant to the President, both representing Sinclair Coal Company, Kansas City, Missouri. The field experiment has been made at Hume, Missouri, at the Tiger Mine of Hume-Sinclair Coal Mining Company.

In nature, the "Electrocarbonization" process is a direct heating method by means of electric current. Any kind of hydrocarbon can be carbonized or distilled (oil shale, oil in depleted fields, and tar sand deposits) underground by this method. The induced permeability simplifies the further gasification of residue without electric current.*

A large-scale underground gasification test has been made by the Bureau of Mines in Gorgas, Alabama.†

There is a marked difference in the two methods mentioned above. The gasification unit in Alabama is not a shaftless gasification, but exten-

* Mining Congress Journal, January 1950, p. 18.
* Popular Mechanics, April 1950.
† Bureau of Mines Report of Investigation: 4164 and 4651.

sive underground work is necessary. However, the scientists of the Bureau of Mines have solved the problem, and about 3,000 tons of coal has been burnt in Gorgas, Alabama.

An underground gasification test made by Carbon Chemical Corp. has yielded good quality gas. The preparation of the seam has been performed by horizontal drill holes, which is an excellent method for outcropping seams.

In the last five years a considerable effort has been devoted to the development of underground gasification in this country. From the technical point of view, we have started to investigate the problem under very unfavorable conditions, i.e., gasifying thin seams. The further progress of underground gasification in this country depends largely on the attitude of the coal industry.

It could be expected that sooner or later an organization will be formed by the coal industry which will be able to solve the problem completely.

*The following paper was presented by Fred W. Richart of Carterville, Illinois, at the November 2, 1950 meeting of the Mining Electrical Group at West Frankfort, Illinois. At this meeting there were in attendance 22 seniors of the School of Mining & Metallurgical Engineering of the University of Illinois, who were making a field trip.*

*Mr. Richart was graduated from University of Illinois class of 1891, received degree of B.S. in M.E.; was given a Professional Degree of Mechanical Engineer in 1902 at the University of Illinois. He has served the coal mining industry of Illinois faithfully and well since that time.*

# SIXTY YEARS OF POST GRADUATE WORK IN COAL MINING

FRED W. RICHART

Carterville, Illinois

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*Mr. Richart was elected an Honorary Member of the Illinois Mining Institute just prior to his passing away on December 10, 1950. He will be missed by all.*

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My first contact with a coal mine was in 1886, when commercial mines of Illinois had a capacity of about 500 tons of coal per day. This was graded into lump and screenings by dumping over a fixed bar screen. Screenings often had no sale value, and were hauled away and dumped. Carterville had one of the five banks of coke ovens in this area, which salvaged some screenings. The only cleaning device then in use was a tiny jig that processed the coal to be coked. Coking passed out about this date.

Five hundred tons, twenty-five 20-ton cars was a train load. I saw Bob Cavett, conductor-receiver for the Carbondale & Shawneetown Railroad, point with pride to a shiny locomotive on a side-track and say, "That is our new freight locomotive. She weighs forty tons!"

Itching to be an engineer, I farmed mystelf out to Alex Hope as an apprentice on the construction of the power plant for the new Fredonia Mine being developed by Ethan Allen Hitchcock for Cryatal Plate Glass Company just below St. Louis. My pay was what skill I absorbed. The power plant consisted of two 42-inch by 20-feet cylinder boilers (with no flues), two tiny steam pumps, one 12 by 24-inch, single cylinder, reversing engine, geared to a hoist drum, two non-dumping cages for 1½-ton pit cars, and a little steam driven mine fan. It was a modern mine in that day.

It took an expert hoisting engineer to stop the engine crank off center, so it would always restart without rolling the fly-wheel by hand.

The most I learned was how to drill a hole in boiler steel with a hammer and round-nose cold chisel; that one should never go to sleep on duty; that unprotected water lines may freeze in cold weather; and quite a good deal about human nature.

The mine boss had let a pipe line freeze and burst, after being warned by Alex to protect it. The entire gang worked like fury to repair the damage before the dapper Super, Dundas Simpson, arrived the next morning. We got it done.

The job finished, I was made fireman for a day, then made night watchman, for the engineer had plenty of time to do the firing. I slept comfortably, the steam went down and a pump froze up. The broken part might have cost $2 at the Blakeslee factory in DuQuoin. Alex could have made the gadget out of wood for the 60-pound pressure. But no one was pulling my chestnuts out of the fire. So I caught Dundas on the way to the train and resigned. In a week I was back in school preparing to enter the University of Illinois.

Less than nine years after that lucky incident, Hiram Willson, a new Super at that same Fredonia Mine, set me to work designing the No. 7 Mine of Big Muddy Coal & Iron Company, which we built in 1896. This company was headed by the same stern looking Mr. Hitchcock, Secretary of the Interior under President McKinley. He was a man of many interests, iron ore and plate glass in Missouri, an iron furnace at Grand Tower, mines, and coke ovens at Murphysboro, the Carbondale & Grand Tower Railroad (and Bryan's Train), which, by this time, had been extended through Herrin to Johnston City under the name, Chicago & Texas.

No. 7 was a milestone in coal mining. Conservatively built for 1500 tons in ten hours, during World War I it produced 2500 tons day after day — eight-hour days. Here is where I became a professional. I drew those plans three times before we were satisfied. We scrapped the fashion of square timber construction in favor of flat timbers interwoven and bolted together. Other new ideas were self-dumping cages, easy-tripping weigh hoppers, spring-driven shaking screens, heavy mine rails, 3-ton pit cars, a 600-foot square block of coal left under the tipple and planned under-ground workings that were religiously adhered to. I wore out my Kents' Hand Book, but it was well worth it. I experimented to learn the correct angle for a weigh-hopper bottom. Thirty-five degrees is correct.

John V. Schaefer, one of the founders of Roberts & Schaefer, was a year ahead of me at Illinois, and was working for Link-Belt Company. When it came to coal handling and a washery, I invited him to see us. We discussed the project a couple of days. A depression was on. Mr. Hitchcock did not want to spend the money for a complicated Luhrig washery, such as Sam Brush and Charles Dawes had built at Carterville two years before. That was a Link-Belt plant, the second such plant in America, I am told, the first being at Birmingham, Alabama.

Link-Belt also represented the Campbell washer, a simple bumping table affair of considerable capacity. We bought the rights to use this device, and built it ourselves, except for the power transmission and coal handling equipment. Schaefer took that order back to Chicago. I worked out the plans for the complete plant. It did a good job of cleaning for a plant of such trifling cost. Timber cost $10 a thousand. Mechanics got $2 a day. We had a bit of trouble making adjustments. The inventor, Mr. Campbell, came from Nashville, Tenn., and made the adjustments in a matter of minutes. In one day he taught us to be experts.

All the engineering above and below ground, laying out all the heavy timbers and supervising construction was my job. The plant was built on concrete foundations, another new wrinkle. I do not recall that a single error showed up on the job. And the only accident one cut finger. I enjoyed the responsibility, seeing the structures and equipment rise to completion, and the plant begin to turn out coal. That mine proved that there was coal outside the Murphysboro and Carterville areas. Other new mines quickly followed. It was the sparkplug for what you now see in this area.

In the booming 1900's I had my own little engineering business that kept me busy. We designed a dozen coal tipples, most of which were built. We had 25 mine surveying accounts. I got deep into electric power, and competition took much of the mining work. Mining surveys were then seldom made to guide the work. The mine manager did that with a small compass until the entries became so crooked the Super demurred. Paid-for surveys were made because the State inspector demanded maps of the workings. The map filed, management rested easy until he got another prod from the inspector a year or two later. When our gang started on a survey, the boss demanded, "How damn quick can you get through and get away from here?"

A side light to this was the tests I made in No. 7 to find out how truthful a compass could be in the maze of pipe-lines, tracks, pumps and hot trolleys. I found it off as much as 25 degrees and seldom within five degrees of correct. We had but two accounts where it was a pleasure to work, No. 7 and Mine A of Chicago-Carterville Coal Company. They wanted accurate work – and got it. That meant a lot of checking. Lack of a tie-in, or the least suspicion might call for several days of work. We decided that – and were never questioned. After ten years of wabbly working the Brush and Burr Mines wanted to be sure they were on their own properties. We made complete resurveys.

In 1900 Herrin promised to become a city. I had built several toy power plants and wanted to be a utility magnate. Mr. Eph Herrin was mayor and gave four of us a franchise. With little money and less credit we built the plant. Two partners got cold feet; I took their shares. We two could not beg or borrow enough to keep up with the town. We took on a stranger whose man Friday went haywire after making grandiose promises. It turned out that our third principal had troubles of his own, in connection with building a new statehouse (it wasn't Illinois), that he could not get rid of. There I was, Vice-president with a broke power company on my hands. After a receivership, in which I was it, we paid off the creditors and reorganized. That took five years, and the court never asked a question.

We bought a 500 Kw steam turbine, took on Carterville over a 33,000 volt transmission line, operated at 11,000 volts, and stuck our thumbs in our vests. I guess that was the first steam turbine in southern Illinois, outside of East St. Louis, and the first 33,000 volt line in Egypt. Quite soon Sam Insull's C.I.P.S. Company had growing pains and we sold out. For two years I ran this District C for Mr. Samsell, its president. When Samsell consolidated his 15 districts to three, I was out on the street.

With a reputation as a receiver, a coal receivership was my next job. It gave me an inside view in action. Production was quickly built up from 400 to 1200 tons per day, then a miracle happened. It was the sort that has happened many times to coal mines. It may be good or bad. This was good. Overnight coal went from $1.50 to $3.10 per ton, cash in hand before the cars were moved. Within the year the mine was handed back to the owners with a clean bill of health. I was out in the street again.

Very soon, I crawled under the tent into G.E. My chief asset was having been inside a coal mine. That was the knowhow G.E. happened to want at the moment. The reaction at home was not so comforting. My wife said, and she was deadly in earnest, "Why did you take that job? You can't sell anything!"

I was aware she might be right. I did have a raft of handicaps. I didn't smoke, drink or spew tobacco juice. Even worse, I couldn't repeat the tall tales that are the salesmans side-line. But I said to her, "I'll be there when the whistle blows."

Fortunately, for six months all I had to do was to get a certified promise from Schenectady when we would ship. We had a war then. I also listened patiently to complaints of how badly our G.E. equipment acted up. Apparently, mine superintendents, store-keepers and electricians had never before been able to out-talk a salesman. I said little. Sometimes I fixed the trouble, or told them what to do. Other cases were referred to the office or factory.

I realized the bad impression my reports were making, when a high-up Erie engineer refused to notice me in the St. Louis office. I just sat tight. Soon after, I ran into a hot complaint. Jim Mayor had worked for me at No. 7. He was wedging a ball race into its recess. I said, "Jim! You are wrong." He said, "But here is what happens." We didn't know too much about ball bearings then. It was Greek to me. A wire brought that same engineer, pronto. He fixed it in minutes and ordered the change made on about 80 locomotives. Thereafter, I got hearings and—Pat Heap.

You seniors don't know about Pat. He was one of G.E.'s. crack trouble shooters. Wise and tactful enough to be sent all over the Mid-West — on occasion. If it was too deep for Pat, we had the District Engineer or Schenectady on tap. You boys may well learn that service and team-work will make friends anywhere — even your enemies will buckle under if you are persistent.

I got into G.E. just in time to cash in on the huge business from the strip mines of this area. Many problems were to be solved. I had the pleasure of being helpful on many of them. In the early twenties, coal stripping used a collection of badly designed, inadequate machines that were full of grief. Today, everything does that massive job on schedule, and without flinching. Thirty years have shown us what engineers can do, once they realize the difficulties. Mining is a mans' job, any way you look at it.

Perhaps you do not realize that fashions play as great a part in mining machinery as they do in women's dress. However, there are more engineering reasons behind machinery styles than are involved in clothing. It is interesting to note how quickly new machines and methods sweep through the industry, once they meet the test. Look at rubber belt hoists. They are in style and are successful. Development of some modern machines has taken many years; sixty for coal cutters, twenty for a loading machine. Very few satisfactory mining gadgets come directly from the drawing board. It usually takes years of heart-breaking work to get *all* the bugs out. Trial and error finally triumphs.

From a sales engineer's point of view, getting a head start has real advantages. That was my good luck in introducing electric arc welding and selling to strip mines, and, coal washers as well. It also leaves sore spots if your products fail to make the grade. Portable electric cables were one of my bad dreams, until G.E. got down to brass tacks. John Foster was one of my friends who could not wait. Then it was almost too late, for Bill Davis had a lot of my customers wrapped around his finger. I want to say that our Illinois coal mines have done their share in helping to develop better tools for their work.

That coal washer item, just mentioned, needs some explanation. In the early 1900's there were 15 coal washers around here. They all went out during World War I, because raw coal sold for just as much money. They were never resurrected. The present boom in coal washers was started by Charles F. Hamilton at the Pyramid Mine in 1933, because he had to do something about his "Standard" screenings. He had bought that first little washer, with motors and control, before I had heard a word of it. My face was really red. Lucky for me, it was all G.E. It might be that I had given Charley the G.E. habit.

For, more than ten years before, he had ordered a $60 volt-meter by mail, for his first, toy sized, steam driven, strip mine, near Marion. I hadn't called because it was steam, and I hadn't met Charlie. My morning mail brought a copy of a letter to him, asking that he accept a C.O.D. It sent me to his mine in high. I drove an open Ford runabout, and there wasn't a mile of concrete highway in Illinois.

When I arrived, Charlie had decided to cancel the order. We talked, got acquainted and he said "Let it come, it doesn't make any difference." I replied, "I think it makes a lot of difference." I knew that C.O.D.'s were not relished, besides, George F. Campbell was Vice-President of his company. I drove to St. Louis at once. It took six hours in the 4-inch dust.

Next morning I faced a new credit manager, a green lad. He slammed a fistful of papers on the desk, and said, "It's *all* water!" I pointed to George Campbell's name on the letter head and said. "*He* runs Old Ben Coal Company. Old Ben is our best coal mining customer in Illinois." That set the young man back a bit. After a long silence he decided, "I guess we can take a chance." I replied, "We better." The meter was shipped open account.

Charlie Hamilton's companies have given G.E. more than a million dollars of business. I don't know how much more.

I wish to address a few words to our guests. New engineering developments in coal mining appear at such a rate that you must be ready, any day, to change your minds as to materials, machines and methods to be used. With G.E., I came to the point of expecting a new gadget or method every Monday morning. The coal industry has been made over several times since my freshman days. For example, haulage has gone from man-power to mule-power, to wire rope, to electric locomotives, to rubber-tired vehicles, to rubber belts. Only new mines in the making are apt to have all the up-to-date gadgets. The application of new and unusual materials is endless.

Safety is a top bracket subject at all coal meetings. Here are a few items originating or developed here in Egypt. Rock dusting was originated by Old Ben Corporation. Cardox and Airdox were invented by Dent Ferrell and his friend Helmholtz, and put into use by the Bell & Zoller Coal Company interests. Dent is a graduate of Illinois. Roof bolting was devised by C. C. Conway of Consolidated Coal Company, another graduate of Illinois. Loxite, liquid oxygen and soot, was introduced here by Don McCloud for blasting strip mine overburden. His company, Airmite-Midwest Inc., perfected it.

You men will find no finer mines or more modern equipment in America than you see on this trip. Still I can vouch for the fact that it has been no breakfast spell to sell some of the most needed devices. Enclosed motors, weatherproof switchgear, better cables, electric arc welders and 100-percent lightning protection have come because some one dared to buy first. In spite of my handicaps I have enjoyed the humble part I have played – helping others.

Now we come to the most important adjunct of the coal mine, the men who run it. Interesting as all these other items are, they are topped by the men who keep the wheels turning. Whether president or trip-rider, engineer or salesman, they command your attention. You may learn something you need from any one of them. The more quickly you absorb their knowledge and slide smoothly into gear, the sooner you will reach the control room. Regardless of the "*A*'s" on your grade card, you have to live and work with them. The climb isn't too hard, and is rewarding.

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# CONTINUOUS MINING IN ILLINOIS

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First, let us consider what continuous mining will mean to the coal mining industry. Continuous mining makes possible greater concentration of the working places than with any other method of mining known today. This will decrease ventilation problems, serve to concentrate supervision at the face where required, simplify power distribution, reduce the equipment required for haulage, and increase the rate of opening a mine or of developing a new section. Of possibly even greater importance in a fully mechanized mine will be the simplification of maintenance by decreasing the many different types of machinery used at the face and the resultant reduction in inventory of a wide variety of parts and supplies. All of this contributes to lower cost coal production.

## Early Experience

The Old Ben Coal Corporation installed one of the early model Joy Continuous Miners in February, 1949. This model has an operating range from about 56 in. up to 96 in. maximum seam thickness. This machine was originally used for heading development work with one 7-ton shuttle car acting as a surge bin remaining directly behind the Miner at all times. Another 7-ton shuttle was used as a transportation car discharging directly into 7-ton mine cars.

We are using four men on each loader at the face, the crew consisting of two operators, one shuttle car operator and one motorman. The surge car has an extension control at the miner so that the operator can unload it into the shuttle, which relieves the second operator for other work such as line brattices, hose for water spray, taking sights, handling power cable and keeping the surge car under the discharge conveyor of the miner.

Some mechanical problems were encountered which had to be worked out over a period of time by careful observation of actual operations, by our own maintenance crews and by factory engineers. Among the most serious of the early problems was excessive leakage of hydraulic oil and bursting of hydraulic lines and hoses which is being overcome by improved piping methods and higher pressure hose lines. One of the basic problems of our first machine was its inability to clean-up coal spillage on the mine floor; this had to be loaded out by hand shoveling or by a Joy Loader.

Our second continuous miner was received at Mine No. 9 in December, 1949. This machine was equipped with hydraulically driven retractable clean-up scrolls which function to move the spillage coal from either side of the machine to the center where it is loaded by the action of the ripper head. This is not considered the most desirable arrangement and later models are being equipped with a scroll arrangement which will load the spillage coal directly onto the conveyor chain. Another feature of the new machine is an automatic high pressure lubrication system for the large turntable bearings and for most of the other moving parts. This system provides continuous lubrication to these bearings and overcomes a tendency for the main turntable to become sluggish in operation as was experienced on the first machine.

### Present Practices in Operation and Maintenance

We have done considerable experimenting to improve the size consist of the coal produced. In cooperation with the engineers of the Joy Company, our third continuous miner was equipped with a 5-chain ripper head instead of the conventional 6-chain. The 5 chains are spaced farther apart so as to leave a larger core between; in addition, the chain speed was reduced by changing the gear ratio from 6.9 to 1 to 8.5 to 1.

A comparative analysis of size consist from the standard machine and from the modified machine is given herewith. Cumulative consist data for the five-chain unit shows a reduction of 1.67% of $\frac{3}{16}$ in. carbon ratio, 4.98% less ¾ in. x 0 and 2.25% less 1½ in. x 0. Unfavorable results are shown within the coarse coal divisions where the lump dropped from 2.8% to 0.6% and the 6 x 3 in. dropped from 5.2% to 3.6%. The plus 3 in. material dropped from 8.0% to 4.2% with the loss equalized in the earlier divisions above 2 in. compared to the present finding of 16.3%.

It should be of general interest to compare maintenance data with similar data from a fully mechanized mechanical loader section. Our maintenance cost on the continuous miners for the year to date for labor, supplies, lubricating oil, dust control and bit sharpening is .1413¢ per ton, while the maintenance cost on our fully mechanized loader section is .1407¢ per ton.

Since the major part of the power in a continuous miner is expended ripping out the coal, it is evident that one of the major sources of maintenance will be in the ripper head mechanism and with the bits. The ripper chains and ripper head guides on our last machine have been substantially redesigned, based on experience and weaknesses which developed in the earlier machines. It has been found that very substantial guides must be extended the full length of the ripper bar in order to securely hold the chains in place particularly when digging the firm hard coal in the Illinois No. 6 Seam. Since the bits must take much abuse, we recommend that the manufacturers do substantial research to provide better bits for this service. We understand from the manufacturer's engineers that a new type has just been tried in a mine in the East that more than doubles bit life. These have not yet been tried in our conditions in the No. 6 Seam.

The requirement of dust control is really higher than it has been with our other types of operation. For each miner we have two 1800-gallon water tanks, a turbine pump, pressure tank with pressure switch set to start the pump when the pressure drops to 190 pounds and stops the pump when the pressure reaches 230 pounds. The water is piped from the pump set as close as possible to the miner through a 1 in. pipe to within 200 feet of the miner, then through a 1 in. hose to the miner. We are using 8 cone-spray nozzles on our machine, 4 of the spray nozzles are located above the ripper bar and 4 nozzles below the ripper bar using 5 gallons of water per ton of coal mined.

Of utmost importance for continuous operation is good power. With conventional equipment we can get by on low voltage but such is not the case with the continuous miner because of substantially reduced productive capacity when operating on bad power. Good power is a "must" with this machine. Our demand records show a root-mean-square average of approximately 85 KW with occasional 200 KW peaks for a 30 second period. A 300 KW power source should provide adequate power for two continuous machines, providing sufficient size distribution cables are used.

## Conclusion

We understand that results secured with continuous mining in other coal seams vary widely from results secured in our particular conditions. This variation affects size of coal, productive capacity, roof control, and bit life. Only careful analysis of each condition by men experienced with continuous mining work will make possible a general forecast of the usage of these machines on a nation-wide basis.

In conclusion our experience indicates that continuous mining is now an accomplished reality and that substantial cost savings can definitely be effected today as compared with any other known mechanized method of mining. How great these savings will be and how generally continuous machines can be applied will depend largely on the degree of perfection possible on current machines and on more conclusive tests as to the sizes of coal which can be produced by these machines and marketed.

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# SERVICE HAULAGE FOR CONTINUOUS MINING

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If a continuous mining machine is to be truly continuous, coal must flow from it without interruption. Several different methods of doing this have been tried using various types and combinations of equipment. Each method can be made to provide an uninterrupted flow for a given mining plan and for a given set of physical conditions. Distances are constantly changing. Mining conditions may change quickly. Both invariably result in an interruption in the transportation system which, in turn, causes a stoppage of the continuous mining machine.

## Shuttle and Surge Cars

Shuttle cars have been most commonly used behind continuous mining machines, usually in pairs. They were first used in the same manner as when serving a conventional caterpillar mechanical loader. This system resulted in delays to the operation because of shuttle car change time. The next step was to use one shuttle as a surge or storage car. Its purpose is to take the discharge of the continuous machine while the second car trams to the belt or loading station, unloads and returns to the surge car.

The success of this system in providing continuous transportation depends on the production rate of the mining machine, capacity of the surge car, and distance to the loading station. A typical example will illustrate. In a seam of coal 45 inches thick, the present day continuous machine will average one ton per minute through its cycle across the face. The average shuttle car that has been used in this thickness will hold about three tons of coal. Thus the mining machine will fill the surge car in three minutes. The second shuttle car must therefore, receive its load from the surge car, tram to the loading station, unload itself, and tram back to the surge car in three minutes.

A shuttle car averages about three miles per hour tramming speed or about 264 feet per minute. It requires about 30 seconds to receive its surge car load, and about 30 seconds to discharge its load at the loading station. Only two minutes are left for the round trip of the transportation car. This time limit permits a maximum distance from the loading station to the machine of only 264 feet. Beyond that distance it is impossible to have continuous operation because there is no longer continuous transportation. Even at 264 feet, the shuttle car may be slowed down, by soft bottom, close timbering, or grades.

Thicker seams permit the use of larger capacity shuttle and storage cars. If the car capacity can be doubled to six tons, then theoretically the one-way tramming distance can be 660 feet, or 2½ times as long as when using the three ton car.

The advantages of the shuttle car-surge car method may be listed as follows:

*Flexibility:* Shuttle cars, when used within proper tramming limits and certain mining plans, are probably the most flexible of any system used today.

*Portability:* Shuttle cars are the most portable of any type equipment. They are instantly movable, under their own power, when it is necessary to move the continuous machine to another place.

Some of the disadvantages of the shuttle car system are as follows:

*High Capital Cost:* A shuttle car and a surge car together cost about $25,000.

*Limited Application:* There are certain mining systems to which shuttle cars cannot be applied without difficulty. This is particularly true where pillars are pulled on the retreat, where space limitations usually prevent the most effective use of shuttle cars. It is difficult to keep the surge car directly behind the continuous mining machine when making 90° turns. This same difficulty is encountered between the surge car and the transportation car.

*High Maintenance Costs:* There is a considerable amount of machinery involved in two shuttle cars. This enhances the chance of breakdowns. It also increases the probability of stoppage to the continuous mining machine.

*Operational Limitations:* When the coal seam has a soft fireclay bottom, the water used to lay the dust softens the fireclay and shuttle cars tend to mire. This slows them down, or stops them completely, unless the roadway is planked.

### Caterpillar Loaders Supplement the Haulage

A second plan has been tried to a limited extent, using a combination of equipment, consisting of a medium capacity caterpillar loader and one shuttle car. With this system the coal coming from the continuous machine is spilled directly to the mine floor. The caterpillar loader picks up this coal and loads it into the shuttle car for transportation to the loading station. This plan makes the continuous machine independent of the transportation system and allows it to work continuously.

The main advantages of this method are:

*Flexibility:* It permits of more flexibility than the plan using two shuttle cars.

*Portability:* It is equally as portable as the first plan.

*Continuous Transportation:* This combination, although intermittent in its operation, actually serves as a continuous system in that it permits the mining machine to operate continuously.

*Ability to Clean Up:* Normally, the continuous machines leave an appreciable percentage of coal on the mine floor which must be loaded by hand. In this case the tractor loader will load out all the coal mechanically unless prevented by close timbering.

This system naturally has its disadvantages. The loader replaces the surge car in the first system. Its cost is higher than a shuttle car, therefore, the capital cost is somewhat greater. Maintenance costs most certainly will not be less than the first system and probably will be somewhat higher. This equipment also is somewhat inflexible in retreat pillar drawing. Too, it has the same operational limitations, as has the first system, when working over soft fireclay bottom. The tractor loader would also have a tendency to pick up fireclay.

## Shaker Conveyors

A third system being tried involves the use of shaker conveyors used in conjunction with 45° angle troughs and Duckbills. The shaker drive is set to discharge on a belt. A new design of column trough is used. It is made of special lightweight alloy steel or aluminum which reduces the trough weight by 25%. It has quick-acting clamps instead of bolts for connecting troughs together. By using the extensible telescopic trough the continuous machine may advance a total of 26 feet before it is necessary to add troughs to the pan line. Sideboards can be added to the head of the Duckbill forming a receiving hopper beneath the discharge of the continuous mining machine.

The use of two 45° swivels allows the shaker to follow the continuous machine through a 45° cross-cut to either left or right parallel headings, and to continue the driving of the parallel headings until the next cross-cut is started.

Some of the advantages of this equipment are as follows:

*Flexibility:* The shaker conveyor is quite flexible, especially when used behind the continuous machine in development work. Lengths up to 400 feet can be used.

*Continuous Transportation:* Shaker equipment provides continuous transportation except for pan-up time. This operation may occur from two to four times per shift, depending on the rate of advance of the continuous machine, and, with modern equipment, will average about ten minutes per extension.

*Adaptable to Soft Bottom:* The shaker will operate successfully over soft fireclay bottom.

*Low Cost:* The capital cost is less than one-half that of shuttle cars or shuttle car and loader.

*Maintenance Cost:* Should be considerably less than that of the first two systems.

Disadvantages of this equipment may be listed as:

*Immobility:* When the place is finished, or the limit of pan line length has been reached, it is necessary to move the drive and pan line either forward or to the next working place. This moving time must be done on an off shift and represents a cost not found in the first two systems.

*Grades Decrease Capacity:* Adverse grades against the load reduce the capacity of the shaker. Larger cross sections of troughs and increased strokes per minute, coupled with dimpled lagging of the bottom and sides of the trough, will offset average grades. Nevertheless, where extreme adverse grades are found the shaker capacity will be greatly reducd.

*Not Suitable for Pillar Drawing:* Space limitations and inability to drive a Duckbill at 90° to the pan line prohibit successful use in pillar work.

### Haulage Experiments in Progress

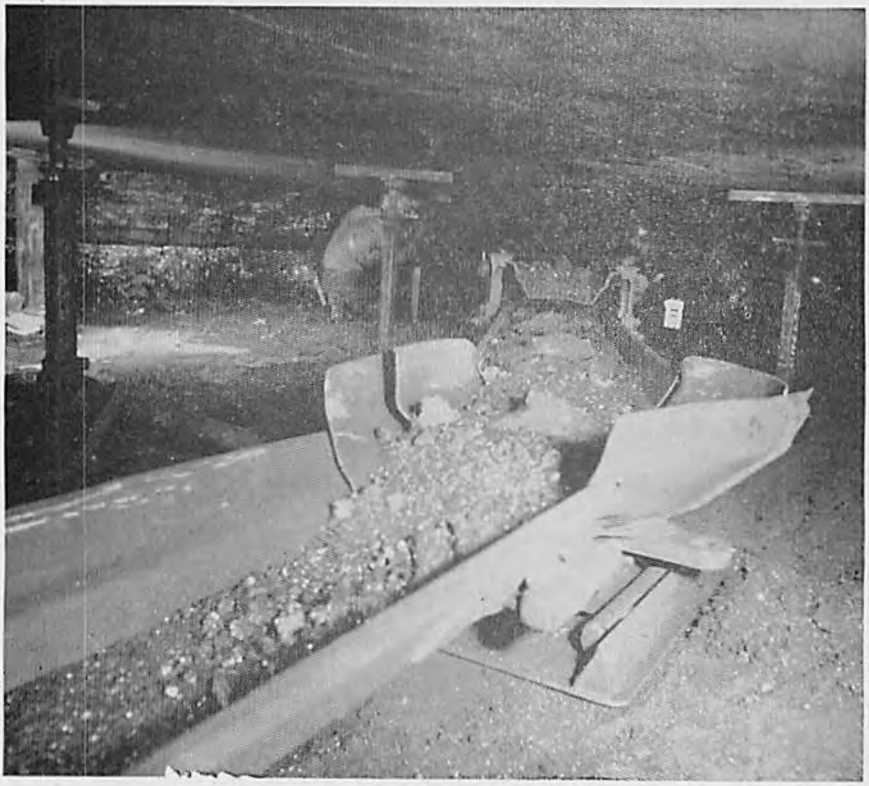
It will be noticed that all three transportation methods described work quite well in advance or development mining. All three have a common weakness—they do not lend themselves to retreat or pillar mining. Several schemes have been suggested to overcome this weakness. Some are in use now, and others are still in the planning stage.

One experiment, now in use, employs a series of light, portable belt conveyors operating in tandem, between the continuous mining machine and the inby end of either a belt chain or shaker conveyor. These portable belts are made largely of aluminum and weigh about 750 pounds each. They are about 19 ft. long, mounted on two rubber tired wheels and each unit has its own drive motor. This combination has not been in use long enough to give it a fair trial. The main complaint so far has been the awkwardness in handling and the difficulty in keeping them lined up with each other to prevent spillage.

Another experiment now on trial uses a "Piggyback" conveyor between the continuous mining machine and a shaker conveyor. The "Piggyback" is a chain conveyor 33 ft. long with the outby end attached to the column type trough of the shaker. This end of the chain conveyor travels on rollers along the trough line. A patented swivel arrangement keeps the discharge directly over the center of the shaker trough, even when the "Piggyback" is at right angles to the shaker.

The inby end has a receiving hopper, mounted on rubber tires that can be steered manually. The hopper end follows the continuous mining machine, working at right angles to the heading while the discharge end travels along the pan line. This experiment has been in operation only a few shifts and not too much is known regarding its advantages or disadvantages.

Many minds are working on the problem of continuous transportation behind continuous mining machines. Different mining systems will bring forth different types or combinations of machinery to eventually provide continuous transportation.



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# POWER FOR CONTINUOUS MINING

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The development of electrically powered mining machines now in use throughout the coal industry has been largely responsible for the fact that American mines produce more coal per man-day than mines in any other part of the world. This entire mechanization program has required the solution of many new problems never before encountered in underground mining operations. Perhaps the most important of these has been the necessity of devising more effective means of providing adequate power for the machines which have replaced human efforts.

The elimination of hand labor through the use of machinery has been a gradual process recently climaxed by the development of continuous mining machines. These machines and their associated power supply and control units represent a major investment on the part of the mine owners. In order to obtain the greatest possible benefits from these machines, it is important that they be operated at peak efficiency as much of the time as possible.

The newest continuous mining machines combine all cutting, loading, and blasting in one operation. For this reason, it is essential that they operate on a truly continuous basis. When the power supply fails or the machine itself is shut down, coal production is immediately reduced to zero. When mining machines are made up of several separate components each doing a portion of the work, the failure of one machine does not necessarily shut down all of the other devices. It is for this reason that special care must be taken to assure uninterrupted operation.

## PART I — POWER SUPPLY

In order to achieve maximum effectiveness from continuous mining machines, several factors must be considered. These include: design of the mining equipment itself, mining plans and power design. This paper will consider power supply requirements for continuous mining machines, but it should be stated that the discussion following is based on available data, which is by no means complete. Several types of con-

FIGURE 1
"SUMMARY AND COMPARISON OF CONTINUOUS MINER LOADS"

| Unit | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|
| R.M.S.I. | 262.5 | 365 | 416 | 260 | 305.6 | 371.4 | 384 | 145 | 300 | 150 |
| R.M.S. K.W. | 66 | 91 | 104 | 65 | 73 | 81 | 96 | 77 | 66 | 80 |
| Peak Amps. | 700 | 800 | 900 | 680 | 700 | 780 | 740 | 242 | 675 | 240 |
| Min. Volts | 215 | 230 | 230 | 250 | 200 | 120 | 210 | 483 | 150 | 475 |
| Max. Volts | 290 | 255 | 270 | 270 | 260 | 270 | 270 | 564 | 270 | 560 |
| Coal Seam | Ind. #7 | Ill. #6 | Ill. #6 | Ill. #6 | Ill. #6 | Ill. #6 | Ill. #6 | Pitts. | Ill. #6 | Lower Freeport |

1. All figures at nips except for #8 and #9. Readings for #8 and #9 taken at machine.
2. Machines #6, #8, #9 and #10 equipped with 300 ft. of 2/0 cable. All others equipped with 300 ft. of 4/0.
3. R.M.S.I. and R.M.S. K.W. includes down time.
4. Power losses in feeders not included.

tinuous miners have been announced, but only one has been used in production, in various seams, under a variety of mining conditions, and therefore this discussion is based on this type of machine only.

The primary purpose of any power supply is to provide adequate power, at an adequate voltage, at the desired point. Although adequacy is of primary importance, cost will necessarily affect the definition of "adequate." It is not the intent of this paper, however, to consider the subject of costs, but to discuss the most efficient manner of supplying power to the continuous miner.

## Results of Power Tests

It is necessary, as a preliminary step, to define "adequate power" and "adequate voltage" in more concrete terms. To do this, we have taken several typical load curves of individual mining machine motors, continuous mining machines and face operations and attempted to analyze them as to the actual power requirements. Average loads, peak loads and characteristics of the cycle vary with the nature of the coal seam, the height of coal, and other factors which cause widely different readings, even in the same mine. However, the curves taken will indicate the general nature of the load imposed by these mining operations.

Figure 1 is a tabulation of the results of several power studies on continuous miner installations in several seams of coal. Units 8 and 10 are 500 volt, the rest are 250 volt machines. The root mean square currents and kilowatts may be somewhat misleading, since downtime was including in calculating them. The peak amperes indicate the maximum demand on the distribution system. The average peak current of the 250 volt units is 747 amperes, and of the 500 volt units 241 amperes. The minimum volts show a very wide range, indicating a considerable difference in distribution systems. It is also possible that haulage or other loads affected the voltage readings.

Figure 2 shows voltage and current readings on a continuous miner motor in operation. The high current peaks, which are matched by voltage dips, indicate high torque requirement on the motor. It should be noted that this high current peak, occurring once each cycle, is matched by a corresponding voltage dip.

Figures 3, 4 and 5 are load curves taken on an actual operation, and include not only the miner, but its associated equipment, that is, shuttle cars, high pressure pumps, etc.

Figures 3A and 3B were taken out of a full shift chart on a set-up consisting of one continuous miner and two shuttle cars. Each curved time interval represents 10 seconds, and the ampere scale is 600 amperes for full scale. Figure 3A shows a peak current of 264 amperes and RMS current of approximately 156 amperes. Figure 3B shows a peak current of 240 amperes, and a RMS current of approximately 167 amperes. This machine is operating on a 500 volt system. It is apparent that there is considerable variation in load, even under identical conditions.

Figures 4A and 4B were taken on a twin set-up which included two continuous miners, four shuttle cars, a high pressure pump, a 25 HP belt conveyor and a 10 HP car spotter. The miners were working on opposite sides of the belt conveyor. Current and time scales are the same as Figure 3A and 3B. Figure 4A shows a peak current of 510

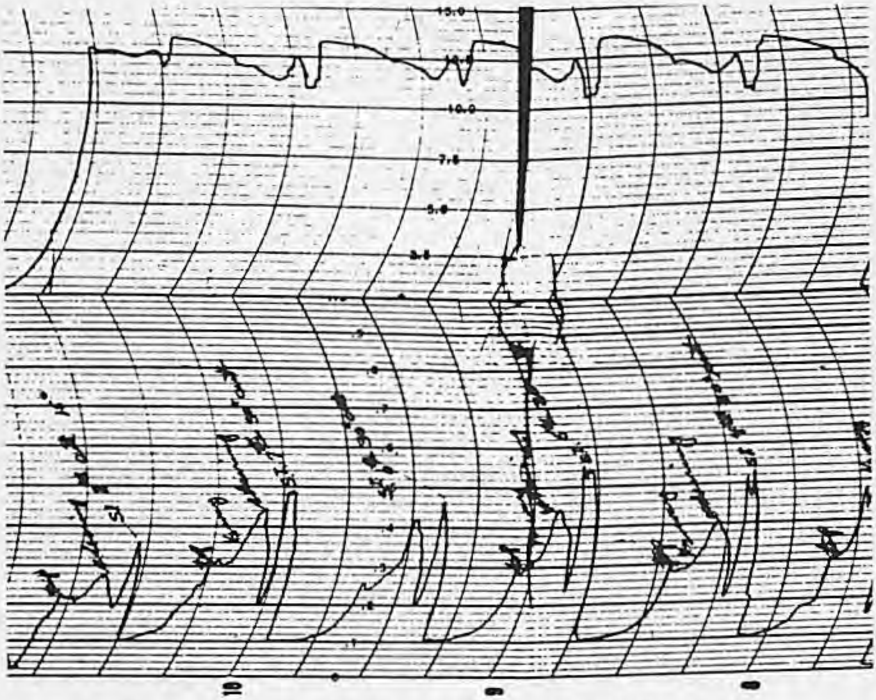
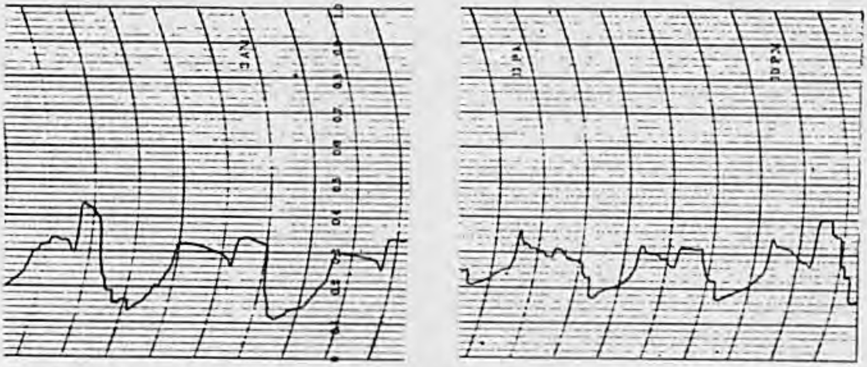


Fig. 2. Typical voltage and current readings on a continuous miner



Figs. 3a and 3b. Typical load charts of single continuous mining unit including two shuttle cars

amperes, and a RMS current of 350 amperes. Figure 4B also shows a peak current of 510 amperes, with a RMS current of 340 amperes. The peak currents of Figures 4A and 4B are 195% of the peak current of Figure 3A, and 212% of the peak of Figure 3B. Comparing maximum RMS currents the twin set-up requires 203% of the single set-up. It must be remembered that the high pressure pump, belt and car spotter are not included in Figures 3A and 3B.

Apparently the diversity obtained from two machines is rather small, both as to peak currents and RMS currents. It would therefore seem advisable to ignore diversity in designing the distribution system.

Figure 5 shows a substation load chart. The substation capacity was 500 kw, and the load included three continuous miner units and one conventional mining set-up, and haulage. It is shown to indicate the type of loads handled by substations in mining service. The voltage at the substation was about 575 volts, and rated load current is 878 amperes.

## Power Requirements

One interesting characteristic of the continuous miner is its torque requirements. Torque required increases rapidly with decrease in speed, and it is possible to stall the machine with decreased speed. Since speed is a function of voltage, it is evident that good voltage regulation is imperative. There is, therefore, a definite minimum voltage required, and the system must be designed with that in view.

Power requirements may be considered in two ways: first, peak load, and second, root mean square, or what we might call effective load. Peak load will determine distribution copper, since copper large enough to give low voltage drop during peak periods will ordinarily have ample carrying capacity for average loads. RMS load, however, will probably be the determining factor in the size of conversion unit, with peak loads a secondary consideration.

According to the best information available, the lowest allowable voltage at the machine is from 200-210 volts, on a 250 volt machine. Let us assume that 200 volts is to be maintained at the machine. However, there will always be about 300 feet of trailing cable attached to the machine, and choice of cable size for this service will be a compromise, based on physical size and electrical characteristics. At present, a 3 conductor 4/0 round cable is being used on these machines. This cable is 2 in. diameter and weighs 4.2 lb. per foot, and it is apparent that a larger cable would be much more difficult to handle.

Since the resistance 4/0 wire is 0.05 ohms per 1000 ft., 300 ft. of cable will have a resistance of 0.03 ohms. This resistance can be considered a permanent part of the machine, and we will state our minimum voltage as at the nips rather than at the machine. At 500 amperes, this would represent 15 volts, at 600 amperes 18 volts. For the purposes of this study, we will assume that the trailing cable represents 20 volts drop at peak current.

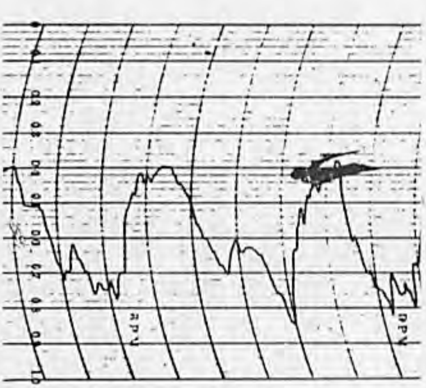
We can therefore say that we must provide 220 volts minimum at the cable nips. If we maintain 290 volts at the substation, we have 70 volts for line drop.

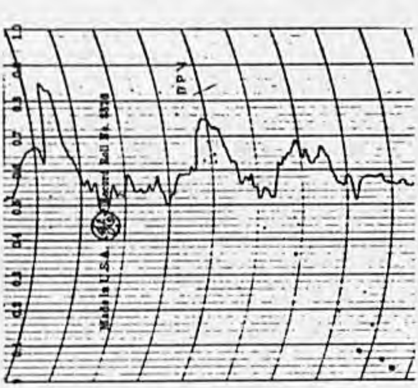
It is our opinion that 750 amperes can be safely assumed as the peak current requirement of the miner, two shuttle cars and high pressure pump. This is about the average of the continuous miner peak currents shown in Figure 1. Experience has shown that the shuttle cars have little effect on peak currents. If this load were supplied over 500,000 cir mils feed and return, the minimum voltage could be maintained at a distance of approximately 2500 ft. from the substation. With 1,000,000 cir mils the distance would be 5000 ft.

## Power for an Assumed Mining Panel

The case just stated is more or less academic, since it is difficult to imagine continuous miner set-up with no other equipment. Let us assume an installation and apply the figures used above. We will assume butt headings 2500 ft. long with belts with 300 ft. rooms worked off both sides. This arrangement is shown schematically in Figure 6. These butts would be spaced about 700 ft. apart.

In this case, using 500,000 cir mils feedline and return, the substation would have to be located at the end of the butt heading. Or we could





Figs. 4a and 4b. Typical load charts of two continuous mining units and auxiliary equipment, including shuttle cars, belt, hoist and high pressure pump locate the substation between two butt headings and supply a miner in each butt heading. Or we could run 1,000,000 cir mils up the butt heading and operate two machines in the same butt.

If we use 500 volt machines, the power remains the same, the current is halved, and the voltage required at the machine is doubled. It is customary to use 3 conductor 2/0 cable on a 500 volt machine. The resistance of a 300 foot trailing cable is 0.048 ohms, representing a 12 volt drop at 250 amperes, or about 14 volts at 300 amperes. Thus we have

| | |
|---|---|
| Voltage at mine | 400 |
| Drop in cable | 15 |
| Voltage required at nips | 415 |

Assuming 570 volts at the substation, the allowable voltage drop is 135 volts. Using 500 MCM feed and return, the allowable distance is about 10,000 ft. at 350 amperes. With 4/0 feedline and return, the distance becomes 4500 ft.

If we apply these figures to our 2500 ft. butt headings, using one miner, we can place the substation at the foot of a butt heading using 4/0 feedline and mine out four butt headings before it is necessary to move the conversion unit. Or, one substation location can supply four miners in four butt headings, using 4/0 feedline and return in the butts, and the proper copper in the flat heading. It would appear that considerable savings in investment, as well as better voltage regulation, is possible with the higher voltage.

## A Theoretically Ideal Arrangement

From a power standpoint only, the ideal arrangement would be to keep the conversion unit as near the continuous miner as possible. If we assume two miners working on opposite sides of a belt, a conversion unit could be placed between them in the butt heading. This assumes

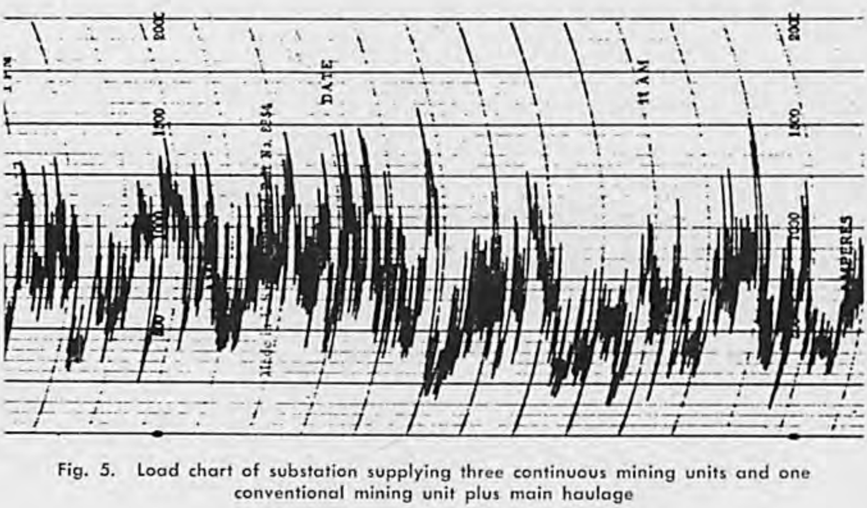



Fig. 5. Load chart of substation supplying three continuous mining units and one conventional mining unit plus main haulage

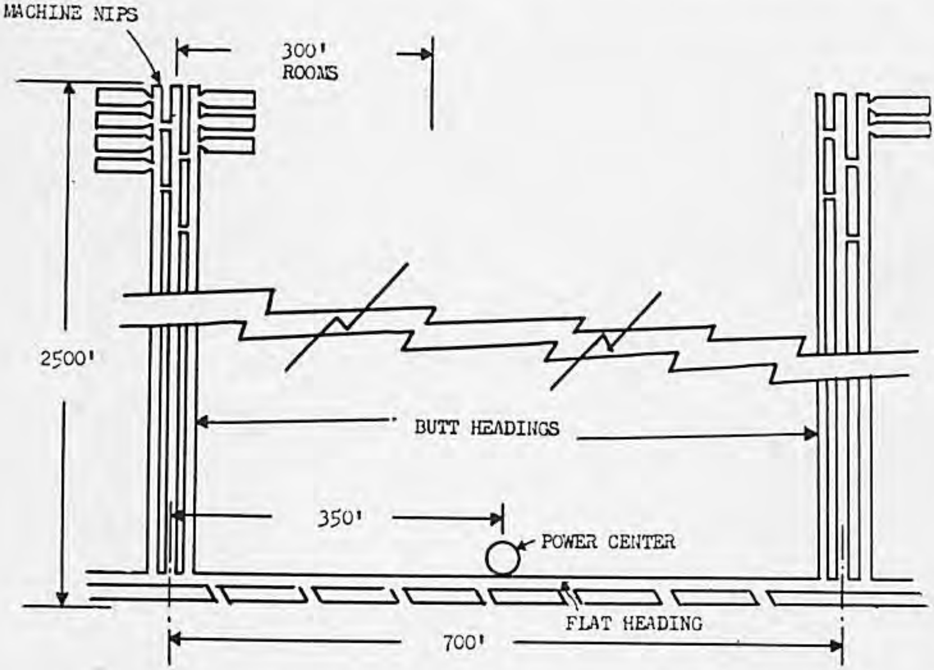



Fig. 6. Possible power center locations and distribution systems for continuous mining

that it is possible to install high voltage cable in the butt heading, and to develop a conversion unit which will not require fire proof enclosure. This method of supply would reduce power lost in transmission and maintain good voltage at the machines. It would be particularly suited for AC operation, since the conversion unit would consist of a transformer bank, without rotating equipment. Disadvantages include the problem of frequent moving of heavy equipment, and the installation of high voltage cable to accommodate frequent moves. It is evident that this system is completely impractical under present laws governing installations of electrical equipment.

## Substation Capacity

As was previously stated, root mean square loads will largely determine substation capacity. It is our judgment that the average power operation will be approximately 450 amperes at the machine, or about 100 kw. This means approximately 130 kw at 290 volts at the substation. Peak power requirement, at the substation would be about 215 kw. This peak requirement is less than a 50% overload on a 150 kw conversion unit, so we can safely say that a 150 kw unit is adequate for one miner, and a 300 kw unit for two. In one case four miners and main line haulage were supplied from a 500 kw unit. However, this unit was somewhat overloaded at times.

Practically all conversion units are designed for 150% load for two hours, and 200% for 2 minutes. These ratings are based on the thermal limits of the equipment. In the case of a continuous miner load, the duration of peak loads is very short, and peak load capacity of the conversion unit is more likely to depend on commutation and stability than on heating. It is obvious that efficient utilization of equipment requires utilization of overload capacity. How much overload should be applied must be determined for each installation, giving due consideration to both financial and engineering factors. A safe rule would be to limit peak loads on the substation to the two hour rating, or 200% of rated load. This would allow a 300 kw unit to supply two continuous miner set-ups.

## Main and Belt Haulage

We have not so far considered main haulage load requirements. These vary over such a wide range that generalization is impossible. However, some characteristics are common to all haulage loads. First, rather high voltage regulation is tolerable, in most cases. Second, power requirements are usually highest on starting, with much less demand after the trip is rolling. The principal effect of low voltage on a locomotive is to decrease speed. For that reason, it is customary to allow excessive voltage drop on current peaks, permitting substations to be spaced relatively far apart.

In connection with continuous miners, one precaution is advisable. The haulage feeders and trolley should be isolated from the production feeders. Power may be supplied to both loads from the same substation, provided capacity is adequate, but they should be supplied through separate circuits. This will eliminate the possiblity of high haulage peaks coinciding with high production peaks to cause low voltage at the face. Also haulage circuits are much more liable to faults than production circuits. While some delays can be tolerated on haulage in most cases, it is essential to avoid any interruptions to production. In most cases this isolation of production feeders is easy to obtain. In case conversion capacity is limited, circuit breakers can be arranged to give production load priority at the expense of haulage.

It seems logical to include gathering haulage, in case belts are not used in the production load. However, whenever possible, this haulage load should be isolated from the mining machine feeders. If track is used as return, care should be taken to see that return capacity is ample, and that bonding is properly maintained.

## Transmission System

The installation as outlined will greatly reduce the resistance between substation and load, and will therefore impose a greater interrupting duty on circuit breakers. Circuit breakers with higher interrupting capacity will no doubt be necessary. In addition, sectionalizing is desirable to limit production loss due to power outage. In some cases manual reclosing breakers are satisfactory, for instance where a boom-boy is stationed at the end of the butt heading. In many cases automatic reclosing

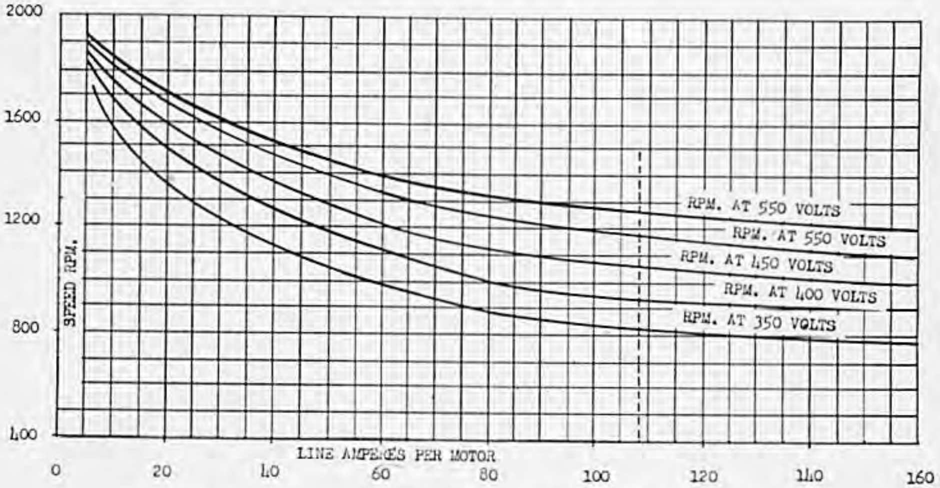



**Fig. 7. Dynamometer performance curve of continous miner main motor**

circuit breakers will be desirable. In either case care should be taken to provide ample capacity, both continuous and interrupting.

In many cases, transmission line capacity should be investigated. Transmission line regulation is especially important when rectifiers and rotary converters are used, since D.C. voltage depends directly on A.C. voltage. Excessive line regulation can cause trouble even on motor-generators. Regulation can be improved in several ways, among them increased line copper, or increased voltage. With the same line copper, and the same losses, 4160 volts will deliver about three times as much power as 2300 volts, and is ordinarily easy to obtain.

Continuous miners using A.C. motors are now in service, but as of the time of this writing, insufficient data is available to allow any conclusions to be drawn. However, use of alternating current will probably increase the importance of good face voltage, and can very easily increase the difficulty of maintaining it. An A.C. motor is much more sensitive to low voltage than a D.C. motor, the torque varying as the square of the voltage. Satisfactory operation require 10% maximum drop. The fact that A.C. induction motors operate at less than unity power factor require more amperes per kilowatt than D.C. machines, and this makes it more difficult to maintain satisfactory face voltage. Against these adverse factors we must weigh the lower maintenance and simpler and cheaper conversion equipment possible with A.C. motors. More experience than is now available will be necessary to evaluate the advantages and disadvantages of the system.

## Summary

The use of continuous miners will undoubtedly lead to more concentrated mining, and in that way will increase the problems connected with power supply. More frequent moves of substations, more copper in feeders and returns will be necessary. Coordinated of mining plans and power supply plans will be essential. At the present stage of development it is impossible to lay down definite rules. Conditions at each operation must be considered in determining the power supply system.

In summation, the following conclusions may be drawn:

First, good voltage at the miner is essential to proper operation and satisfactory results.

Second, present information indicates the minimum substation capacity as 150 kw for one miner, 330 kw for two miners and 500 kw for four miners,, if main haulage load is not considered.

Third, maximum distance from substation to miner, at 250 volts, is 2500 ft. with 500,000 cir mils, 5000 ft. with 1,000,000 cir mils. At 500 volts it will be 10,000 ft. with 500,000 cir mils and 4500 ft. with 4/0 feedline.

Fourth, it is essential to isolate production feeders from main haulage loads, or any other highly variable load wihch will affect production voltage. Isolation is cheaper and, usually, easier than increasing copper.

Fifth, each new installation should be considered as a separate problem, at least until sufficient experience is gained to allow standardization.

## PART II — CONVERSION EQUIPMENT

In the first part of this paper we have discussed the demands which are imposed on the power distribution system and substation by the new system of continuous mining. The manner in which this will affect the distribution system has been well covered. It is the intent of this section of our paper to discuss the requirements which this new type of mining imposes on power conversion equipment and the various types of such equipment now available on the market.

There are three types of power conversion units in use today as mine direct current power sources. Principal among these are the rotary convertor, the synchronous motor generator set, and the mercury arc rectifier. Newcomers to the field of mining are the selenium rectifier and a new mechanical rectifier. We have only shown the underground motor generator set and the mercury arc rectifier because these are the only units available today which are designed for service in low height coal. A selenium rectifier is being designed for this type of service but it had not been placed in service at time this paper was submitted and a picture was therefore not available.

It is not the purpose of this paper to launch into a technical discussion of how each of these units converts alternating current power to direct current power. Nor is it our intention to launch into a detailed discussion of relative costs. As a matter of fact the original scope of this paper did not include coverage of power conversion equipment. The advent of continuous mining, however, has created a lively interest on the part of operators in this type of equipment in a genuine effort to secure the best power supply available. This was so much in evidence, it was quite apparent that the subject "Power for Continuous Mining," if it were to be properly covered, should include a section of D.C. power sources.

It is quite obvious from the preceding section that the two most important requirements of a power conversion unit for continuous mining are: a. Reliability, and b. Excellent voltage characteristics. Reliability; because when the continuous mining unit goes down the flow of coal is stopped immediately, excellent voltage characteristics; to obtain maximum production. Mobility of the power conversion unit is of almost equal importance and will become more so as knowledge of how to obtain greater production from the continuous mining unit increases.

Consideration of whether a unit is reliable or not involves a number of factors and characteristics. The ideal unit should be capable of uninterrupted operation. This necessitates freedom from flashover and ability to carry heavy overloads for a short time from an operational standpoint. It should also be free from mechanical and electrical faults. This implies simplified design and a minimum number of parts. Automatic restarting features should be incorporated in the unit. Disturbances in the A.C. supply line should not affect it. If the unit is about to give trouble it is desirable that it give some warning.

### Characteristics of Conversion Units

The rotary converter and the motor generator set have been in use for many years and much is known about the ability of these units to meet these requirements. The mercury arc rectifier has not been in use as long, having been introduced in its present form to the field about twelve years ago, but sufficient numbers have been installed to provide a good comparison. Lack of experience with the selenium and mechanical rectifiers prevent giving an analysis of these units from the standpoint of reliability.

It is commonly known that the rotary converter is quite unstable because of its tendency to flashover with the sudden application of heavy overloads. This is probably one of the main reasons for the fact that the rotary converter has not been more popular. A condition called arcback occurs on the mercury arc rectifier at times but not nearly as frequently as in the case of the converter. This is caused by excessive tube temperatures or overloads in excess of the guaranteed overload capacity of 200% full load or a combination of the two. Over the years during which this type of unit has been in use, experience has indicated that trouble from excessive temperatures can be minimized by the installation of warning and protective devices in the cooling system. The synchronous motor generator may flashover when subjected to severe short time overloads somewhat in excess of 200% full load.

From the standpoint of simplicity of mechanical and electrical design the synchronous motor set is probably best for the principal reason that no transformer be required since the driving motor can be operated from a 2300 or 4160 volt source. The circuits of both the synchronous motor generator set and the rotary converter are simpler than the circuits of the mercury arc rectifier. One electro-mechanical fault common to the water cooled tube type of rectifier has to do with electrolysis which takes place due to the shell of the steel tube being positive and the frame negative. Electrolysis can be controlled to a certain extent (1) by using distilled water, and (2) by electrically insulating the heat exchanger from the frame and reversing the polarity of the system thereby eliminating potential across the cooling water. One practice is to use a replaceable copper target which eliminates the loss of metal from the tube. One or more of these steps are taken on new installations.

Automatic restarting in case of A.C. power interruption or for any other reason is provided in all types under discussion. Automatic reclosing D.C. breakers are recommended, also.

Disturbances in the A.C. supply line, other than a complete failure, of course, have varying effects on the units under discussion. All of them can, and should be protected from lightning. Sudden surges of voltage will be reflected to the D.C. system through the rotary converter, and through any type of rectifier and may cause D.C. motors to flashover. The motor generator set is not subject to this fault because the driving motor absorbs sudden increases or decreases in supply voltage.

Practically all of the units have under-voltage protection to remove the load if the voltage drops off.

The mercury arc rectifier and the motor generator set do not require much in the way of operating care and maintenance. In the case of the mercury arc rectifier a periodic check of the cooling system is of first importance. One operator with rectifiers in use reports that he changes the water twice a year and adds anti-freeze in the winter if the unit is subjected to freezing temperatures. In the case of the motor generator set the commutator and brushes should be given visual inspection periodically. Several years' life is quite common for a set of brushes. The bearings on the unit require lubrication occasionally in accordance with the manufacturer's recommendations. Motor generator sets have proven to be reasonably trouble free and reliable by years of experience.

The brush life on the rotary converter is not as good as that to be expected on a motor generator set because of the greater tendency of the machine to arc or flashover.

All units are available with warning or protective devices to guard against major failures such as bearing temperature protective relays, water temperature controls and protective cutouts, overload and undervoltage protective devices. It is generally recognized that motor generator sets give advance indication of needed attention to brushes and commutators through observation of sparking conditions at the brushes.

## Maintenance of Voltage

The rate at which coal is removed from the face by the continuous miner is materially affected by the voltage supplied to the machine. This in itself is not surprisingly new because this fact has always been well understood and taken into consideration by production minded operators experienced in the operation of the conventional mechanical mining system. The need for excellent voltage characteristics for the continuous miner is clearly and forcefully appreciated upon observing the drop off in speed in revolutions per minute of the main motor of a continuous miner which occurs as load current increases for various conditions of voltage at the motor. The effect of voltage differences, for example, is about 450 rpm. in the speed of the motor at full load current with 350 volts as compared to 550 volts.

Also, when low voltage is impressed on the main motors a stall condition will develop due to the decrease in available torque and the increased torque demand of the slowly moving head. This increases the time required to remove the coal from the face because, under these conditions, the machine has to be eased into the coal.

For these reasons the ideal power source for continuous mining should have rising voltage characteristics to compensate for the voltage drop in the feeder and cable and to maintain rated voltage at the machine. In addition fluctuations in the A.C. input voltage should not be reflected in the D.C. output voltage.

The synchronous motor generator set is best in this regard because it can be built for this work with inherent characteristics which result in a voltage output normally of 250 volts at no load and rises, as the load increases to 275 volts at full load. In addition, as was mentioned previously, fluctuations in the A.C. input do not affect the D.C. output voltage.

Rectifiers and rotary converters have voltage output curves which are essentially flat, that is 275 volts no load and 250 volts full load. This can be compensated for by adding a regulator to produce the desired characteristics. A.C. voltage fluctuations are reflected through to the D.C. output and it is therefore desirable to regulate the A.C. input to these units.

On the other hand for power sources for haulage loads it is not necessary to have rising voltage characteristics and, in fact, a flat or drooping voltage characteristic is probably more desirable, especially where several units are operated in parallel and must share the load. This point is emphasized to support the recommendation made earlier that the haulage and production loads should be separated. It is desirable to have a power source for the production units separate from that for the haulage units.

### Portability Is a Desirable Feature

The question of how frequently a continuous mining power supply will have to be moved is hard to answer for it will ultimately depend on the mining plan adopted. New plans for obtaining best production are being tried and proposed continually. At present it is conceivable that it will have to be moved every five or six months.

We do know that the power source has to be located fairly close to the unit as described previously. Therefore, of necessity in most cases, the power conversion unit must be designed for use underground. The exception will be those mines where the overburden will permit the D.C. power to be dropped through bore holes to the units underground.

The underground power unit should be light and at the same time extremely rugged. It should be low in height and as small in length and width as possible. It should be so constructed as to make it possible to wheel or skid it into position depending on the mining layout. Mercury arc rectifiers and synchronous motor generator sets are designed to make that possible.

One of the main problems in connection with portability of these conversion units arises when it is desired to move one of the units into an area where belt or shuttle car haulage only is in use. Moving these units by hand on rollers is a hard, tedious, time consuming job.

We believe the best solution in such a case would be to use a small car puller hoist in conjunction with an air cooled transformer tapped in to the high voltage cable and winch the unit from the old location to the new position.

## Summary

1. The continuous miner power unit must be reliable, it must have excellent voltage characteristics, and it should be reasonably portable.

2. Mercury arc rectifiers designed for underground service and one synchronous motor generator set recently introduced can be considered reliable and reasonably portable. The motor generator set, referred to, having been specifically designed for the power needs of continuous mining machines has, therefore, also the excellent voltage characteristics.

3. Power sources should be supplied for continuous mining units separate from that used for the haulage loads. A separate power source for each individual mining section of one, two or three continuous mining units rather than paralleled sources is necessary in order not to sacrifice the characteristic of rising voltage with increased load.

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# POWER REQUIREMENTS FOR STRIP MINES

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One of the first electrical problems confronted in a strip mine operation is the choice of a method for the distribution of power to the machines removing overburden and loading coal. In general three methods as outlined below that have been used successfully for different types and sizes of operation:

*(1)* Overhead pole line distribution, with one main substation where the incoming voltage is stepped down to the usual 4160 volts for distribution. The utility company usually furnishes this substation and the metering is done on the low voltage side of the transformer bank. The mining company then builds its own overhead pole line to the working area, keeping the main power line behind the line of recovery and building overhead lines laterally from the main line to the crop line side of area to be stripped. This is the cheapest type of distribution system to build and if the mine can be depleted without having to move the substation, this is the most economical method of purchasing and distributing power. This method is applicable to mines where no "island stripping" is involved, and the area to be mined does not lie in pockets, but is concentrated.

*(2)* The second method used is similar to the first in regard to the substation and the main line being built beyond the recovery line, but instead of using overhead construction on the laterals, portable high voltage cables are used to distribute the power from the main line to pit. This method is more economical where the "island stripping" is likely to be encountered or where the coal bed lies in the crowns of a series of hills. In the latter case, the area to be stripped becomes a number of long narrow "fingers," and the flexibility of portable cables is required to maneuver the power line out of the way of stripping machines and drills.

*(3)* The third method used is where the power is purchased from the utility company at a primary transmission voltage such as 33,000 volts and the mining company is responsible for installing and maintaining substations necessary to reduce the voltage to 4160 for the shovels and loaders. Where the areas to be stripped are separated several miles or where the preparation plant cannot be located in

close proximity to the stripping shovels, this method of power distribution has many advantages over the other types and is recommended for the following types of operations:

*a.* Crop line stripping where the advance of the shovels from original power source will be increasing at a comparatively high rate.

*b.* Stripping areas where the coal lies in pockets that are separated by several miles.

*c.* In pits where the concentration of electrical load is very high, as for example when several large shovels or draglines are working in tandem.

*d.* Where two or more widely separated pits are being mined simultaneously.

As the more desirable areas for strip mine operation become depleted and such areas become harder and harder to find, the types of operation mentioned above will be increasing. Areas with higher ratios of overburden to coal requiring more of the large stripping shovels or draglines will be worked. This high concentration of electrical load will decrease the economic transmission distance of a 4160 volt system. Areas with several separate coal reserves that require two or more pits for adequate production will increase in number and these are contributing factors in the trend toward the purchase of electrical energy at a primary voltage.

The most economical plan of distribution of power for any operation is the one that results in the least amount of money being spent for investment and operating costs from the time the mining operation starts until it is depleted.

In any of the four types of operation described as requiring primary power distribution, the mining company has the added investment cost of the transformers, switches, lightning arresters and structure for the substation, and usually has the advantage of a five per cent reduction in the energy charge portion of the power bill plus the cheaper cost of building a high voltage overhead line, and the decrease in power loss in the transmission lines. In order to realize the maximum economy of power distribution, the substation should be made portable, either mounted on skids or wheels complete with primary disconnect means, lightning arresters, secondary neutral resistor and oil circuit breaker. This will eliminate the cost of building a permanent type structure whenever it becomes necessary to move the substation.

The building of overhead pole lines for the secondary or 4160 volt distribution can be entirely eliminated by using a system of portable high voltage cables from the substation to the stripping machines. The initial cost of a cable system is higher than the conventional overhead method. For a conductor size of 2/0 a portable mine feeder cable will cost approximately $2.00 per foot or $10,560.00 per mile. A mile of overhead distribution line of the same conductor size will cost about $6,000.00 for material and labor. Although the initial investment is higher, if it is certain that the line will have to be moved at least once, the additional expense will be justified. The portable cable can be either rubber-covered or armored, and for a maximum degree of mobility, the rubber-covered will be more advantageous.

### Determining Adequate Capacity of Cable

In determining the proper size of cable to use in a distribution system, there are two conditions that must be satisfied:

1. The current carrying capacity must be large enough to avoid overheating of the cable.

2. The voltage drop must be kept within allowable limits.

The capacity of any given size of conductor is not a fixed quantity and is in general limited by the permissible voltage drop. Determination of the proper conductor size requires data on line voltage, peak kilowatt load, load factor, and power factor. The load factor is defined as "the ratio of the average power to the maximum demand for a 730 hour month." This ratio is less than unity and is important in considering the current carrying capacity of a cable, since the capacity increases as the load decreases.

By installing watthour meters with demand register attachments on stripping and loading machines, a great deal of useful information can be gathered. These meters should also have a ratchet attachment so that the total power drawn from the power system is read on the meters and not the difference between the power supplied to the machine and the power regenerated to the supply system on the lowering cycle. The demand register indicates the maximum rate of power consumption over a definite integral of time, usually fifteen minutes, and this is called the maximum demand of the machine, and is a value less than the nameplate reading of the motor driving the motor-generator set. The total number of kilowatt hours drawn from the supply system is read on the dials of the watthour meter. From these two readings, total kilowatt hours and maximum demand, the load factor can be calculated.

The following example will illustrate the value of the load factor for a 20 yard stripping machine: Total kilowatt hours used in one month was 213,800; the maximum demand was 400 kilowatts. The average power used during the month was 213,800 ÷ 730 or 289 kilowatts. The load factor is then 289 ÷ 400 or 72.4 per cent. The fact that the portable cable used on this machine is, on the average, only carrying 72.4 per cent of its maximum demand load is useful in selecting the proper size conductors because a smaller size can be used. The synchronous motor on this 20 yard shovel is rated at 800 KVA. It is readily seen that the cable size selected on the basis of name-plate reading would be considerably larger than that actually required. Therefore, the maximum demand and the load factor should be the basis for satisfying the first condition, that of overheating, in selecting a proper size conductor.

The other condition to be satisfied, voltage drop, requires data on peak kilowatts and power factor. The most convenient way to get this information is to connect an Industrial Analyzer in the line supplying power to the machine. This analyzer is a measuring instrument that gives indicating values of voltage, current, kilowatts, and power factor, and also indicates whether the power factor is a leading or lagging value. Synchronous motors usually draw a leading component of current, and with this type of load the voltage drop for a given ampere load is less than it would be with the same amperage drawn by induction motors. However, in shovel operation the load varies, and with a fixed value of field excitation, the power factor also varies, and the shift is in the direction from a leading current to a lagging one as the load increases.

The values of peak kilowatts and power factor were read simultaneously on the Industrial Analyzer. The values of maximum demand were obtained from the watthour meters on the machines. The values of load factor were calculated by dividing the average kilowatt hours used during the month by the maximum demand. The values of average current were calculated from the values of maximum demand.

In determining the voltage drop on a given size conductor, the value of current calculated from the peak kilowatt load should be used along

TABLE I

POWER REQUIREMENTS OF STRIPPING AND LOADING MACHINES

| *No.* | *Type of Motor* | *HP* | *Peak KW* | *Power Factor* | *Maximum Demand* | *Load Factor* | *Average Current* |
|---|---|---|---|---|---|---|---|
| 1 | Induction | 125 | 175 | .92 Lag | 100 | 16.7% | 15.2 |
| 2 | Induction | 375 | 350 | .94 Lag | 210 | 44.3% | 31.8 |
| 3 | Synchronous | 650 | 800 | 1.00 | 370 | 67.7% | 51.5 |
| 4 | Synchronous | 660 | 1000 | .98 Lead | 320 | 67.7% | 44.5 |
| 5 | Synchronous | 800 | 960 | .96 Lead | 400 | 73.0% | 55.6 |
| 6 | Synchronous | 900 | 1050 | .98 Lead | 490 | 68.0% | 68.2 |
| 7 | Synchronous | 900 | 1200 | .98 Lead | 510 | 78.0% | 70.8 |
| 8 | Synchronous | 1150 | 1560 | .98 Lag | 700 | 60.0% | 95 |

with the power factor at this maximum load. Keeping the voltage drop within allowable limits will usually be the determining factor in selecting the size of conductor to use.

The following example will illustrate this point: The number 8 machine in the table draws an average current of 95 amperes. A manufacturer's manual shows that a size 2 cable has a carrying capacity of 90 amperes so that this should be adequate from the heating standpoint. Solving the fundamental equation for voltage drop for this size cable for a 1500 foot length shows the voltage drop at peak loads to be 2.29 per cent. A 2/0 size cable of the same length gives a voltage drop of 1.17

METHOD OF CALCULATING POWER COSTS

*Meter Readings*

| | Demand | KWH |
|---|---|---|
| Shovel | 400 | 213,800 |
| Tipple | 325 | 45,500 |
| Shop | 25 | 10,100 |
| Loader | 100 | 30,000 |
| Total | 850 | 299,400 |

*Power Bill*

| | |
|---|---|
| Demand Charge | $1,333.50 |
| Energy Charge | 2,662.96 |
| Total Charge | $3,996.46 |

*Stripping Power*

Demand charge $\frac{400}{850} \times \$1,333.50 = \$\ 627.50$

Energy charge $\frac{213,800}{299,400} \times \$2,662.96 = \$1,901.60$

$2,529.10

*Preparation and Shops*

Demand charge $\frac{350}{850} \times \$1,333.50 = \$\ 549.08$

Energy charge $\frac{55,600}{299,400} \times \$2,662.96 = \$\ 494.52$

$1,043.60

*Coal Loading*

Demand charge $\frac{100}{850} \times \$1,333.50 = \$\ 156.92$

Energy charge $\frac{30,000}{299,400} \times \$2,662.96 = \$\ 266.84$

$ 423.76

*Summary*

| | Demand | Energy | Total |
|---|---|---|---|
| Stripping | $ 627.50 | $1,901.60 | $2,529.10 |
| Preparation | 549.08 | 494.52 | 1,043.60 |
| Loading | 156.92 | 266.84 | 423.76 |
| | $1,333.50 | $2,662.96 | $3,996.46 |

per cent. 4/0 size gives a drop of .75 per cent. The 2/0 size would be a good selection for this load, and a cable distribution system a mile in length would have a voltage drop of less than 5 per cent. Keeping the voltage drop on the 4160 volt system down to about six per cent will allow for a voltage drop in the primary transmission lines and transformers and still keep the overall drop, from the source of supply to the machine, within good operating limits.

### Allocation of Power Charges

Another advantage of metering the stripping and loading machines and the coal preparation plants, is that it affords one means of allocating the power charges to the proper operating accounts. Power charges amount to ten to sixteen cents per ton of coal and should be allocated according to where it is used.

In our operating reports, the power charges are made to Stripping, Coal Preparation, and Coal Loading. However, the power bill includes the total power consumption so it is necessary to calculate the power charge for each division.

Most utility rates are based on a "demand charge" and an "energy charge," the total power bill being the sum of these two. The meter readings are used to prorate the demand charge and energy charge to each machine or tipple, and the accompanying example shows how this is carried out. In this example, the shop charge is added to the coal preparation plant. Allocation by this means is accurate enough for practical purposes and is obtained with a minimum amount of work involved.

*Reprinted from 1950 "Coal Mine Modernization" Yearbook through courtesy of The American Mining Congress, papers presented at the American Mining Congress, Cleveland, Ohio, April 24, 25 and 26, 1950.*

# USE OF VOLTAGES HIGHER THAN 4000 FOR LARGE EQUIPMENT

By J. E. BORLAND

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In recent years there have been indications of growing interest in the possible advantages of higher voltage power distribution in strip mines, particularly in those using shovels or draglines of the largest sizes. The matter was discussed briefly in the 1948 meeting of the Open Pit Mining Association, and the use of higher voltages is being considered seriously for future shovels or draglines of larger sizes than now in use.

The largest machines now have ratings totalling more than 2000 horsepower in the a-c motors driving the m-g sets, about three times that in shovels which not so many years ago were thought to be about the ultimate in size. But the voltage at which a-c power is supplied to these larger equipments, with proportionally heavier power demands, has remained unchanged at 4000 volts. At the same time is is noteworthy that 5000 volt power long has been used in a few open-pit metal mines, such as Utah Copper Company and Chile Exploration, for concentrations of shovels or about 5 yard dipper size with 275 horsepower a-c motors, and a number of shovels of such size have been exported for operation on 6000 volt power.

As is well known, the power demands of a shovel or dragline vary over a wide range during each operating cycle, from a high peak during digging and hoisting to negative values when power is regenerated by lowering the bucket. Peak demands of different equipments may reach 2 to 2½ times the rated full load input to the a-c motors.

Figure 1, reproduced from a test chart of a-c power input to a large dragline having motors of about 2000 horsepower rating, shows the typically wide changes of power demand during two successive cycles, with a peak about 3000 kw. Other sections of the same test, taken with slower chart speed, show occasional peaks approaching 4000 kw. Regenerated power was not recorded, as the zero adjustment of the pen was at the bottom of the chart, but the intervals during which regeneration occurs can be observed where the pen deflection is below zero.

With such variations and high peak power demands of the larger shovels and draglines that have been placed in service in recent years, it has become increasingly difficult to hold within proper limits the variation in a-c voltage received at the machines. Usually it has been necessary to keep the mine substation within about a mile of the load, and to facilitate

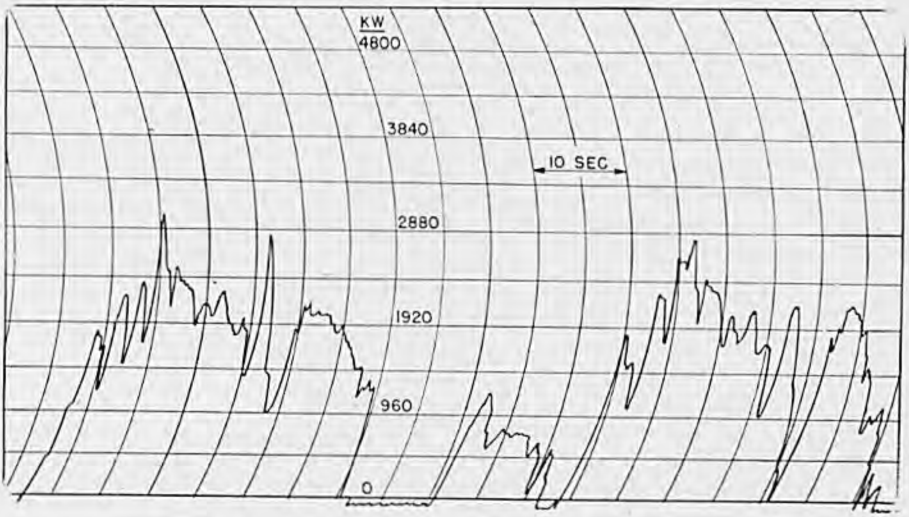


Fig. 1. Power input to large dragline—two operating cycles

relocations to keep within such distance a number of mines have adopted portable unit substations.

## Voltage Variations in A-C Circuits

It may be worthwhile here to review briefly some of the factors which affect the variation of a-c voltage received at a shovel or dragline. Each element of the a-c power distribution system—transformers, overhead lines and cables—has a certain amount of resistance and inductive reactance, in which voltage drops occur, proportional to the value of the current flowing. These drops do not subtract directly from the substation voltage, but at angles depending upon the phase relation between the current and voltage, or in other words, the power factor. The voltage drop in the resistance is in phase with the current, and that in the reactance at right angles to the current.

The resistances of all elements which are in series in the circuits may be added to obtain the total resistance, likewise the reactance added to obtain the total reactance, and these totals multiplied by the current in amperes gives the respective voltage drops at that particular current. These voltage drops are then added vectorially to the phase-to-neutral voltage at the receiving end to obtain the required substation voltage. In the case of three phase circuits, with which we are now concerned, the phase-to-neutral voltage is the voltage between phase wires divided by the square root of three.

Such vector additions may be done graphically by the use of diagrams similar to those shown in Figure 2. In such a diagram the angle between the current and the voltage vectors is the angle the cosine of which is equal to the power factor. The three diagrams of Figure 2 show the relations with the same amount of power transmitted at lagging power factor, at unity power factor and at leading power factor, in circuits having the same amounts of resistance and reactance.

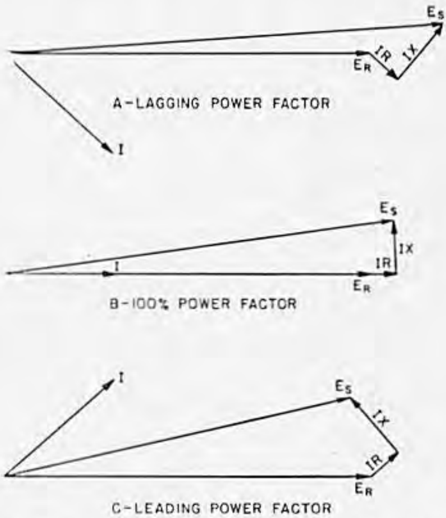


Fig. 2. Vector diagrams of distribution circuits

I — Current
IR — Voltage drop in resistance
IX — Voltage drop in reactance
$E_r$ — Volts to neutral at receiving end
$E_s$ — Volts to neutral at sending end

These diagrams illustrate the benefit of maintaining high power factor (near unity) in minimizing the voltage drop with a given amount of power transmitted, particularly where the reactance in the circuits is large in proportion to the resistance. Also that unless the reactance is small in proportion to the resistance, currents leading the voltage at a large angle (low leading power factor) may cause the voltage at the receiving end to rise above that at the substation.

## Characteristics of Synchronous Motors

As synchronous motors are used to drive the motor-generator sets of large shovels and draglines it may be well to consider the influence of voltage variations on the performance of such motors. On shovel or dragline equipments they usually are designed for operation at 80 percent or for 90 percent leading power factor at rated load. This means that with the d-c field excitation adjusted at rated value, when the motor is carrying full load at rated voltage the current input to the stator will lead the voltage (to neutral) by an angle the cosine of which is equal to the

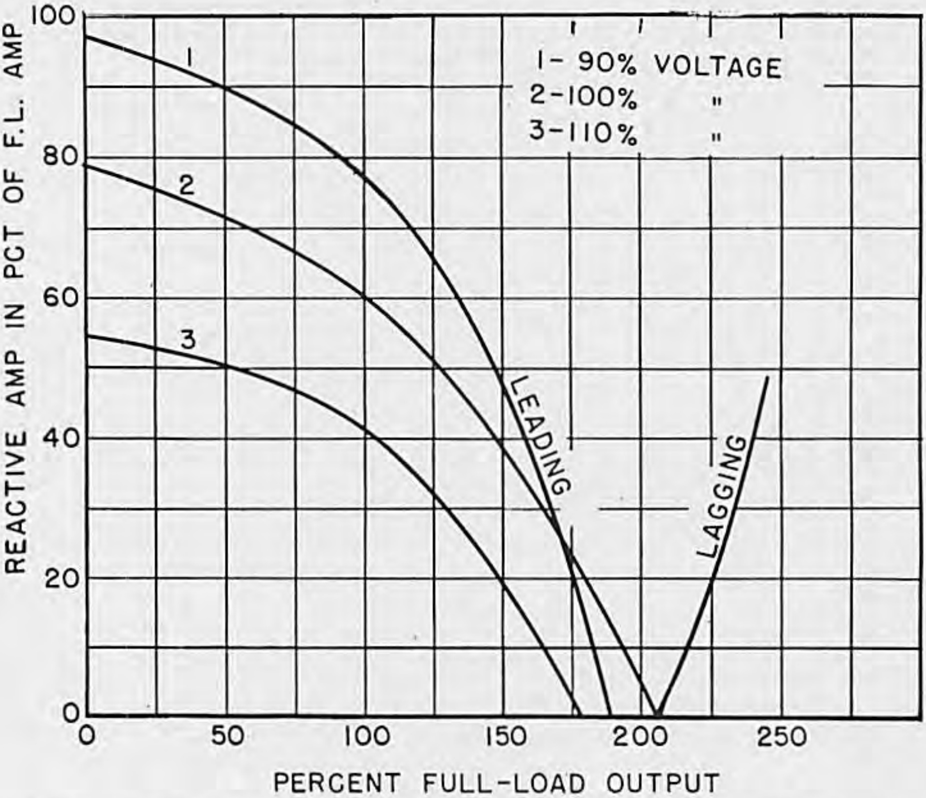


Fig. 3 Variation of reactive currents of 80 percent power factor synchronous motors with load at different A-C voltages

rated power factor. Such leading currents may be considered as composed of two components:

1. A current in phase with the voltage required to develop the power demanded of the motor, plus the motor losses.

2. A current leading the voltage by 90 degrees. This is known as the "wattless" current, as it results in no useful work. It is known also as the reactive current.

The leading component of current input to the synchronous motor results from "over-excitation" of the field; that is, from a d-c field excitation large enough to tend to generate in the stator windings a voltage greater than that applied to the motor. Leading current in the stator windings have a demagnetizing action, and the motor will draw such currents as are required to compensate for over-excitation of the fields. Thus an increase in field excitation of a synchronous motor will cause it to draw a larger leading current and a decrease in excitation will reduce the leading current.

As the load currents also have demagnetizing effects, the amount of leading current drawn becomes less with increase in load on the motor. That is, with a given applied a-c voltage and d-c field excitation the component of stator current at a right angle to the voltage is at a maximum at no-load, and it decreases with increasing load on the motor. In an 80 percent factor motor operating at rated voltage the manner in which the leading current decreases with load is similar to that shown by Curve 2 in Figure 3. At a certain overload (in this case slightly over 200 percent full load) the leading current required is zero, and the motor will carry this particular load at unity power factor. At loads above this value components of current lagging the voltage are required to produce the necessary magnetizing action. At such heavy overloads, therefore, the motor will operate at lagging power factors, if the a-c voltage and the field excitation remain fixed.

The particular load point at which a synchronous motor will operate at unity power factor will not be the same for all motors of the same rating, but will depend upon the design constants. In and 80 percent power factor motor designed for a pull-out torque 250 percent of full-load torque the point usually will be a little over 200 percent of full load, about as shown by Curve 2, Figure3. It will be seen that a small increase in load beyond this point will result in a heavy lagging current, or in other words, lagging power factor.

As mentioned previously, Curve 2 is on the basis of fixed d-c field excitation and a-c voltage at rated values. An increase of field excitation will cause larger leading currents to be drawn by the motor, and a decrease in excitation will lower the leading currents. Thus with sufficient increase in excitation the motor may be made to operate at unity power factor at any particular value of peak load, or by decrease in excitation the leadings currents at light loads may be held very low. By automatic regulation of the synchronous motor field excitation, therefore, the power factor may be held approximately constant at a desirable value over the full range of load from no-load to the peak demand.

If the a-c voltage at the motor terminals is less than rated value, and the field excitation is unchanged, more demagnetizing effect is needed, and the motor will draw heavier reactive (leading) currents. If the a-c voltage is high the reactive currents will be less. The variations of reactive currents with load at 90 percent voltage and at 110 percent voltage, with fixed field excitation, will be similar to those shown by Curves 1 and 3 in Figure 3.

It should be mentioned here that these curves and others which follow are not intended to apply to any specific motor, but only to illustrate the general manner in which the performance of a synchronous motor is affected by variations in a-c voltage.

Reactive components of current such as those shown by Figure 3, which are at 90 degree phase relationship with the voltage added vectorially to the load currents, which are in phase with the voltage, give the actual currents in the stator windings. The stator currents for 90, 100 and 110 percent voltage, all at fixed field excitation, are shown by Figure 4. It may be seen from these curves that with reduced a-c voltages much larger currents are required over the full range of load, with increased I-R losses in the stator winding.

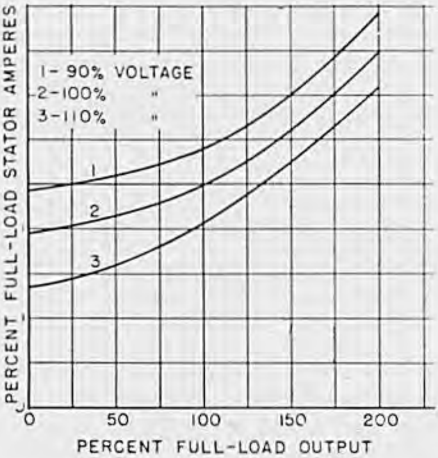


Fig. 4. Variation of stator currents of 80 percent power factor synchronous motors with load at different A-C voltages

A large part of the total losses which heat the stator of a synchronous motor occur in the steel laminations. This loss, generally known as the core loss, increases rapidly with voltages above rated value, and at 125 percent voltage it may be about twice normal. The total losses of a synchronous motor, less the constant loss in the d-c field windings, will vary with different applied a-c voltages somewhat as shown by the curves in Figure 5. When operating at no-load at 125 percent rated voltage the loss may amount to as much as 1.4 times the full load loss at rated voltage. A motor operated at such voltage for any length of time may overheat, even when running at no-load.

On the other hand the pull-out torque of a synchronous motor with fixed field excitation is lowered almost directly with the applied a-c voltage. It is necessary, therefore, that the minimum voltage be kept above the value that will cause the motor to pull out of synchronism at peak loads. Most motors in shovel and dragline sets are designed with sufficient pull-out torque to carry the anticipated peak loads at 90 percent voltage. Additional margin will be provided if the motor field excitation is increased at peak loads for power factor improvements, as the pull-out torque increases almost directly with the excitation.

There is also, of course, the necessity of avoiding the danger of insulation breakdown at excessive voltage. Although standard practice calls for the insulation of new machines to be capable of withstanding for one minute a test voltage of twice rated voltage plus 1000 volts, it is well known that with age and deterioration in service breakdown may occur at much lower voltage.

Considering these divergent effects of voltage on the performance and reliability of a synchronous motor, a good general rule is that the a-c voltage at the motor terminals should not be allowed to vary more than from a minimum of 90 percent of rated voltage at peak loading to a maximum of 110 percent at light or regenerative loading.

## Operation at 4000 Volts and at Higher Voltages

In order to evaluate the possible benefits of higher a-c voltages in the operation of large shovels and draglines, by comparison with 4000 volt operation, estimates have been made of the approximate maximum distribution distances and energy losses in the distribution systems for several large equipments under comparable conditions of loading and distribution layouts. The comparisons are shown in the tabulations which follow.

These analyses have been made for 4000, 6900 and 13,800 volts and the maximum distribution distances estimated to hold voltage at the motors within 110 percent of rated voltage at no-load to 90 percent at peak load. The voltages considered are standard voltages in the ratio

### CASE NUMBER 1

Assumptions:

A shovel or dragline with a-c motors totalling 1750 horsepower driving the m-g sets.
Peak demand 2800 kw at 1.0 power factor.
Power supplied from a 2000 kva transformer over pole lines of different lengths and 1000 feet of trailing cable.
Peak-load voltage at motors 90 percent of rated motor voltage.
No-load voltage at motors 110 percent of rated motor voltage.

| | | | | | | |
|---|---|---|---|---|---|---|
| Rated voltage of motors | 4000 v. | | 6900 v. | | 13,800 v. | |
| Current at peak load | 450 amp. | | 260 amp. | | 130 amp. | |
| Assumed: | | | | | | |
| Transformer reactance | 6% | | 6% | | 6% | |
| Pole-line wire size | 4/0 | | No. 1 | | No. 4 | |
| Pole-line equivalent spacing | 23 in. | | 34 in. | | 45 in. | |
| Cable wire size | 2/0 | | No. 2 | | No. 6 | |
| Length of pole lines | 8400 ft. | | 12,200 ft. | | 27,500 ft. | |
| Resistance and reactance values | R *ohms* | X *ohms* | R *ohms* | X *ohms* | R *ohms* | X *ohms* |
| Transformers | 0.21 | 0.52 | 0.63 | 1.56 | 2.52 | 6.25 |
| Pole lines | 0.52 | 0.92 | 1.93 | 1.59 | 8.52 | 3.96 |
| Cable (1000 ft.) | 0.10 | 0.04 | 0.21 | 0.04 | 0.52 | 0.05 |
| Totals | 0.83 | 1.48 | 2.77 | 3.19 | 11.56 | 10.26 |
| | IR | IX | IR | IX | IR | IX |
| Voltage drops at peak loads | 374 v. | 666 v. | 750 v. | 829 v. | 1503 v. | 1334 v. |
| Assumed motor voltages at peak loads | 3600 volts | | 6210 volts | | 12,420 volts | |
| No-load voltages required to supply above voltages at peak loads | 4400 volts | | 7590 volts | | 15,180 volts | |
| Assumed rms currents | 225 amps | | 130 amps | | 65 amps | |
| Energy losses in distribution circuits, at above rms currents 600 hours per month | 25,000 kwh | | 28,000 kwh | | 29,000 kwh | |

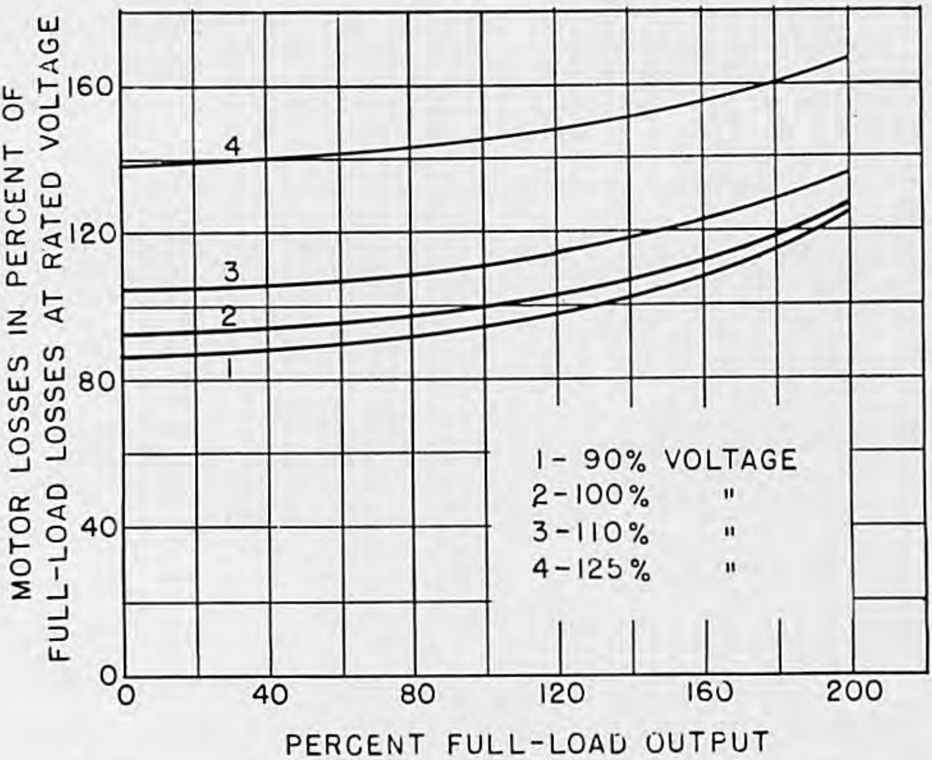


**Fig. 5.** Variation of losses of 80 percent power factor synchronous motor with load at different A-C voltages, excluding constant rotor losses

of 1 to $\sqrt{3}$ to $2\sqrt{3}$. Although large equipment and power distribution apparatus could be designed for other voltages, it probably will prove desirable to keep closely to existing standards.

The maximum distances from the transformer substation to the shovel or dragline shown by the preceding tabulations are somewhat optimistic, as the estimates do not allow for:

(a) Variations of voltage on the high tension side of the transformers, which will be carried through to the mine distribution circuits and will add to the voltage variations at shovels or draglines.

(b) Loads on the pole-lines or main feeder cable from other equipment in the mine.

(c) The increase in maximum voltage when power is generated and when the synchronous motor field excitation is such as to produce leading currents at light loads or regeneration.

(d) The reduction in minimum voltage that will occur when the excitation is such that the power factor is lagging at peak loads.

Such additional factors will have more or less influence in different mines, but in any case they will have about the same proportional effect on variations of any of the voltages shown in the tabulations. Accordingly estimated maximum distribution distances are comparable with one another.

From these comparisons the following conclusions may be drawn:

With 4000 volt power supplied over a pole line and 1000 feet trailing cable to a shovel or dragline having peak demand of the order of 2800 kw the maximum distribution distance that will permit holding voltages at the motors within 90 to 110 percent of rated motor voltage is about 1.5 miles. In the usual case it probably will be much less than 1.5 miles, depending upon the influence of the other factors noted.

With the same conditions of loading and voltage variations, and comparable design of distribution circuits, 6900 volts will permit a maximum distance approximately 50 percent greater than at 4000 volts.

At 13,800 volts the maximum permissible distance in more than three times that at 4000 volts.

With cables only in the distribution circuits the maximum permissible distribution distance at any of the voltages considered will be somewhat greater than with a pole line. The indicated gain is of the order of 20 percent for 4000 volts, and somewhat less for higher voltages.

For future shovels or draglines with peak power demands upwards of twice that of the largest machines now in use power supply at 4000

CASE NUMBER 2

Conditions the same as in Case Number 1, excepting with power distribution entirely over type SHD cables.

| | | | | | | |
|---|---|---|---|---|---|---|
| Rated voltage of motors | 4000 v. | | 6900 v. | | 13,800 v. | |
| Current at peak load | 450 amp. | | 260 amp. | | 130 amp. | |
| Current at no load | 0 | | 0 | | 0 | |
| Assumed: | | | | | | |
| Transformer reactance | 6% | | 6% | | 6% | |
| Wire size in main cable | 4/0 | | No. 1 | | No. 4 | |
| Wire size in trailing cable | 2/0 | | No. 2 | | No. 6 | |
| Length of main cable | 10,000 ft. | | 13,000 ft. | | 28,300 ft. | |
| Resistance and reactance values | R *ohms* | X *ohms* | R *ohms* | X *ohms* | R *ohms* | X *ohms* |
| Transformers | 0.21 | 0.52 | 0.63 | 1.56 | 2.52 | 6.25 |
| Main cable | 0.64 | 0.36 | 2.1 | 0.52 | 8.88 | 1.27 |
| Trailing cable (1000 ft.) | 0.10 | 0.04 | 0.21 | 0.04 | 0.52 | 0.05 |
| Totals | 0.95 | 0.92 | 2.94 | 2.12 | 11.92 | 7.57 |
| | IR | IX | IR | IX | IR | IX |
| Voltage drops at peak loads | 428 v. | 414 v. | 764 v. | 551 v. | 1550 v. | 984 v. |
| Assumed motor voltages at peak loads | 3600 volts | | 6210 volts | | 12,420 volts | |
| No-load voltages rquired to supply above voltages at peak loads | 4400 volts | | 7590 volts | | 15,180 volts | |
| Assumed rms currents | 225 amps | | 130 amps | | 65 amps | |
| Energy losses in distribution circuits at above rms amperes 600 hours per month | 29,000 kwh | | 30,000 kwh | | 30,000 kwh | |

volts probably will be impractical, as the indications are that at this voltage the transformer would have to be kept within about half a mile of the machine. At 6900 volts the permissible distance may be about two-thirds greater or at 13,800 volts nearly two and one-half times that at 4000 volts.

At the longer distances permissible at the higher voltages no savings in energy losses in the distribution circuits are indicated. However, at distances less than the maximum there may be an appreciable savings.

Accordingly it appears that 6900 volts definitely is to be recommended for any shovels or draglines that may be designed in the near future which will have power demands appreciably greater than those of the largest machines now in use. Also, in some cases 6900 volts probably will be advantageous for new machines of the present largest sizes, depending upon the mine layouts and the desirability of avoiding the necessity of frequent relocation of the mine substation.

The higher voltage, 13,800 volts, seems to offer further advantage, and may warrant consideration for large equipment, particularly if there is to be a concentration of several large equipment on a common distribution system. However, such voltage may introduce certain undesirable complications in the design of electrical equipment of a shovel or dragline.

This brings up questions of the effects of higher voltages on the design and cost of the apparatus in the distribution systems and that required to power the mine equipment.

## Transformer Substations

Transformers and switchgear are available for any of the distribution voltages considered. The increase in cost of 6900 volt apparatus over that for 4000 volts probably will not exceed 20 percent, and for 13,800 volts only slightly more.

## Pole Lines

The longer pole lines or main feeder cables permissible in the higher voltage circuits would add to the cost of installation and maintenance. However, in all probability the circuits would be kept much shorter than the maximum lengths indicated for the higher voltages.

## Cables

Cables of Type SH-D four-conductor construction are available in insulation classes up to 15,000 volts. Although such cables with the same wire size will be more costly with 8000 volt insulation than with 5000 volt insulation, and much more costly in the 15,000 volt class, the smaller wire sizes in the higher voltage cables may more than offset the increased costs of higher voltage insulation. This is illustrated by the following data on cables of comparable current-carrying ratings in different voltage classes:

CASE NUMBER 3

Assumptions:

A future shovel or dragline with a-c motor ratings and peak demands approximately twice those of the largest machines now in use.

Peak demand 7000 kw at 1.0 power factor.

Power supplied from a 3750 kva transformer through pole lines of different lengths and 1000 feet of trailing cable.

Peak-load voltage at motors 90 percent of rated motor voltage.

No-load voltage at motors 110 percent of rated motor voltage.

| | | | | | | |
|---|---|---|---|---|---|---|
| Rated voltage of motors | 4000 v. | | 6900 v. | | 13,800 v. | |
| Current at peak load | 1120 amp. | | 650 amp. | | 325 amp. | |
| Current at no-load | 0 | | 0 | | 0 | |
| Assumed: | | | | | | |
| Transformer reactance | 6% | | 6% | | 6% | |
| Pole line wire size | 300 MCM | | 2/0 | | No. 4 | |
| Pole line equiv. spacing | 23 in. | | 34 in. | | 45 in. | |
| Cable wire size | 2-2/0 | | 3/0 | | 1/0 | |
| Length of pole-line | 3600 ft. | | 6500 ft. | | 10,000 ft. | |
| Resistance and reactance values | R *ohms* | X *ohms* | R *ohms* | X *ohms* | R *ohms* | X *ohms* |
| Transformer | 0.10 | 0.28 | 0.30 | 0.83 | 1.20 | 3.33 |
| Pole line | 0.16 | 0.39 | 0.64 | 0.81 | 3.14 | 1.45 |
| Cable | 0.05 | 0.02 | 0.08 | 0.04 | 0.13 | 4.82 |
| Totals | 0.31 | 0.69 | 1.02 | 1.68 | 4.47 | 4.82 |
| | IR | IX | IR | IX | IR | IX |
| Voltage drops at peak loads | 347 v. | 773 v. | 663 v. | 1092 v. | 1453 v. | 1567 v. |
| Assumed motor voltages at peak loads | 3600 volts | | 6210 volts | | 12,420 volts | |
| No-load voltages required to supply above voltages at peak loads | 4400 volts | | 7590 volts | | 15,180 volts | |
| Assumed rms current | 400 amps | | 230 amps | | 115 amps | |
| Energy losses in distribution circuits at above currents 600 hours per month | 30,000 kwh | | 32,000 kwh | | 36,000 kwh | |

This indicates that the cables required in higher voltage distribution circuits may be somewhat smaller, lighter and of lower cost.

## A-C Switchgear

Circuit breakers and autotransformers or reactors for starting higher voltage a-c motors would be somewhat larger and more costly than in existing 4000 volt equipment. Circuit breakers now manufactured fall in 7200 volt and 13,800 volt classes. To avoid exceeding these voltages much under light load conditions, something less than 6900 volt or 13,800 volt motor ratings may be advisable in any further considerations of power distribution at higher voltages, in order that the maximum voltage at the shovel or dragline will not exceed the circuit breaker rating. From this standpoint it would seem that motor voltage ratings should not exceed 6600 volts or 11,500 volts.

While such circuit breakers are available for manual operation, electrical operation of the larger breakers in the 7200 volt and 13,800 volt ratings certainly is to be recommended. For such voltages metal-enclosed switchgear with air circuit breakers, designed in accordance with modern switchgear practice, might be considered.

Collectors for 6900 volt service probably would impose no serious problem in shovel design, excepting perhaps in the smallest sizes, and the additional space required by higher voltage collectors possibly can be provided in the largest machines.

## A-C Motors

For an a-c motor of given horsepower and speed rating there is a fairly definite limit of practical design, beyond which the motor tends to become unduly large and costly, or otherwise undesirable.

Synchronous and induction motors of all ratings now used on shovel and dragline motor-generator sets are available in 4000 volt designs. Motors of 275 horsepower and larger ratings could be designed for 6600 volts, and possibly motors somewhat smaller than 275 horsepower, but motors of the ratings used in smaller loading shovels probably would prove undesirable at 6600 volts. Motors of 1000 horsepower and larger ratings could be designed for 11,500 volts, but this rating tends to become somewhat undesirable below 1500 horsepower.

As the size and cost of an a-c motor of a given horsepower and speed rating increase rapidly with the voltage, motor-generator sets with higher voltage motors will necessarily be more costly than 4000 volt sets. For small m-g sets the proportional increase in cost will be greater than in large sets.

Consideration of higher voltages for large shovels or draglines involves also the problem of power supply to loading shovels and other auxiliary equipment, as it hardly would be satisfactory to carry two different circuits into the pit. A possible solution of the problem of power supply to motors on loading shovels, of ratings to small for the higher voltage used to power the stripping machine, might be the use of a small three-phase transformer in the pit, to step down the voltage to a lower value suitable for such small motors and for the pit transformers supplying circuits to drills, pumps and other auxiliaries. As the rating required in such a transformer would be comparatively small, it might

| | | | |
|---|---|---|---|
| Insulation classes | 5000 v. | 8000 v. | 1500 v. |
| Wire sizes | 4/0 | No. 1 | No. 4 |
| Current ratings (75°C. copper) | 245 amp. | 142 amp. | *91 amp. |
| Approximate cost ratios | 1 | 0.8 | 0.9 |
| Outside diameter | 3.02 in. | 2.65 in. | 2.94 in. |
| Weight per foot | 6.79 lb. | 4.95 lb. | 5.2 lb. |

* The 91 ampere rating of this cable is large by comparison with other cables listed.

be skid-mounted, or in some cases space might be found to mount it conveniently on the large machine, which then would require only one high voltage cable in the pit.

As to safety, unquestionably there will be more hazard in operation at higher voltages. The well known system of protection generally adopted for 4000 volt circuits, using a resistor in the sub-station neutral to limit the maximum ground fault current, has to a very large degree eliminated the risk of a dangerous voltage appearing between earth and the frame of a shovel or dragline. Similar protection can be provided for higher voltage circuits, but with the greater lengths and smaller sizes of ground wires in such circuits the maximum ground fault currents should be limited to lower values than in present 4000 volt systems, if the voltages from the shovel or dragline frames are to be held to the same low values.

Even with the protective system mentioned there remains the element of risk of dangerous voltages in case of simultaneous ground faults on two different phases, and these may be much greater in higher voltage circuits. Such possibilities indicate the necessity of much greater care in maintaining a good margin of safety of insulation throughout any higher voltage circuits that may be adopted.

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# MECHANICAL DRYING IN WEST KENTUCKY

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and
GEORGE LAND
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Broad statements about operating principles and tables of general data are of interest to anyone who is trying to become familiar with a given machine operation. However, the man or men charged with the responsibility for the operation of a machine or process soon leave the general stage and become very much interested in specific detail concerning machines which are their responsibilities. For that reason this paper will be concerned with specific details about the operation and performance of two C.M.I. mechanical dryers at the East Diamond preparation plant of West Kentucky Coal Company.

This plant, located two miles east of Madisonville in Hopkins county, western Kentucky, has been described in detail by Clayton Ball in the February 1947 issue of *Mechanization*. For the purpose of this paper the following description of the fine coal circuit should be sufficient.

### Fine Coal Flow System

Minus $\frac{1}{4}$ in. coal is removed from the raw feed to the washing plant on three triple deck vibrating screens, the bottom decks of which are fitted with $\frac{3}{16}$ x $2\frac{1}{8}$ in. slot type cloth. The $\frac{3}{16}$ in. minus, together with the underflow from the settling tank, form the feed to two 6 ft. hydrotators.

Overflow from the hydrotators is passed over 5 x 12 ft. Ripl-flow screens fitted with Tyrod 9501 cloth, which is considered as 10 mesh. The over product $\frac{3}{16}$ in. x 10 mesh, forms the feed to the No. 2 C.M.I. dryer. The underflow of the Ripl-flow screens goes to a classifier from which the product passes over a 5 x 12 ft. Low-Head screen fitted with Ludlow-Saylor .027 x .446 in. Rectang screen cloth, which we call 28 mesh, becomes the feed to the No. 1 dryer.

The dried product from the two dryers is discharged to a two compartment conveyor which returns the finished carbon sizes to a loading point or mixing conveyor. Facilities are such that the two sizes, $\frac{1}{4}$ in. x 10 mesh and the 10 x 28 mesh, may be loaded separately or together; or either one or both may be mixed with larger sizes for loading.

Figure 1 shows the schematic arrangement of the equipment in the carbon system at East Diamond. Water and solids balance figures for average operating conditions are also shown in this figure.

## Performance Data and Costs

Table I shows the results of a series of tests on the dryer feed and product for each dryer. These tests were made during the month of

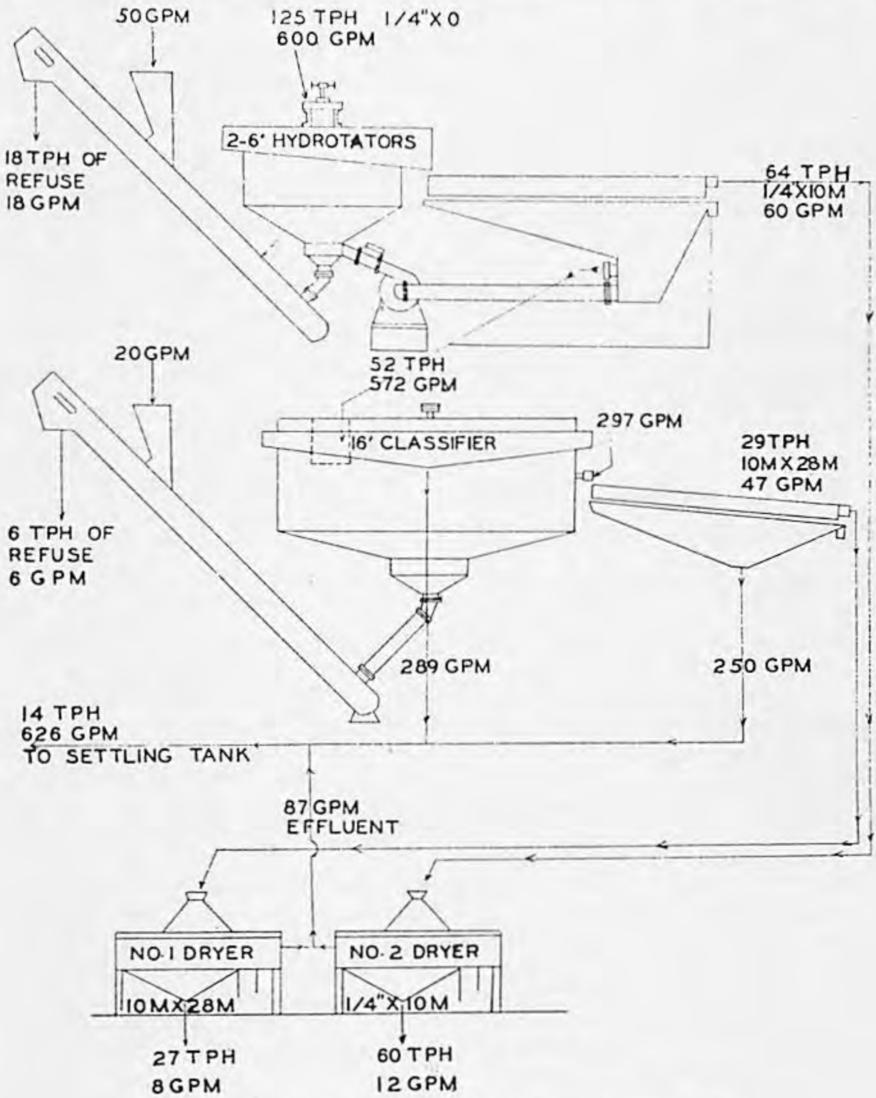


Fig. 1. Coal and water balance at East Diamond carbon system

February and represent 21 days' operating time. These results check quite closely the results which have been obtained on previous tests of similar nature, and are therefore representative of the general performance of these units.

Our experiences with these machines has shown that the secret of successful performance is proper "preventive" maintenance. We have learned that the average screen life for the No. 1 dryer, which has 1 mm

TABLE I

Average Screen Analyses of 21 Samples
Taken From Feb. 7, 1950 to March 7, 1950 Inclusive

| Size | ¼ x 10m Dryer Feed | ¼ x 10m Product | 10 x 28m Dryer Feed | 10 x 28m Product |
|---|---|---|---|---|
| +4 Mesh | 8.56 | 2.98 | ........ | ........ |
| 4 x 10 Mesh | 69.29 | 44.85 | 12.68 | 8.78 |
| 10 x 28 Mesh | 14.88 | 30.82 | 57.87 | 56.21 |
| 28 x 48 Mesh | 3.19 | 10.56 | 17.95 | 22.26 |
| —48 Mesh | 4.08 | 10.79 | 11.50 | 12.75 |
| | 10.000 | 100.00 | 100.00 | 100.00 |
| Average Surface Moisture | 8.561 | 5.15 | 28.97 | 7.92 |
| Average Ash | 7.08 | 6.71 | 7.93 | 6.47 |

(called 28 mesh) openings, is 24 hours' operation, while that for the No. 2 dryer is 48 hours. This screen has 1/16 in. openings (called 10 mesh). An extra basket is kept ready for each dryer and when it becomes necessary to renew the screens the baskets are replaced. The worn screens are then removed from their baskets and replaced by the shift mechanic at his convenience. Whenever possible, basket changes are made on the third, or maintenance shift; however, by use of the spare basket technique, new screens can be placed in service "on shift" in about one-half hour, if necessary.

By maintenance of a regular schedule of sampling of the dryer feed and product of each dryer, a continuous and close check is kept on the dryer performance. We have learned that when performance as measured by the reduction in surface moisture from feed to product begins to fall off, it is necessary to reposition the central cone of the dryers. This is done to maintain the minimum clearance between the rotor flights and the screen basket. 1/16 in. at the screen lap seems to be the clearance for best performance with our coal.

This repositioning is quite tedious, requiring the shimming of the rotor cone by trial and error, until the proper clearance is obtained. Our experience has been that such procedure is necessary three or four times per year, if the reduction in surface moisture by the dryer is to be kept at the highest possible level.

TABLE II — OPERATING COSTS

Cost Per Ton Operating C.M.I. Dryers
Jan. 1 to Dec. 31, 1949, Production 227,945 Tons

| | |
|---|---|
| Repairs and Supplies: | |
| Screen plates 1 mm (28 mesh dryer) | 1.51¢ |
| Screen plates 1/16″ (10 mesh dryer) | .76 |
| Repairing cones, rotors and flights | 1.02 |
| Launders, liners, shields, etc. | .98 |
| Miscellaneous, clamping rings, shears pins, couplings, bearings, etc. | 94 |
| Total repairs and supplies | 5.21¢ |
| Power @ 1½¢ kwh | 2.62 |
| Labor | 1.57 |
| Total operating cost, cents per ton | 9.40¢* |

* This figure does not include depreciation, taxes, or other fixed charges.

In conclusion, let us say that our experience with the C.M.I. centrifugal dryers at our East Diamond mine has been highly satisfactory. Required maintenance is high compared to other equipment in the cleaning plant, but if properly scheduled, is not excessive in view of the results obtained. No better or less expensive mechanical method of moisture removal from fine coal such as ours is known to us.

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# SAFETY PRACTICES IN INDIANA

By RALPH WHITMAN
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This report will describe some of the safety practices with special attention to roof conditions, that we use at the Ditney Hill Mine of the Ingle Coal Corporation, located two miles south of Elberfeld, Indiana. This is a slope opening into the No. 6 seam which varies in thickness from six to ten feet. The slope is on a 16 degree angle and is approximately 350 feet in length and has a 36 in. Goodrich cord belt to bring the coal to the surface. The average depth of cover over the coal is approximately 200 feet.

The mine is fully mechanized, using short wall cutting machines, post mounted electric drills 11 BU loading machines and Joy shuttle cars. On the main haulage seven-ton Sanford-Day drop bottom cars are used.

Belt slope supported with steel lining

Bad roof problems were met by systematic timbering plan

The coal is mined on the room and pillar system, with Airdox to break down the coal. We are using the Airdox for various safety reasons; because it won't crack the coal left at the top to support the shale above it, and of course, it permits on-shift shooting. Airdox was a wise choice also because we found that after working in the mine for a couple of months that for efficiency, as well as safety, speed in working out panels was essential. The faster we worked out a section the safer it became, because the men were withdrawn before the roof deteriorated. It was also possible to recover more props than ordinarily because of the fact that they were removed before too much weight settled on them.

Main and panel entries are driven in sets of five. Haulage entries are 14 ft. wide and all of the others are 12 ft. wide. After panel entries have been developed, rooms are worked from inby to outby from both sides. Rooms are driven 22 ft. wide on 45 ft. centers and worked to a depth of 300 ft. After all rooms on the section have been worked up to the line, recovery of room pillars then starts and continues until the section has caved. After the section has caved it is sealed at once.

The company had known about this particular No. 6 vein for approximately ten years before it opened the mine in 1939. Due to a particularly soft shale averaging two to twenty feet thick just above the coal, the management was hesitant about operating here but after studying the core drillings the conclusion was reached that it would be possible to mine this seam if about 18 in. of coal was left in the roof as a support. It was realized that a good system of timbering had to be worked out to hold the roof, as the shale would not support its own weight. Feeling that the quality of the coal warranted the gamble, the shaft was opened in the fall of 1939.

Steel pins and stringers support cross bars over main haulage ways

## Roof Support Methods

After a careful study of the roof and mining methods, the management decided on the following system of timbering rooms and haulage entries. Two parallel rows of posts are set in rooms on 4 ft. square centers, to within 12 ft. of the face. One row is 6 ft. from the right rib and the other is 10 ft. from the right rib. This leaves 12 ft. clearances for shuttle car roadways on left of rooms. Extra posts are set if needed. Safety posts are set to within 8 ft. of the face.

Wood cross bars, 6 x 6 in., are used when needed, except on main haulage ways. After the loading crew has loaded out and moved to another place, a clean-up man and a timberman take down any loose coal from the face and roof, and properly timber up the place before other men of the crew move in. Each section of the mine is supervised by a section foreman who examines his section and directs the men working there. After a face has been shut down the section foreman examines the place, checking the roof and testing for gas before loading crews move in.

Main haulage ways are timbered with 60 to 90 lbs. rail sections. All haulage entries are driven 14 ft. wide thus permitting adequate clearance on each side of the track. Steel pins and stringers are used almost exclusively to support the cross bars over the main haulage way. These pins are drilled into the ribs from 3 to 5 ft. on both sides thus assuring adequate support. At entry turnouts and other special places, I-beams and H-beams are put up on concrete piers or walls constructed of concrete blocks. The number of cross-bars used is governed by the condition of the roof. At the present time the management is experimenting with roof bolting.

Temporary overcasts are built of 48 in. steel pipes

### Haulage Maintenance and Operation

Proper consideration is given to main line haulage grades. All track is laid with 60 lb. rails on wooden ties. Both rails of the main line track are welded and cross bonded at 300 ft. intervals. Steel gauge rods are used on all the curves and switches. All switches have bridle-bars and throws. Electric switch throws are used where motormen would be required to get off of their motors to throw the switch. These are particularly good in that they keep the men from jumping off of their motors thereby endangering themselves. The track is kept clean with Canton track cleaner; this cleans to the top of the ties, between the rails and the distance of 30 inches outside the rails. All of our track is cleaned at least once a week, and some sections are cleaned as often as is necessary. The main line track is sprinkled with water at least once a week following the cleaning.

Our haulage is directed by a haulage boss and two dispatchers. Signal lights, radio-phones and telephones are provided at each dispatcher's station, and each loading point. All locomotives are equipped with a radio-phone for communication with the dispatchers and haulage boss. We have found that the radio-phones have paid for themselves many times. They have eliminated any possibility of accidents caused by any mistakes that a dispatcher might have made. All motormen can hear the conversations between other motormen and the dispatchers at all times. Consequently, if one motor is being ordered out on the main line, and another one is coming in an opposite direction, the dispatcher can stop the motor coming out in time to avoid an accident. It is also possible for motormen upon finding any difficulties along the haulage road to notify the dispatchers of the difficulties. These phones also have provided an excellent means of communication from various sections in the mines. Foremen and managers can be notified immediately if they are needed in any section. All locomotives have twin headlights with independent storage battery power. These seal-beam lights provide adequate lights for all locomotive operations.

All locomotives are equipped with radio phone

No trip-rider is used. Instead, an auxiliary locomotive is used on each main line trip. This eliminates the pushing of cars on a return trip. Men are transported in and out of the mine in special steel covered Differential man-trip cars.

### Ventilation and Dust Control

Fresh air is provided by two exhaust fans, one a five foot Jeffrey Aerodyne, and the other a four foot Jeffrey. These fans provide at least 6000 ft. of air at the last cross-cut. The slope is used for air intake and an auxiliary shaft has been put down at the head of the main entries also. This auxiliary shaft is a down cast, and can be used for an escape way in case of an emergency. The main fan is equipped with a gasoline engine for emergency use in case of power failure.

All air shafts and slopes are lined with Armco steel lining. Permanent stoppings are built of concrete blocks, and permanent overcasts are of concrete, concrete blocks and steel. The temporary overcasts are built of 30 in. and 48 in. Armco steel pipes; the mine is laid out to eliminate as many doors as possible on haulage-ways and at present only one trap door is in use on the motor haulage road. There is an attendant at this door.

Special attention is given to dust problems. All cutting machines have Sullivan-bugdusters. Calcium chloride is used extensively on all shuttle car haulage roads; this not only lays the dust, but makes a firm road. As mentioned before, our main haulage ways are sprayed at least once

SUMMARY AND ANALYSIS OF ACCIDENTS FROM THE INGLE COAL CORP. MINE, DITNEY HILL, FROM 1941 TO 1949, INCLUSIVE (9 YEARS)

| | | | |
|---|---|---|---|
| Mining machines | 19.62% | Days lost | 5,759 |
| Slate or top coal | 15.09% | Days lost | 4,431 |
| Haulage | 14.75% | Days lost | 4,330 |
| Loading machines | 12.36% | Days lost | 3,627 |
| Face coal | 12.05% | Days lost | 3,539 |
| Railroad cars | 7.65% | Days lost | 2,246 |
| Handling material | 6.09% | Days lost | 1,789 |
| All other accident | 12.39% | Days lost | 3,631 |
| | 100.0 % | | 29,352 |

CAUSE OF FATAL ACCIDENTS

| | |
|---|---|
| Caught or hit by mining machine | 2 |
| Fall of slate or top coal | 1 |
| Caught or hit by loading machine | 1 |
| Railroad cars (surface) | 1 |
| | 5 |

PERMANENTS AND CAUSE:

| | | |
|---|---|---|
| Face coal | 3 | 2 partial perm., 1 loss of 1 finger |
| Loading machine | 2 | 1 loss of 3 fingers<br>1 loss of 1 finger |
| Run over by motor | 1 | 1 loss of arm |
| Coupling cars | 1 | 1 loss of 1 finger |
| Hand tools | 1 | 1 loss of 1 finger |

| | | |
|---|---|---|
| Tons produced for nine years | | 6,341,480 |
| Fatality per million tons produced | | 0.79 |
| Man hour exposure | (9 years) | 4,525,966 |
| Severity rating | (9 years) | 6.485 |
| Frequency rating | (9 years) | 60.54— |
| Reported accidents | (9 years) | 859 |
| Time lost accidents | (9 years) | 274 |
| Compensation accidents | (9 years) | 228 |
| Fatal accidents | (9 years) | 5 |
| Permanent accidents | (9 years) | 8 |

Respectfully submitted,
(Signed) J. OGILVIE,
Jack Ogilvie, Safety Eng.

a week and more often when necessary. The mine is thoroughly rock-dusted which is kept not further than 80 ft. from the face. The maintenance crew on the third shift normally rock-dusts to the face every evening after a run. The whole mine, other than the working face, is periodically rockdusted.

## Conclusion

It is the policy of the management to cooperate, as fully as possible, with the State and Federal Inspection Departments, and the local Safety Committeemen in accident prevention programs. The success of a safety program depends on the employee, as well as the management, and we have striven throughout the life of this mine to educate the men and to maintain their cooperation on safety. Management can win this cooperation only by education of the employee, and by a sincere effort on the part of all.

After ten years of operation at this mine, employing the above described practices, we feel that we have attained a certain amount of success. We have produced 6,341,480 tons of coal with only one fatal accident from fall of slate, and three permanent injuries from fall of face coal. The national fatality rating per million tons is 1.24 for the year 1949; our average for the 10 years of operation is 0.79. This is a figure of which we are justly proud, but it is regarded at Ditney Hill as merely an indicator of the ultimately lower figure which a conscientious and consistent safety program can produce.

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# EDUCATIONAL PROGRAMS TO DEVELOP SUPERVISORS

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In discussing this subject I believe I am safe in making the general statement that with rare exceptions the coal mining industry is without organized training programs to develop supervisory personnel. I do not know of a single organized training program operated by a mining company in the state of Illinois. This is, of course, regrettable but I am not certain that the industry should be vigorously criticized for the deficiency in view of the fact that coal mining is essentially composed of a multitude of rather small and independent units of operation. It is therefore different from other, highly organized industries such as the electrical, metallurgical, farm equipment, automotive, and public utilities who find it highly desirable and profitable to maintain training programs not only for the benefit of their employees, but for the industry itself.

## Illinois State Requirements

For this discussion I shall make the assumption that supervisors for positions underground, above ground, around the tipple, in shops, cleaning plants, etc., do not include office or engineering personnel. In Illinois as well as other coal producing states, the coal mining laws specify minimum ages and time limits of practical experience at which operating personnel can be promoted to supervisory positions. Using Illinois as an example, boys may not work underground until they are 16 years of age. They cannot secure their second class miner's papers until after one year of experience, their first miner's papers until after two years of experience, nor their mine examiner's papers until after four years of experience and a minimum age of 21 years.

In Illinois certified mine examiner's papers are required before an employee can be promoted to face boss. This, then, means that a boy not finishing high school but entering the mines at the minimum age of 16 years may become foreman after five years of experience and at 21 years of age. On the other hand, if a graduate from high school at the minimum age of 18 years enters the mining industry, he must satisfy the practical experience requirements of a minimum of four years to secure his examiner's papers which are required for a foreman's position, and this would mean he would be at a minimum age of 22 years. The college graduate who finishes at the minimum age of 22 years is also required to have four years of practical experience before securing the examiner's papers, which would then permit him to become a face boss at the age of 26 years.

It is therefore possible for a boy entering the mines at the minimum age of 16 years and with not more, or even less, than two years of high school training to become a face boss at the age of 21 years, or five years before a graduate engineer could hold the same position. One might argue that it is highly improbable that a young man 21 years of age would be promoted to a supervisory position but the possibility is nevertheless there, and in this respect the graduates of universities and colleges are being penalized because of their advanced training.

The above is a rather serious detriment to interesting young mining engineers or other professional engineers in seeking employment in underground operations. The technical graduate considers four years of mining experience, which is essentially at labor, entirely too long before he may expect any real kind of recognition for his services and abilities. These same experience requirements exists in most other coal-producing states with the exception that employees may occupy supervisory positions from one to two years younger than is possible in Illinois.

The Illinois Mining Institute has passed a resolution endorsing a proposed change in the mining laws which would permit the substitution of two years of university training for two years of practical experience in securing his mine examiner's papers, provided the graduate holds a degree from an accredited college or university. This change would permit the college graduate to receive his examiner's papers and become a supervisor after two years of practical experience at the minimum age of 24 years, and he would therefore be penalized only three years in comparison to the boy who entered the mine at the minimum age of 16 years. This is therefore a constructive step forward in interesting young technical graduates to enter the production side of mining operations and come up through the supervisory force to administrative and executive positions in the coal company.

I should also like to mention that the years of practical underground experience required before a graduate can expect to make real use of his education and talents is a serious hindrance to technical men entering the production side of mining coal. These experience requirements are also a reason why more coal companies do not provide training programs for new employees. By the time the experience requirements have been satisfied it is expected that the graduate will have pulled himself up by his bootstraps or have quit in disgust and disillusionment.

### University of Illinois Curriculum

At the University of Illinois the mining engineering curriculum contains such courses as economics, mine administration, labor problems, and personnel administration. It is hoped that these courses will be of benefit to the young graduate engineer in adjusting himself to industrial conditions and of benefit also when he becomes eligible for and is promoted to his first supervisory position. In addition to the on-campus courses the University Division of Extension is offering three courses for present employees. These extramural courses are taught by graduate mining engineers in the local coal mining communities, in the form of evening classes. The University collects a nominal fee of $12 per course, in addition the student must buy text book materials.

These courses are not specifically designed to make supervisors of men employed in industry. However, it is hoped that the knowledge they receive about mining operations from the classroom lectures and demonstrations will benefit them to the extent that they become better employees and will be promoted to positions of greater responsibility, including supervisory positions, at a much earlier age than would otherwise be possible.

In the state of Illinois we are also interesting community high schools in offering a one year course in the science of coal mining for senior high school students. It is hoped that this year of instruction will not only interest more of the high school graduates in entering the coal mining industry but that the instruction will also make them more valuable to the industry and assist them in receiving promotions to supervisory positions in the earliest possible time. Since the high school programs are just now getting under way, we do not have a sufficient amount of experience with the program to offer data, conclusions or recommendations to interested parties. I am, however, confident and hopeful that the high school program will be of real benefit to the coal mining industry and to the future employees of the coal mining industry.

### University Extension Courses

The University of Illinois through its extension division also offers courses of instruction in supervisory training for industries within the state. These courses are not specifically designated for any one type of industry and could very well be adapted to coal mining. So far as I am aware, no coal company is now taking advantage of the supervisory courses but it seems to me they could very well do so.

Perhaps one of the disadvantages of the courses is that they are designed for "on-the-job training" and it may not be feasible to move mine personnel to the class room for two or more periods per week of classroom instruction and discussion. It has been felt that mine employees would not be greatly interested in supervisory training courses offered in the evening and without the support and cooperation of the individual mining companies.

Another type of program which is badly needed by the coal mining industry, and which, to the best of my knowledge, is not now available, is the vocational trade school where young men interested in coal mining could go to school full-time for a period of from six months to two years to learn various aspects of coal mining. The trade school I have in mind is similar to the type now offering courses in electricity, automotive mechanics, electronics, plastics, gun-smithing, heating, ventilation, refrigeration, etc. I visualize a trade school for coal mining where a young man might go and, upon the payment of a nominal fee, receive instruction in various phases. Such instruction could very well be in mine equipment maintenance; in private correspondence I have received an excellent outline for such a trade school course of study. (See Appendix E.) Another idea suggested is coal preparation, plant maintenance and operation. This course would emphasize a-c electricity and cleaning plant equipment.

The greatest obstacle to the establishment of trade schools is the heavy financial investment required to establish the school, in terms of shops, machines, floor space and instructional staff. There is a possibility that trade schools already in existence might be interested in adding such a course of instruction to their existing curricula. I should therefore like to suggest that the Bituminous Coal Institute Director of Education, and the Institute's committee on education give this suggestion consideration, with the prospect of establishing at least one such school in an already established trade school, preferably in a centralized location with respect to the coal mining industry. It seems to me that such a course of instruction might very well be broken down into units of instruction so that a new class would be admitted at regular intervals of say three or six months, and the new student would progress from one unit of instruction to another until graduation had been achieved.

### Industry Training Programs

All of the above discussion has been based upon educational programs outside of and not under the guidance of individual coal companies in which young men are already employed. Let us now examine what exists in the industry in the form of training programs and the indicated need for more such programs.

One of the most crucial problems facing the coal industry in America is the development of leaders for the future—in both the technical and management areas. The leaders will be drawn more and more from the ranks of professionally trained men. The quality of preparation these young men are now receiving in colleges and their in-service training are therefore a joint responsibility of the colleges and the industry. The universities and colleges have been preparing potential engineers and leaders for mining for many years; now the industry must realize its responsibilities in providing training for the advancement of the college graduate.

The coal industry is becoming more and more mechanized and the magnitude of mining operations is increasing. It has become increasingly technical along with mechanization, and the complexity of operations is resulting in a very high degree of specialization and division of labor. The independent craftsmen of yesterday are being replaced by men having specialized knowledges and abilities in certain areas of endeavor. No longer does the individual miner drill, shoot and load his coal. Specialists now operate complex mining machinery to do these tasks. This specialization, with the growth of modern mining business, has brought about powerful labor unions and countless government agencies, each exerting its influence on business activities with respect to the mining industry. The level of education in the mining industry is therefore rising throughout the nation, and management is becoming more responsive to the reactions of the worker and the opinions of the consuming public. The increasing complexities of mining operations consequently require the employment in increasing numbers of college graduates with technical backgrounds and a broad professional outlook toward management.

With the advent of mechanization and the higher degree of specialization in the mining industry some people have erroneously concluded that the colleges should train specialists. This is a serious misconception. Actually the best education for the mining industry consists of sound fundamentals. Specialized jobs in the mining industry cannot be learned in college but only through experience in applying fundamental principles to mining operations. I hold that it is the responsibility of the universities and colleges to train young graduates for careers rather than for specific jobs.

### Development of Leadership

In developing leaders for the future the mining industry should be in search of men who have (1) intellectual competence, (2) the personality and ability to deal with large groups of people, and (3) the desire to learn, lead, and get ahead. Assuming that management has recognized the potentialities for future leadership it then becomes management's responsibility to provide the industrial know-how and specialization required for the job, and to be continuously concerned with the development of the man.

One of the first requirements for the effective development of future leaders is a favorable atmosphere in which the individual may grow. This means that an enlightened management must fully realize that of all the ingredients going into a successful business, satisfied personnel is the most important. There is little question that young men must be prepared to work for a period of time beneath their abilities, but management should attempt to use men's abilities at the highest possible level and at the same time provide opportunities for further development. Management must therefore not be blinded to the important role played by its attitude at all employment levels; this includes association with superiors who have a healthful outlook toward their job, their industry and life in general.

Educational and training programs for the development of supervisory personnel will not bring the desired results unless competent men are available for such training. It then becomes management's responsibility to select the right type of men for employment in the coal industry. The careful screening of candidates is essential, since a high school or college diploma is not in itself evidence of fitness for a particular kind of employment in a given company.

### Orientation of Training and Practice

I should also mention, as a caution, that there is little use in recruiting men of outstanding abilities unless some provision is made to give these men the orientation and training they need to do a job and to progress into positions of supervisory and managerial responsibilities. Somewhere along the line there should be an opportunity to become acquainted with the personnel, organization, and policies of the company; the young graduates need work experience in the different aspects of the company's operations so that they may learn at first hand the avenues of opportunity which are open to them.

The first year of employment should include a series of work assignments of several months, each of which will give them a better understanding of the many fields in the mining industry. When a young college or high school graduate joins a company he is making an investment of his time and talents in the organization, and the organization is making an investment in him. The new employee's usefulness to the employer will be determined in large measure by the type of training and guidance he receives during his first year or two of employment. An investment in training and guidance will bring good financial returns to the company as well as to the individual.

Orientation and initial training are not enough. There is a need for follow-up training, on an informal basis, as a new employee moves along in his career. One of the best keys to good work is job satisfaction. Too frequently in the past the mining industry considered men on jobs to be either round or square. Men are neither round or square—they are of many different shapes from the standpoint of aptitudes, abilities and interests. It is much better to provide jobs designed to fit the man rather than forcing the man into a sort of mold that he is ill adapted to fit. Job rotation broadens the young employee's experience and assists materially in developing leaders. A promotional system based on individual performance contributes to the employee's peace of mind and thus creates a favorable condition for professional growth into leadership and management.

I do not wish to propose specific types of programs for training young graduates for supervisory positions. In private correspondence outlines of programs have been received from companies who operate planned and supervised training programs for their employees, and I have their permission to attach the following appendices as being examples of training programs now being offered by individual companies of the coal mining industry.* I can recommend a careful study of these programs as examples of what can be done and can also recommend that each of you make an honest effort to initiate a program designed to meet your individual needs.

Small companies need a training and development program as much as big corporations, but it must be tailored to fit the needs of the smaller companies. It could be a mistake for small inexperienced companies to adopt the programs and methods of large business; it is much better to set down a few practical objectives and reach an agreement on how the objectives can be attained. All that is needed is the active support of top management and some one who is interested in the young recruit and his professional development.

# APPENDIX

The following Appendices A-F are accounts submitted to the author by coal companies outlining educational and training programs now being carried on within their own organizations.

## Appendix A

We have had training programs designed to prepare miners for supervisory positions but have not limited our applicants to high school graduates or graduate engineers. The men selected for this training had to meet several specifications, one of which was education, but we found we had to waive the educational requirements in order to fulfill requirements we felt were more important.

This training program consisted of a varied work experience and classroom work for a period of twenty-eight weeks. The work experience included assignments to our underground maintenance shops and staff departments such as Industrial Engineering, Preparation, Safety, etc. The classroom work consisted of several of the TWI programs such as Job Methods training, Job Relations training, and Job Instructor training; also Mine Rescue, First Aid, The Job of a Section Foreman, Union Contract, Unemployment and Workman's Compensation Practices, Company Policy and Procedures, and an intensive course in the West Virginia State Mine Law. During their training, the foreman candidates were given every opportunity to substitute as section bosses.

## Appendix B

All new engineers are hired for mine labor work. They will be assigned to the tipple for a short time and then sent underground. While underground they will be worked on all phases of work for a sufficient time to permit them to become fully aware of the how, why, etc., about each job. They will then be placed in the repair department for about three months. In all, this program of working on the job as a mine worker will take approximately fifteen months. Upon the completion of this work the employee will then be put on salary and assigned to the laboratory, warehouse and engineering for three months in each department. Following these assignments the employee will work in our industrial engineering department for six months to a year. He will then be assigned as a section foreman.

This plan covers a period of three years from time of employment to supervision. If the employee is interested in remaining in engineering instead of going into operations, then he is placed in the Industrial Engineering Department for three months prior to going to the Mine Engineering Department. In the instances of Electrical or Mechanical Engineers we will give them more work as repair mechanic helpers and will place them as supervisors in the Maintenance Department instead of foremen on the sections inside the mine. In consideration of the various circumstances of the individuals and the company needs, we will alter this plan accordingly. However, we are of the opinion that the entire operation will function more smoothly and the individual will profit, if all of the supervisory personnel are well acquainted with the work and problems of other departments. The supervisors will be able to coordinate their efforts more effectively. From the position of foreman, the men will be promoted according to their ability to handle the jobs, accept responsibility, handle people, and give or carry out orders.

APPENDIX C

Our company, after trial and many errors, does not have a formal training program for integrating graduate engineers into the management group of the company.

The Pennsylvania Bituminous Law requires a college graduate in Engineering to have at least three years' experience in and around the Pennsylvania mines before he is eligible to take the examinations and receive the state certificate for supervisory work. During the time between graduation and taking the examination, each graduate is placed in one of our mines on a laboring job. He is paid the union rate and is required to join the union. We have followed the policy of giving the graduates five days' work per week even at times when the mine is idle for extended periods.

The training the graduate receives is *on-the-job training*. It is under the direction and supervision of the local Mine Management. He is placed on various jobs throughout the mine so he can become familiar with all the types of work a foreman should know about. If he can attend union meetings without engendering the feeling among his fellow workers that he is a "stooge" he is requested to do so. Every precaution is taken by the local management, however, to keep good relations between him and his fellow workers. Otherwise his experience with the workers will not be natural and a very important part of his training may give him a false basis on which to build his human relationships.

We have discovered by experience that so far as our company is concerned this type of program has possibilities for greater success than the former method we used. We formerly scheduled our graduate engineers through our personnel office and they were placed on various jobs as "observers." They looked to the Industrial Relations Department as a sort of godfather and as a result did not feel they had any responsibility to the local management. This arrangement resulted in quite a lot of dissatisfaction among the "trainees" (a poor word to use in this connection). Now when a graduate enters the company he does so as an employee who assumes the responsibilities of any job he is given. He has full opportunity to show the advantages of his knowledge, education and other abilities. He "sells" himself – he is not a protege of the personnel manager who is trying to make a job for him.

It is difficult for me to write without bias on this subject because I am so thoroughly in favor of our present type of program. It has its limitations, of course. The quantity and quality of the training depends, in a great measure, on our local mine management. The higher echelons of management, however, do make it a matter of concern to see that the right kind of training is given so that we feel our mistakes here will be limited and that the advantages will far outweigh any disadvantages which may become apparent.

The job of supervision in a coal mine is not easy to attain. It is one which is difficult and requires a high type of management. Everyone will agree that there is room for considerable improvement in our methods of training – both those who now hold those jobs and their understudies. However, it is a job where satisfaction of accomplishment brings a reward that is greater than in most supervisory work. A mine supervisor who is getting results can and does feel that he has done so in spite of many difficulties which are peculiar to coal mining only.

In these days of transition to mechanized mining it is important that we have a program for developing the managerial abilities of all our supervisors. The type of program will depend on the size of the company and how it is organized. What would work for one may not work for another. We must watch carefully not to put the graduate engineer in a class by himself. He should be a part of the company team from the earliest possible moment – this is only being fair to him.

## Appendix D

During the War, many companies were in various stages of mechanization. New technical problems faced men at the different supervisory levels. These men were considered good men under existing conditions and methods. So long as problems were common with their experiences, they could be expected to solve them. New conditions and problems resulting from mechanization and the pressure for maximum production placed a load upon these men beyond their capacity to carry satisfactorily. The conclusion was that the Industry needed more men with engineering training.

At this time there was considerable thought given to the training of men for "bossing" or the first level of supervision. Many agreed that the engineer would not be interested in the lower levels of supervision; hence it would be necessary to develop young men, who had high school educations, for these supervisory positions. It was the thought that these men could acquire the technical knowledge necessary for such jobs. By a selective process a certain percentage would become good supervisors. Those with exceptional ability could advance in the organization to far more responsible positions. The gist of the thinking was that there must be more emphasis on brains and less upon brawn for the mine supervisor of tomorrow.

In planning for the training of young engineers, we placed emphasis on securing and training men for mine operations and maintenance work and for cleaning plant operation and maintenance. We believe that there is no great problem in securing a sufficient number of engineers for engineering departments and for power plant and power distribution work.

Our engineer trainees may be grouped roughly as follows:

1. Mine operations – this group is made up of mining engineers.

2. Mine equipment maintenance – mining, electrical and mechanical engineers.

3. Cleaning plant operation and maintenance – mining, electrical and mechanical engineers.

The early training has consisted of varied work experience. It is our thought that the young engineer should become familiar with every job which later will come under his supervision. State Mining Law requirements make it necessary for the mining engineer to have a minimum of three years of mine experience before he can be certified for mine supervisory work. This requirement allows time for a diversified work experience program and gives the trainee an opportunity to demonstrate his adaptability to working in mines and with mining people.

As soon as an engineer can be advanced to supervisory work (depending upon necessary certification, experience and maturity) he is given as much diversity as possible so that he works with different crews in different mines or cleaning plants and under different officials. In this manner his experience is broadened and there is an opportunity to judge his ability and capacity for growth. Advancement will be made as rapidly as the trainee demonstrates the ability to handle added responsibility.

We believe there are a few fundamental principles which must be followed in developing the graduate engineer.

1. Selection of the trainee. To date there has been a limited choice, but this situation is rapidly being corrected. We like to secure engineers who have some mine work experience. They understand mine conditions and have considered this aspect when choosing a mining career. Intelligence, scholastic record, previous work record, personality, and dependability are among other factors considered. Where possible, candidates for jobs are given an opportunity to work in the mines during summer vacations. In this way some observations can be made which aid in making selections.

2. Security during the training period. Many trainees are ex-servicemen. Usually they are married and have family responsibilities. They need a regular income to aid in establishing homes. For this reason, we believe the engineer trainee must be assured a minimum monthly income during his period of training. He is not willing to run the risk of loss of income due to extended strikes, etc. If such assurance is not provided he will seek work where he can plan on a regular income.

3. A proper understanding of the plan for training. The trainee should be a party to the planning for his training. He must understand the reasons for the types of experience being provided, the approximate time required, and what is expected of him. The training plan will vary according to the needs of the individual, available opportunities, and the needs of the organization.

4. Periodic check-ups. Check-ups on the trainees' progress must be made at frequent intervals. This can be done by check with his

superiors. In addition, the trainee must be interviewed frequently. Any problems must be corrected promptly.

5. The trainee must progress. Proper opportunity must be given for the trainee to progress. If he fails to make satisfactory progress, due to his own limitations, he should be released. When employed, this should be understood very definitely. The reaction of the young engineer, when this policy is explained to him, is that he wants to be told at once when it is apparent that he does not fit so that he can locate other employment and not waste more time at work at which he is not suited.

There are several viewpoints on the training of the high school graduate for mine supervision. Our main arguments for wanting high school graduates are:

1. There is little excuse today for failure to complete high school. In most cases failure is due to:

   a. Lack of ambition.
   b. Lack of intellectual ability.
   c. Lack of ability to make adjustments with others — fellow students, teachers.

2. A satisfactory high school record should be an indication of ability to acquire technical information.

The usual training for the high school graduate consists of mine work experience, attendance to evening mining classes, and the preparation for examinations for state certification as a mine official. This is a selective process which depends largely upon the individual. He must acquire his state certificate. As a beginning official he must be given close attention and guidance until he adjusts himself to supervisory work.

Several years ago a number of companies in Central Pennsylvania, in cooperation with a college centrally located in the area, opened a summer school for young men in the Industry. The object was to encourage the better young men to develop their mental muscles and to broaden their viewpoints on the problems of the Industry. It is too early to give any estimate of the value of this type of training. Emphasis is on general courses rather than strictly technical work. As young men complete this work it is planned to give them rather broad and varied mine work experience with a view of developing key workers, maintenance men and supervisors. (Editor's Note: Saint Francis College, Loretto, Pa. Summer Session for Mining Men.)

During the past year some of us have been discussing the need for something similar to trade school training for young men who desire to follow mining. From present indications, it appears that the Industry will employ only a limited number of young men in the immediate future. An over-supply of coal plus the increase in mechanization means that fewer miners will be employed. This situation will have some influence on decisions to organize high school mining courses on a vocational basis simply because the Industry will not absorb the graduates.

The thought has been advanced that the young men who are employed should be carefully selected. Practically all miners will operate or repair some type of equipment. Therefore, they should have training in the care, operation, and repair of mine equipment. This could be done by centrally located trade schools especially organized and equipped for this purpose. At present there are no schools of this type. Our young men who wish to get technical training usually take electrical courses at Coyne in Chicago or Bliss in Washington, D. C. It appears that several private schools could operate profitably for training future miners. The personnel and facilities of most companies do not permit the operation of a company-sponsored school, nor do evening extension classes offer the solution.

APPENDIX E

Trade school training in Mine Equipment Maintenance should be available for young men now in the industry who desire to advance, as well as for high school graduates who seek employment in the mining industry. Before any prospective student is accepted he should be interviewed by experienced vocational counselors and properly tested to make reasonably certain of his interests and adaptability. No man should be encouraged to take training except those definitely qualified. The type of course I have in mind would cover a period of at least six months and would include such items as the following:

1. Welding.
2. Related metallurgy.
3. Related mathematics.
4. Print reading and lay-out work.
5. Pipe threading and fitting.
6. Types and sizes of screws, bolts, fittings, etc.
7. Electricity.
    - (a) Fundamentals.
    - (b) D-C motors — operation, care and repair.
    - (c) Wiring systems, controls, etc.
8. Mine equipment.
    - (a) Types.
    - (b) Mechanical principles.
    - (c) Assembling.
    - (d) Fitting and adjusting bearings.
    - (e) Lubrication.
    - (f) Hydraulic systems.
    - (g) "Trouble shooting."
    - (h) Repair methods.
    - (i) Economics — outages, temporary repairs, replacement of parts, etc.

With certain changes this course could be adapted to coal preparation plant maintenance. The emphasis would be placed on a-c electricity and cleaning plant equipment, or small scale models would be needed in place of mine equipment.

As I visualize this type of program, the school would require a continuous supply of students to operate efficiently. Cost of instruction would be high due to the type of instructors required, and the limited size of classes. A large amount of floor space for shop purposes would be required. This is one of the biggest obstacles. The cost will, of necessity, definitely limit the number of such schools. Tuition costs, along with living costs, will have a direct bearing on the number of men who would enroll. If such a school could be organized while G.I. benefits are available it would assist in getting started.

The above idea has been discussed with representatives of several mine equipment manufacturing companies. They have assured me that their companies would welcome an opportunity to cooperate by loaning equipment. Of course there is a limit to the number of such schools that manufacturers would be willing to equip.

Frequently, young men who work for us come to me for information relative to trade school training which would be helpful to them. Most of our maintenance men lack a good foundation in electricity and, for this reason, I have been suggesting electrical trade schools. I don't know anything else to suggest. It seems to me that our industry is large enough to support at least one or two trade schools which would definitely train men in the maintenance of the vast amount of electrically operated mine and cleaning plant equipment.

The type of training which I have attempted to outline above is that needed by key men and men who will likely develop for the lower levels of maintenance supervision. In fact, it is training which every employee in a mechanical mine should have. This training will not lessen the need for evening extension classes and on-the-job training for the majority of our present employees who cannot avail themselves of the type of training outlined above. It does seem that new employees and replacements should be carefully selected and should have some preliminary training on mine equipment before being placed.

## Appendix F

### Training Program for Graduates

#### BASIC TRAINING PLAN

1. Varied work experience in all phases of mining.
2. Regular courses in safety, supervision, labor relations, job methods, first aid, and mine resuce training.
3. Discussion meetings with key executives on mining subjects.

MINING ENGINEERS

Two-year program leading to positions in Production, Engineering, Preparation, and Industrial Engineering.

Face Work – 6 months (1 month each in 6 different jobs).

Maintenance – 2 months (1 month each in different shops).

Time Study – 2 months (face operations).

Preparation – 2 months (Preparation plants and laboratory).

Surveying – 1 month (inside mines).

Drafting – 1 month (mine maps).

Note: Remaining 9 months' assignments depend on whether man is going into Production, Engineering, Preparation or Industrial Engineering.

ELECTRICAL AND MECHANICAL ENGINEERS

Two-year program leading to positions in Maintenance Engineering.

Face work – 3 months (1 month each on 3 different jobs).

Inside Shops – 6 months (3 months each in 2 mines).

Electrical Shop (outside) – 3 months.

Mechanical Shop (outside) – 3 months.

# 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, pr 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.

# ILLINOIS MINING INSTITUTE

### LIFE MEMBERS

ADAMS, ROY L., V. P. in Chge. of Oper.......... Old Ben Coal Corporation, West Frankfort, Illinois
BALDWIN, RICHARD, Pres.......... Midwest-Radiant Corp., 220 N. Fourth Street, St. Louis 2, Missouri
BALL, CLAYTON G.....Paul Weir Company, 20 North Wacker Dr., Chicago 6, Ill.
BARROW, W. E..........Joy Manufacturing Co., Franklin, Pa.
BELL, J. H., Pres.........Cardox Corporation, 307 North Michigan Ave., Chicago 1, Ill.
BOWMAN, CHARLES L., Pres.......... The Bowdil Company, P.O. Box 470, Canton, Ohio
BROOKS, C. W..........9620 S. Winchester Ave., Chicago 43, Ill.
BROWNING, J. ROY..........120 S. La Salle St., Chicago 3, Ill.
BUCHANAN, D. W., Chmn. of the Bd.......... Old Ben Coal Corp., 230 S. Clark St., Chicago 4, Illinois
BUCHANAN, D. W., JR., Pres.......... Old Ben Coal Corp., 230 S. Clark St., Chicago 4, Illinois
BUDD, RALPH, Chairman.......... Chicago Transit Authority, 175 W. Jackson Blvd., Chicago 4, Ill.
BUTCHER, FRED E..........119 N. Gilbert St., Danville, Ill.
CARNEY, WILLIAM ROY ..........33 S. Clark St., Chicago 3, Ill.
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GARCIA, JOHN A.........Allen & Garcia Co., 332 S. Michigan Ave., Chicago 4, Ill.
GEROW, T. G., Vice Pres.......... Truax-Traer Coal Co., 230 N. Michigan Ave., Chicago 1, Ill.
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HALBERSLEBEN, PAUL, G. S..........Sahara Coal Co., Harrisburg, Ill.

HARRINGTON, GEO. B., Pres.....
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HARRIS, ALLYN.....500 W. Union, Wheaton, Ill.
HARRIS, JOSEPH.....Russell Fork Coal Co., Inc., P. O. Box 173, Praise, Ky.
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Illinois Central System, 135 E. Eleventh Pl., Chicago 5, Ill.
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KOLBE, FRANK F., Pres.....
The United Electric Coal Co's., 307 N. Michigan Ave., Chicago 1, Ill.
LEACH, B. K., Pres.....
Egyptian Tie & Timber Co., 1803 Railway Exchange Bldg., St. Louis, Mo.
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Freeman Coal Mining Corp., 208 S. La Salle St., Chicago 4, Ill.
COLQUHOUN, ALEX. Peabody Coal Co., Taylorville, Ill.
COLTMAN, WILLIAM
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COMPTON, NEAL. General Electric Co., 112 N. Fourth St., St. Louis, Mo.
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CONLON, JOHN, Auditor. Peabody Coal Co., 1129 W. Vine St., Taylorville, Ill.
CONNOLLY, JOHN, Mine Engr. Peabody Coal Co., Div. Office, Marion, Ill.
CONNOR, J. M., V.P. West Penn Power Co., Pittsburgh, Pa.
CONROY, E. D. U. S. Rubber Co., Merchandise Mart, Chicago 54, Ill.
CONWAY, C. C. Consolidated Coal Co., Railway Exchange Bldg., St. Louis, Mo.
CONWAY, JOHN, Rep't. Joy Mfg. Co., 415 Crestview, Henderson, Ky.
CONWAY, LEE. Consolidated Coal Co., Staunton, Ill.
COOK, JOHN. Union Colliery Co., DuQuoin, Ill.
COOK, U. J. DuPont Co., 1814 McCormick Bldg., Chicago 4, Ill.
COOK, WALTER, Vice Pres.
Central Mine Equipment Co., 107 E. Adams, Benton, Ill.
COOKE, WILLIAM H., Pres.
Little Sister Coal Corp., 310 S. Michigan Ave., Chicago 4, Ill.
COOMBES, D. R., Sales Mgr.
Mechanization, Inc., 406 Munsey Bldg., Washington 4, D. C.
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COTTON, HOMER S. Midvale Coal Co., 721 Olive St., St. Louis 1, Mo.
CRAGGS, JOE. Peabody Coal Co., Taylorville, Illinois
CRAIN, HUBERT, Mgr. Sales Calcium Chloride.
Dow-Chemical Co., 3615 Olive St., St. Louis 8, Mo

CRAWFORD, J. G. ........ 18 E. North Ave., Hinsdale, Ill.
CRICHTON, A. B., JR., Asst. to the Pres. ........ Johnstown Coal & Coke Co., Johnstown, Pa.
CROSS, ARCH ........ Sandborn, Indiana
CROTHERS, ARTHUR ........ Fraser Label Co., 732 Federal St., Chicago 5, Ill.
*CROWDER, GORDON G., Vice Pres. ........ Peabody Coal Co., 231 S. La Salle St., Chicago 4, Ill.
CRUIKSHANK, JOHN W., Field Repr. ........ Goodyear Tire & Rubber Co., Inc., 339 Lafayette Blvd., Belleville, Ill.
CULL, A. B., P. A. ........ Consolidated Coal Co., 611 Olive St., St. Louis 1, Mo.
CUNION, EUGENE E. ........ Peabody Coal Co. Mine No. 9, 319 West Franklin St., Taylorville, Ill.
*CUNNINGHAM, M. F. ........ Goodman Mfg. Co., 730 N. Catherine Ave., La Grange Park, Ill.
CURRENCE, D. B., District Mgr. ........ Union Wire Rope Corp., 1144 North Branch St., Chicago 22, Ill.
DAHLBERG, T. L. ........ Hockaday Paint Co., 166 W. Jackson Blvd., Chicago 4, Ill.
DAMES, ROLAND N., Pres. ........ R. J. Bearings Corp., 3300 Lindell Blvd., St. Louis 3, Mo.
DANKS, G. H. ........ E. I. Du Pont de Nemours & Co., Inc., P.O. Box 14, Carbondale, Ill.
DAUGHERTY, C. H. ........ Linde Air Products Co., 230 N. Michigan Ave., Chicago 1, Ill.
DAVIS, E. J., Dist. Mgr. ........ Gates Rubber Co. Sales Div., Inc., 4215 Clayton Ave., St. Louis 10, Mo.
DAVIS, N. L. ........ N. L. Davis Co., 343 S. Dearborn St., Chicago 5, Ill.
DAVIS, PHILIP D., JR. ........ Okonite Co., 20 North Wacker Drive, Chicago, Ill.
DAVIS, T. E. ........ The Jeffrey Mfg Co., 1327 N. Ninth St., Springfield, Ill.
DAVIS, WM. H. ........ Simplex Wire & Cable Co., 564 W. Monroe St., Chicago 6, Ill.
DAVISON, L. A. ........ W. M. Hales Co., Benton, Ill.
DAWSON, HUGH ........ Bethlehem Steel Co., 500 W. Monroe, Herrin, Ill.
DAY, CARL D., JR. ........ United Electric Coal Co., Buckheart Mine, 308 W. Pine St., Canton, Ill.
DAY, MATTHEW, Mine Mgr. ........ Mt. Olive & Staunton Coal Co., Staunton, Ill.
DEAN, CLARENCE ........ Cummins Diesel Sales Corp of Mo., 3311 Washington, St. Louis 6, Mo.
DEASON, JACK W., Engr. Dept. ........ Peabody Coal Co., Marion, Ill.
DEASON, ROY, Engr. ........ Consolidated Coal Co., Herrin, Ill.
DELANEY, J. H. ........ J. R. Engineering Co., Box 906, Zeigler, Ill.
DETWEILER, M. H. ........ Zeigler Coal & Coke Co., Zeigler, Ill.
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DICKSON, RUSSELL J., Dist. Mgr. ........ A. Leschen & Sons Rope Co., 810 W. Washington Blvd., Chicago 7, Ill.
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DINN, T. J.....................................................Ohio Oil Co., West Frankfort, Ill
DOBBINS, JOHN, Mine Mgr.............Old Ben Coal Corp. No. 11, Johnston City, Ill.
DOCTORMAN, A. P., Engr...................................Truax-Traer Coal Co., Elkville, Ill.
DODD BROTHERS, Distributors..........................................................
Shell Oil Co., 208 So. Maple St., Harrisburg, Ill.
DODD, A. F., Gen. Supt.......................................................................
United States Steel Co., R. F. D. No. 1, Georgetown, Ill.
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DUNBAR, LEO A., Mgr. Pump Dept......................................................
Grinnell Co., Inc., 4425 S. Western Ave., Chicago 9, Ill.
DUNCAN, GEORGE, SR.....................Duncan Foundry & Machine Co., Alton, Ill.
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EGELAND, HOWARD.........................Link Belt Co., 317 N. 11th, St. Louis 1, Mo.
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ELLIS, HOWARD R., Slsmn. & Engr. Cardox Corp., 831 Oakland, Mt. Vernon, Ill.

ELLWOOD, E. E., Dist. Sales Mgr. Youngstown Steel Products Co., 611 Shell Bldg., St. Louis 3, Mo.

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EVANS, JOHN H., Supt. Wasson Coal Co., Harrisburg, Ill.

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FARRIMOND, JACK Peabody Coal Co., No. 58, Taylorville, Ill.

FEERY, BERNARD T., Sales Engr. Webster Manufacturing, Inc., 343 S. Dearborn St., Chicago 4, Ill.

FELLMETH, J. W. 7 W. Conron, Danville, Ill.

FERGUSON, FRED Roof Bolting Div., Diamond Supply Co., Inc., Oakland City, Ind.

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FIRMIN, W. H..........Wyoming Tie & Timber Co., Metropolis, Ill.
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FISHER, S. M..........Superior Coal Co., Gillespie, Ill.
FITZGERALD, P. H..........
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FLOTA, DAVID..........Sahara Coal Co., Harrisburg, Ill.
FLOWERS, R. D..........Differential Steel Car Co., Findlay, Ohio
FOLLY, C. L..........Cent. Ill. Pub. Serv. Co., Mattoon, Ill.
FOOKS, W. D..........
Armco Drainage & Metal Prod. Co., 631 Princeton Ave., Springfield, Ill.
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FORD, CLEM C..........Jeffrey Mfg. Co., 307 N. Michigan Ave., Chicago 1, Ill.
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FORSYTH, JAMES G., Pres..........
Forsyth Carterville Coal Co., 20 South Central, Clayton 5, Mo.
FOSTER, C. B., Natl. Accts. Repr..........
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GAMMETER, E.........Paul Weir Company, 20 North Wacker Drive, Chicago 6, Ill.
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Chicago, Wilmington & Franklin Coal Co., West Frankfort, Ill.
GATELY, A. L.........Republic Coal Co., Fullerton & Southport Ave., Chicago 14, Ill.
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GILBERT, A. G................Heyl & Patterson, Inc., 55 Water St., Pittsburgh 22, Pa.
GILES, WM. S...............................Giles Armature & Electric Works, Marion, Ill.
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GIVEN, IVAN A., Editor...........Coal Age, 330 W. 42nd St., New York 18, N. Y.
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Rome Cable Corp., 4505 W. Grand Ave., Chicago 39, Ill.
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GRONE, S. F..........................................................Consolidated Coal Co., Staunton, Ill.
GROSS, J. W.......................Mechanization, Inc., 141 W. Jackson Blvd., Chicago 4, Ill.
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HARRIS, JOE Blue Bird Coal Co., Harrisburg, Ill.
*HARRIS, JOSEPH Russell Fork Coal Co., Inc., P. O. Box 173, Praise, Ky.
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HEPBURN, R. J., P. A.......................................................................................................
United Electric Coal Co., 307 N. Michigan Ave., Chicago 1, Ill.
HERBERT, C. F.........Bituminous Casualty Co., Bituminous Bldg., Rock Island, Ill.
HERMAN, EDWARD, Electn.............Superior Coal Co., P. O. Box 490, Benld, Ill.
HERMAN, JOHN........................................................Superior Coal Co., Gillespie, Ill.
HERRIN, H. C...................Old Ben Coal Corp., 1108 E. Elm St., West Frankfort, Ill.
HERT, A. K.......................................................................................................
Snow Hill Coal Corp., Merchants Nat'l Bank Bldg., Terre Haute, Ind.
HICKS, H. N.......................................................................................................
Truax-Traer Coal Co., 7 Signal Hill Blvd., East St. Louis, Ill.
HIGGINS, GEORGE J., Supt..................................Union Colliery Co., Elkville, Ill.
HIGGINS, T. C., Coal Mine Inspector.......................................................................
Bureau of Mines, 2305 S. Pasfield, Springfield, Ill.
HIMEBAUGH, GRANT S., Sales Engr.........................................................................
Raybestos-Manhattan, Inc., Manhattan Rubber Division, 445 Lake Shore Drive, Chicago 11, Ill.
HOEHN, R. A.........................................................Superior Coal Co., Gillespie, Ill.
HOEHN, ROY O., Mng. Engr....................................Superior Coal Co., Gillespie, Ill.
HOFFMAN, D. M., Pur. Agent.................................................................................
Freeman Coal Mining Corp., 4226 S. Lawndale Ave., Lyons, Ill.
HOHN, H. L., Storekeeper......................................Lumaghi Coal Co., Collinsville, Ill.
‡HOLLAND, WARREN ERNEST.........................................3244 Emmaus, Zion, Ill.
HOLLIS, R. FRANK, Gen. Supt.............Alton Box Board Co., Box 276, Alton, Ill.
HOLMES, ALBERT W., Engr.....................................................................................
Link-Belt Co., 8147 Champlain Ave., Chicago 19, Ill.
HOLMES, JOHN K., President..................................................................................
Robert Holmes & Bros., Inc., 520 Junction Ave., Danville, Ill.
HOPGOOD, TED.........................................................Atlas Powder Co., Chester, Ill.
HOPPER, WALTER I., Asst. Supt................Little Sister Coal Corp., St. David, Ill.
HOUCHARD, VIC......................................................Superior Coal Co., Gillespie, Ill.
HOUSE, GENE..............................John Fabick Tractor Co., Box 296, Marion, Ill.
HOUTS, ROBERT S., Western Mgr.............................................................................
Mechanization Magazine, Rm. 1606, Board of Trade Bldg., Chicago 4, Ill.
HOWARD, HUBERT E., Chmn. of the Bd....................................................................
Pyramid Coal Corp., 230 N. Michigan Ave., Chicago, Ill.
HOWARD, HUBERT E. JR., Asst. Gen. Mgr.................................................................
Pyramid Coal Corp., 2119 Railway Exchange Bldg., St. Louis 1, Mo.
HOWARD, L. BRUCE....................American Brattice Cloth Corp., Warsaw, Ind.
HOWE, A. F.......................................................................................................
Centrifugal & Mech. Industries, Inc., 146 President St., St. Louis 18, Mo.
HUBBART, CURTIS Q..............................................Superior Coal Co., Gillespie, Ill.
HUBRIG, GEO. E., Sls. Mgr.......................................................................................
U. S. Rubber Co., 352 Merchandise Mart, Chicago, Ill.
HUEY, JOHN J., Elect. Engr.......................................................................................
The United Electric Coal Co's., 307 N. Michigan Ave., Chicago 1, Ill.
HUFF, FRED A..........................................................Truax-Traer Coal Co., Elkville, Ill.
HUGILL, E. P., Field Engr.......Gates Rubber Co., P. O. Box 499, Mt. Vernon, Ill.
HUGUS, C. E. JR., Supervisor Mng. Applications.......................................................
Reliance Electric & Engr. Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio
HUMMERT, AUGUST J., V. P. & Gen. Mgr..................................................................
Breese-Trenton Mining Co., Breese, Ill.

HUTSON, CURTIS E., State Mine Inspector............Box 6, Sesser, Ill.
HYETT, LOWELL B.....C. W. & F. Coal Co., 332 S. Michigan Ave., Chicago 4, Ill.
HYLAND, C., Dept. Mgr.........Goodman Mfg. Co., 4834 S. Halsted St., Chicago, Ill.
IMMER, W. L., Wire & Cable Spec............
General Electric Co., 3928 Lindell Blvd., St. Louis 8, Mo.
IRWIN, RALPH H., Gen. Sales Mgr............
John Flocker & Co., 644 Grant St., Pittsburgh, Pa.
ISOM, JOHN, Foreman............Union Colliery Co., Elkville, Ill.
JACKMAN, H. W............Ill. State Geological Survey, Urbana, Ill.
JACKSON, CHESTER H. President............
Southwestern Ill. Coal Corp., 1514 Merchants Bank Bldg., Indianapolis 4, Ind.
‡JACKSON, EDWIN GEORGE............115½ S. Race St., Urbana, Ill.
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Mine Safety Appliances Co., 2417 S. State St., Springfield, Ill.
JACKSON, R. U., Mgr. Mining Div............
Robins Conveyors Div., Hewitt-Robins, Inc., 270 Passaic Ave, Passaic, N. J.
JAMES, D. A., Elec. Engr............
Insulation & Wires, Inc., 3435 Chouteau Ave., St. Louis 3, Mo.
JAMISON, A. R., V. P............
Standard Supply Co., 1549 S. Michigan Ave., Chicago 5, Ill.
JAXON, GEORGE S., Sales Mgr............
Nelson L. Davis Co., 343 S. Dearborn St., Chicago 4, Ill.
JAYNE, JAMES IVOR, Fulton Co. Mine Inspector............Box 195, Cuba, Ill.
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†JENKINS, W. J., Pres............
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JOHNSEN, STANLEY F., Engr.........Carmac Coal Co., 811 W. Prairie, Marion, Ill.
JOHNSON, E. H., Sls. Mgr., Mng. Div............Kennametal, Inc., Latrobe, Pa.
JOHNSON, ELMER.........John A. Roebling's Sons Co., Box 482, Davenport, Iowa
JOHNSON, HARRISON H. JR............
Johnson's Industrial Supply, 32 S. Central Ave., Clayton 5, Mo.
JOHNSON, HENRY A............
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JOHNSON, JOE, Supt............
St. Louis & O'Fallon Coal Co., 416 Portland Ave., Belleville, Ill.
JOHNSON, L. H., Supt............Peabody Coal Co., Mine No. 43, Harrisburg, Ill.
JOHNSON, W. B............R. G. Johnson Co., Farmersville, Ill.
JOHNSON, WALTER J., Pres............
Sheridan-Wyoming Coal Co., Inc., Sheridan, Wyo.
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JOHNSTON, STEWART, Dist. Mgr............
Rome Cable Corp., 4505 W. Grand Ave., Chicago 39, Ill.
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JONES, D. W., Supt............Dering Coal Co., Eldorado, Ill.

JONES, EVERETT, Lubrication Engr.........
Standard Oil Co., Decatur Div., 101 W. Cerro Gordo St., Decatur, Ill.
JONES, ISHAM, Mine Mgr.........Old Ben Coal Corp. No. 11, R. R. 1, Marion, Ill.
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JONES, JOHN E., JR.........National Mine Service Co., Box 32, Beckley, West Va.
JONES, L. L.........Hoe Supply Co., 118 N. McCann St., Benton, Ill.
JONES, R. J.........Western Cartridge Co., East Alton, Ill.
JONES, RAY.........Robt. Holmes & Bros., 510 Junction Ave., Danville, Ill.
JONES, ROBERT.........Superior Coal Co., Gillespie, Ill.
JONES, ROBERT M.........
Euclid Chicago Co., 6027 Northwest Highway, Chicago 31, Ill.
*JONES, WALTER M.........Joy Manufacturing Co., Centralia, Ill.
JOY, DEWEY E.........Cutter Bit Service Co., Christopher, Ill.
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JUNELL, ANDREW.........Truax-Traer Coal Co., St. David, Ill.
JUSTICE, CLYDE H., Pres.........DuQuoin Iron & Supply Co., Inc., DuQuoin, Ill.
KACHIK, D. J.........Paul Weir Co., 20 North Wacker Dr., Chicago 6, Ill.
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KALIES, W. D., Supt.........The L. E. Myers Co., Box 54, Springfield, Ill.
KAMINSKI, ANDREW S. JR.........
Hamilton Rubber Mfg. Corp., 1238-40 W. Washington Blvd., Chicago 7, Ill.
KEARNEY, J. P., Dist. Sls. Mgr.........
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KEELEY, GERALD V., Ind. Engr.........C. I. P. S. Co., Beardstown, Ill.
KEENAN, A. F.........U. S. Rubber Co., Merchandise Mart, Chicago 54, Ill.
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Socony-Vacuum Oil Co., 4140 Lindell Blvd., St. Louis, Mo.
KELLY, E. F. JR.........Central Ill. Pub. Serv. Co., Springfield, Ill.
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KISS, LAWRENCE, Gen. Supt. .......... Superior Coal Co., Gillespie, Ill.
KLEIN ARMATURE WORKS .......... Centralia, Ill.
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KOSTBADE, GEORGE, Mgr. .......... Bearing Service Co., 9 N. W. First St., Evansville, Ind.
KOSTBADE, HOWARD W. .......... Power Transmission Equip. Co., 1249 W. Fulton St., Chicago, Ill.
KOTZMAN, JOHN, Inspr. at Large .......... Dept. Mines & Minerals, 907 E. Leonard, Staunton, Ill.
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KREIDLER, F. L., Sales Engr. .......... Robert Holmes & Bros., 510 Junction Ave., Danville, Ill.
KUHLMAN, C. W., Mgr. .......... Lubricating Oil Dept., Shell Oil Co., 1221 Locust St., St. Louis, Mo.
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LANGTRY, R. W. .......... Commercial Testing & Engineering Co., 307 N. Michigan Ave., Chicago 1, Ill.

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LARSON, E. L. Peabody Coal Co., 231 S. La Salle St., Chicago 4, Ill.
LATIMER, T. H., Engr.
United Electric Coal Co's., 307 N. Michigan Ave., Chicago 1, Ill.
LAUGHNER, JOHN, Mgr. Renewal Parts Div. Joy Mfg. Co., Franklin, Pa.
LAW, WALTER R. Atlas Powder Co., 924 N. Sixth, Quincy, Ill.
LAZZELL, R. GLENN, Asst. to V. P.
Island Creek Coal Co., Guaranty Bank & Trust Bldg., Huntington, W. Va.
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Egyptian Tie & Timber Co., 1803 Railway Exchange Bldg., St. Louis, Mo.
LEACH, R. A. The Bowdil Co., P. O. Box 97, West Frankfort, Ill.
LEAHY, ROBERT W., Asst. to V. P.
Walter Bledsoe & Co., 310 S. Michigan Ave., Chicago 4, Ill.
LEE, ARTHUR F., Chief Engr. Pyramid Coal Co., Pinckneyville, Ill.
LEE, CARL Peabody Coal Co., 231 S. La Salle St., Chicago 4, Ill.
LEE, D. M., Sales Socony-Vacuum Oil Co., 513 W. Harrison St., Sullivan, Ill.
LEHMAN, LEWIS H., Sales Mgr.
Productive Equipment Corp., 2926 W. Lake St., Chicago 12, Ill.
LEIGHTON, M. M. State Geological Survey, Urbana, Ill.
LENTZ, JEROME V., Serv. Engr.
McNally-Pittsburg Mfg. Corp., 115 N. Fruitridge, Terre Haute, Ind.
LESENEY, R. M., Maintenance Engr. Truax-Traer Coal Co., Fiatt, Ill.
LEUVER, JOSEPH A., Sales Mgr.
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LEWIS, CHARLES R., Lubrication Engr.
Standard Oil Co., (Ind.), 23 Pine, La Grange Park, Ill.
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Old Ben Coal Corp., 509 W. Sixth St., Benton, Ill.
LEWIS, WILLIAM EDGAR, Chief Clerk
Carmac Coal Co., Box 64, R. R. 2, Stonefort, Ill.
LEYHE, CAPT. W. H. Eagle Boat Store Co., 804 N. Commercial, St. Louis 2, Mo.
LIBBRA, RAYMOND R. Libbra Company, Livingston, Ill.
LIGHTBODY, PAUL G. Shipping Utilities, 3107 Pine St., St. Louis 3, Mo.
LINDSAY, GEORGE 801 S. English, Springfield, Ill.
LINDSAY, GEORGE C. Mechanization, Munsey Building, Washington 4, D. C.
LINDSAY, LAVERNE
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LINDSAY, ROBERT L.
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LINDSAY, W. L. Socony-Vacuum Oil Co., Benton, Ill.
LINEBARGER, ROY O. Atlas Powder Co., 1606 Field Bldg., Chicago 3, Ill.
LIPSCOMB, G. F., Sales
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LITHGOW, C. H.
Jos. T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago 80, Ill.
LITTLEFAIR, JOE, Mine Mgr.
Old Ben Coal Corp., R. R. 1, Johnston City, Ill.
LODGE, ALLEN D. Ohio Oil Co., Robinson, Ill.
LOEWENHERZ, E., Pres.
K. W. Battery Co., 3705 N. Lincoln Ave., Chicago 13, Ill.

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LOHR, C. P., Repr........................................................
Reliance Electric & Engrg. Co., 1110 S. Brentwood Blvd., St. Louis 17, Mo.
LONG, GENE........................................................Truax-Traer Coal Co., Fiatt, Ill.
LONG, WILLIAM M., Assist. Vice Pres........................................
Illinois Terminal R. R., 710 N. 12th Blvd., St. Louis 8, Mo.
LORD, MERRITT M.........Wedge Wire Corp., 5602 Clark Ave., Cleveland 2, Ohio
LOTT, GEO. M.,........................................................
Mining Machinery Sales Corp., 5331 Cornell Ave., Chicago 15, Ill.
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LOY, JOHN, Shop Supt........................................................
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LYNN, C. M., Engr............................Old Ben Coal Corp., 505 Lawrence, Benton, Ill.
LYONS, ORVILLE R., Coal Prep. Engr........................................
Heyl & Patterson, Inc., 55 Water St., Pittsburgh 22, Pa.
MACALISTER, J. N........................................................
Simplex Wire & Cable Co., 564 W. Monroe St., Chicago 6, Ill.
MACDONALD, J. W., Chief Engr....................Old Ben Coal Corp., Christopher, Ill.
MAC DONALD, JOHN..............................................Superior Coal Co., Gillespie, Ill.
MAC MURDO, GEORGE C........................................................
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MAC QUEEN, G. E., Service Engr........................................................
Macwhyte Company, 1129 Ravenswood Drive, Evansville 13, Ind.
MAC VEAN, GORDON........................................................
National Mine Service Co., 907 Commonwealth Bldg., Pittsburgh 22, Pa.
MACWHYTE CO........................................................Kenosha, Wis.
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MAIZE, EARL R.............National Coal Assn., Southern Bldg., Washington 5, D. C.
MALLABURN, ED., State Mine Inspector, Dist. No. 19........................................
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MALONE, ALBERT, Mine Mgr........................................................
Carmac Coal Co., R. R. No. 1, Carrier Mills, Ill.
MANCHA, RAYMOND.......................Joy Mfg. Co., Oliver Bldg., Pittsburgh, Pa.
MARCOLINA, JOHN...................Mount Olive & Staunton Coal Co., Staunton, Ill.
MARIS, JOHN H........................................................
Maris Engr. Service Co., 1110 Brentwood Blvd., St. Louis 17, Mo.
MARSH, JAMES B........................................................
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MARTIN, FRED S., JR., V. Pres. & Gen. Mgr........................................
Diamond Supply Co., 616 N. W. Second St., Evansville, Ind.
MARTIN, JAMES, Mine Mgr........................................................
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McELHATTAN, D. F., Saf. Engr................................Peabody Coal Co., Marion, Ill.
McELWEE, R. M., Sales Engr...................................................................
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McFADDEN, NAT, Div. Engr.......................................Peabody Coal Co., Taylorville, Ill.
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McKEE, ROBERT,........ Superior Coal Co., Gillespie, Ill.
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McLAREN, W. S........ McLaren Coal Co., Marion, Ill.
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MEALS, C. D........ Bethlehem Steel Co., Williamsport, Pa.
MEDILL, ROBERT M........ R. R. 3, Springfield, Ill.
MEDILL, W. L........ Cantrall Coal Co., Box 132, Springfield, Ill.
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MERIDETH, ELMO, Sls. & Serv........ Joy Mfg. Co., 811 W. St. Louis, West Frankfort, Ill.
MERLE, JAMES J., Asst. Prep. Mgr........ Fairview Collieries Corp., Danville, Ill.
MERRITT, G. W., Vice Pres........ The Nolan Co., Bowerston, Ohio
MESHORER, SYLVAN A........ Amalgamated Steel Co., 7831-35 Broadway, Cleveland, Ohio
MEYER, FRED........ C. B. & Q. Railroad, Centralia, Ill.
MEYERS, EDMUND L., Asst. Ch. Elect........ Superior Coal Co., Gillespie, Ill.
MIDDLETON, RAY....Roberts & Schaefer Co., 130 N. Wells St., Chicago 6, Ill.
MIESNER, HAL........ Dooley Bros., 1201 S. Washington, Peoria, Illinois
MIKESELL, D. B., Pres........ American Brattice Cloth Corp., Warsaw, Ind.
MILKIE, ALBERT A........ Hewitt-Robins, Inc., 402 W. Randolph, Chicago 6, Ill.
MILLER, A. J., City Frt. Agt........ C. B. & Q. R. R. Co., 625 Frisco Bldg., St. Louis 1, Mo.
MILLER, FRED A........ Consolidated Coal Co., 509 N. 11th St., Herrin, Ill.
MILLER, J. W........ National Electric Coil Co., 273 Cornwall Drive, Crete, Ill.
MILLER, JACK........ General Electric Co., 112 N. Fourth St., St. Louis 2, Mo.
MILLER, RICE W........ Nokomis Coal Co., Nokomis, Ill.
MILLER, WM. J., Vice Pres........ Hawthorn Coal Co., 688 Arcade Bldg., St. Louis 1, Mo.
MILLIGAN, EMERY........ Freeman Coal Mining Corp., 208 S. La Salle St., Chicago, Illinois
MINERS, VERNE....Standard Oil Co. (Ind.), 910 S. Michigan Ave., Chicago 5, Ill.
MITCHELL, A. G........ Independent Explosives Co., 828 Pace Ave., Box 87, Mt. Vernon, Ill.
MITCHELL, D. R........ Mineral Industries Bldg., State College, Pa.
MITCHELL, WILLIAM, State Mine Inspr., Eighth Dist........ 510 W. Easton, Gillespie, Ill.

MOEHLMANN, C. T., Vice Pres....
Central Mine Equip. Co., 6200 N. Broadway, St. Louis 15, Mo.
MOHN, B. E....Edward Mohn & Son, Inc., Bartonville 1, Ill.
MONICO, J. A....
Equitable Powder Mfg. Co., 212 N. Pennsylvania Ave., Belleville, Ill.
MONSCHEIN, JOHN, Foreman....Superior Coal Co., Staunton, Ill.
MONTGOMERY, N. L....
Templeton, Kenly & Co., 1020 S. Central Ave., Chicago 44, Ill.
MOORE, R. O., Sales Mgr....Vascoloy Ramet Corp., Waukegan, Ill.
MORAN, FRANK W., Field Repr....
Amer. Mng. Congress, 600 S. Michigan Ave., Chicago, Ill.
MORAN, JOHN THOMAS JR., Mng. Engr....
Superior Coal Co., 205 E. Tenth, Gillespie, Illinois
MOREFIELD, FLOYD, Mine Mgr....
Union Colliery Co., 222 East Cole St., DuQuoin, Ill.
MORGAN, F. D....Peabody Coal Co., Marion, Ill.
MORGAN, J. W., Pres....
Ayrshire Collieries Corp., 105 S. Meridian St., Indianapolis 4, Ind.
MORRIS, ALBERT, State Mine Inspr....
Dept. Mines & Minerals, 706 W. Elm, Taylorville, Ill.
MORRIS, ROBERT N., Prep. Engr....Sahara Coal Co., Harrisburg, Ill.
MORRIS, WILLIAM L., Engr....Wasson Coal Co., 326 E. Ford St., Harrisburg, Ill.
MORROW, J. B., Pres....
Pittsburgh Consolidation Coal Co., 2042 Koppers Building, Pittsburgh 19, Pa.
*MORROW, J. D. A., President....Joy Manufacturing Co., Franklin, Pa.
*MOSES, HARRY M., Pres....
Bituminous Coal Operators Assn., Suite 303 The World Center Bldg., 918 16th St., N.W., Washington 6, D. C.
MOULTRIE, GEORGE, Face Boss....Mt. Olive & Staunton Coal Co., Worden, Ill.
*MUELLER, FRANK E., Pres....
Roberts & Schaefer Co., 130 N. Wells St., Chicago 6, Ill.
MUELLER, JACK L....U. S. Graphite Co., 963 N. Geyer Rd., Kirkwood 22, Mo.
*MULLINS, T. C., Pres....
Northern Illinois Coal Corp., 310 S. Michigan Ave., Chicago 4, Ill.
MULVANEY, C. S., Mining Engr....
Peabody Coal Co., 231 S. La Salle St., Chicago 4, Ill.
MUNRO, W. T....Southern Electric, Inc., 5025 Columbia Ave., Hammond, Ind.
MUNTZ, C. L., Chief Engr....The Nolan Co., Bowerston, Ohio
MURNAHAN, RALPH E....
Standard Oil Co., 820 Division St., Evansville 2, Ind.
*MURPHY, FRANCIS B., Pres....
Peoria Transportation Co., 542 S. Adams St., Peoria, Ill
*MURPHY, H. C., Pres....
Burlington Lines, 547 W. Jackson Blvd., Chicago 6, Ill.
MURPHY, J. T., Dist. Mgr....
Chicago Pneumatic Tool Co., 1931 Washington Ave., St. Louis, Mo.
MURPHY, LT. COMDR. JOHN J. S., USNR....
P. O. Box 338, Balboa Heights, Canal Zone
NASH, J. J....Sligo, Inc., 1301 N. Sixth St., St. Louis 6, Mo.
NEAL, J. D....Consolidated Coal Co., Mt. Olive, Ill.
NEAL, ROSS, Mine Supt....Franklin County Coal Corp., Royalton, Ill.
NEIBCH, KENNETH WM....Bell & Zoller Coal Co., Murdock, Ill.

NEILL, H. WILLIAM, Mgr.....
Cummins Diesel Sales Corp. of Ill., 1700 S. Indiana Ave., Chicago 16, Ill.
NELSON, C. J., Fuel Traffic Mgr.....
C. B. & Q. Railroad, 547 W. Jackson Blvd., Chicago 6, Ill.
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.
NOECKER, D. S.....Cities Service Oil Co., Box 311, Galesburg, Ill.
NOEL, JOHN E.....Kennametal, Inc., 411 W. Sixth St., Benton, Ill.
NOEL, WILLIAM, Asst. Dist. Mgr.....Cardox Corp., Benton, Ill.
NOLD, H. E., Prof. Mine Engr.....Ohio State University, Columbus 10, Ohio
NOLF, D. W., Div. Serv. Engr.....Shell Oil Co., Shell Bldg., St. Louis, Mo.
NORTON, J. W.....B. E. Schonthal & Co., Inc., 209 S. 18th St., Herrin, Ill.
NORTON, R. C.....1514 Merchants Bank Bldg., Indianapolis, Ind.
NOWERS, HENRY, Labor Commissioner.....
Illinois Coal Operators Assoc., Annawan, Ill.
NUCKELS, C. E.....Post-Glover Electric Co., 221 W. Third St., Cincinnati, Ohio
*NUGENT, FRANK.....
Freeman Coal Mining Corp., 208 S. La Salle St., Chicago 4, Illinois
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.
O'CONNOR, J. A.....U. S. Bureau of Mines, Vincennes, Ind.
OETTEL, GILBERT B.....
Power Transmission Equipt. Co., 640 W. Washington Blvd., Chicago 6, Ill.
OLDS, MARSHALL, III.....
Jones & Laughlin Steel Corp., Shell Bldg., St. Louis 3, Mo.
O'LOUGHLIN, IVAN, Engr.....
Northern Illinois Coal Corp., 310 S. Michigan Ave., Chicago 4, Ill.
OLSON, A. J., Asst. Sls. Mgr.....
Joseph T. Ryerson & Son, Inc., 2558 W. 16th St., Chicago 80, Ill.
O'NEAL, BYRON.....Mt. Olive & Staunton Coal Co., Staunton, Ill.
O'NEILL, T. J.....U. S. Rubber Co., Merchandise Mart, Chicago 54, Ill.
ORENBERG, JOE, Dealer.....Taylorville Waste Co., Taylorville, Ill.
O'ROURKE, DAN.....
Sanford-Day Iron Works, 321 N. Seventh St., Terre Haute, Ind.
O'ROURKE, PETE.....W. M. Hales Co., Danville, Ill.
OSBORNE, N. M., Dist. Mgr.....
I-T-E Circuit Breaker Co., Shell Bldg., St. Louis 3, Mo.
OSBORNE, WM. JR.....Superior Coal Co., Gillespie, Ill.
OVERSTREET, J. W.....National Electric Coil Co., Columbus, Ohio
OVERTURF, W. E., Field Serv. Mgr.....Joy Mfg. Co., Washington, Pa.
OWENS, A. D., Lub. Engr.....Ohio Oil Co., Robinson, Ill.
PAGE, D. C., Vice Pres.....
Walter Bledsoe & Co., 603 Safety Bldg., Rock Island, Ill.
PAGE, FARRELL.....B. E. Schonthal & Co., Box 504, Sesser, Ill.

PARIS, J. A., Mng. Engr.........
C. W. & F. Coal Co., Orient No. 1, West Frankfort, Ill.
PARKER, ELTON L.........
Industry Engineering Co., Westinghouse Electric Corp., East Pittsburgh, Pa.
PARKER, GEORGE.........Ohio Oil Co., Vincennes, Ind.
PARKHILL, WAYNE A., Industrial Sales......Cities Service Oil Co., Marion, Ill.
PARLIER, HENRY W., Shop Foreman.........
United Electric Coal Co's., Buckheart Mine, 407 N. Ave., Canton, Ill.
PARMLEY, S. M., Consulting Engr.........
Coal Preparation, Nelson L. Davis Co., 343 S. Dearborn St., Chicago 5, Ill.
PATTERSON, MOSS.........West Kentucky Coal Co., Madisonville, Ky.
PATTERSON, V. E.........
Euclid Sales & Service, Inc., 5231 Manchester Ave., St. Louis 10, Mo.
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.........
Peabody Coal Co., 231 S. La Salle St., Chicago 4, Ill.
PEARSON, T. W., Gen. Supt.........Little Sister Coal Corp., St. David, Ill.
PECHMAN, O. A.........
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
PECKHAM, O. H., Gen. Mgr.........
Oberjuerge Rubber Distributing Co., Inc., 21 S. Third, St. Louis 2, Mo.
PENNYBACKER, M. W., Mgr., Mng. & St. Ry. Sales.........
I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia 30, Pa.
‡PENROD, PAUL R.........Dongola, Illinois
PERRIN, A. C., Sales Engr.........
Reliance Electric & Engr. Co., 159 E. Chicago Ave., Chicago, Ill.
PERRY, R. G.........Sahara Coal Co., Harrisburg, Ill
PERZ, FRANK, Federal Mine Inspr.........1025 S. 18th St., Terre Haute, Ind.
PETERSON, C. A.........Bethlehem Steel Co., Wrigley Bldg., Chicago 11, Ill.
†PFAHLER, F. S., Pres.........Superior Coal Co., 400 W. Madison St., Chicago 6, Ill.
PHELPS, W. D., Repr.........Joy Mfg. Co., 4120 Clayton Ave., St. Louis 10, Mo.
*PHILLIPS, EDGAR R.........
Pittsburgh Gear & Machine Co., 27th & Smallman, Pittsburgh, Pa.
PHILLIPS, JAMES A.........Peabody Coal Co., 2920 S. Douglas, Springfield, Ill.
PHILLIPS, W. J., Asst. to Pres.........
Sunnyhill Coal Co., 3090 W. Liberty Ave., Pittsburgh 16, Pa.
PICKARD, A. E.........The Tamping Bag Co., Mount Vernon, Ill.
PIERRON, EMILE D., Chemist.........
State Geological Survey, 710 W. Hill, Champaign, Illinois
PIERSOL, R. J.........State Geological Survey, Urbana, Ill.
PINGOLT, JOHN, Safety Man......Mount Olive & Staunton Coal Co., Staunton, Ill.
PIPE, FRANK E.......Cummins Diesel Engine Co., 3218 Lucas Ave., St. Louis 3, Mo.
PIROK, STEPHEN, Face Boss.........Mt. Olive & Staunton Coal Co., Worden, Ill.
PLATT, F. J., Purch. Agent.........Little Sister Coal Corp., St. David, Ill.
*PLATTS, E. M.........Joy Mfg. Co., 333 Oliver Bldg., Pittsburgh, Pa.
PLESCHNER, O. J., Mng. Engr.........1231 Oak St., Danville, Ill.
PLUMLEE, ARTHUR W., State Mine Inspector.........Jolly Hotel, Macomb, Ill.
*POLING, GILBERT.........
Evansville Elec. & Mfg. Co., 600 W. Eichel Ave., Evansville, Ind.
POLLACK, HARRY.........Pollack Brothers, Herrin, Ill.
POMEROY, C. M., Tech. Repr.....Du Pont Co., 215 S. 16th St., Mount Vernon, Ill.

PORTER, J. R.........General Electric Co., 840 S. Canal St., Chicago 7, Ill.
‡POUNDS, ROBERT LEE.........1208 W. Prairie, Taylorville, Ill.
*POWERS, F. A.........1033 Butler St., Peoria 6, Ill.
PRATT, STEWART M.........Superior Coal Co., Gillespie, Ill.
PRICKETT, J. RALPH.........
Truax-Traer Coal Co., Burning Star Mine, Elkville, Illinois
PRIEST, LLOYD M., Office Mgr.........Little John Coal Co., Victoria, Ill.
PRINS, KLAAS.........K. Prins & Associates, 104 E. "D" St., Wellston, Ohio
PRITCHARD, W.........Goodman Mfg. Co., 831 Second Ave., Huntington, West Va.
PROX, ROBERT F., JR.........Frank Prox Co., 1201 S. First St., Terre Haute, Ind.
PROX, ROBERT F., SR.........
Frank Prox Co., Inc., 1201 S. First St., Terre Haute, Ind.
*PRUDENT, NORMAN.........Hanna Coal Co., St. Clairsville, Ohio
PSCHIRRER, A. R., Pres.........Pschirrer & Sons Coal Co., R. R. No. 4, Canton, Ill.
PSCHIRRER, JOHN.........Pschirrer & Sons Coal Co., Canton, Ill.
PURICELLIO, CHARLES J.........
Mineweld Company, 9200 Lucia Drive, St. Louis 23, Mo.
PURMORT, A. S.........Hewitt-Robins Corp., 4030 Chouteau Ave., St. Louis 10, Mo.
PURNELL, CHAS. G., Development Rep.........
Carnegie Illinois Steel Corp., 570 Frick Annex, Pittsburgh 30, Pa.
PURSGLOVE, JOSEPH, JR., Vice Pres.........
Pittsburgh Consolidation Coal Co., Research & Development Div.,
Koppers Bldg., Pittsburgh 19, Pa.
QUADE, ROBERT C., Sales Engr.........
Joy Mfg. Co., Mines Equipment Div., 4235 Clayton, St. Louis, Mo.
QUICK, E. H.........Atlas Powder Co., 1531 Boeger Ave., Westchester, Ill.
QUINN, MAURICE L., Electrical Engr.........
Sinclair Coal Co., Rm. 501, 3615 Olive St., St. Louis 8, Mo.
RASSIEUR, T. E., Pres.........
Central Mine Equipment Co., 6200 N. Broadway, St. Louis 15, Mo.
READ, DAVIS, Mining Consultant.........235 E. Noel Ave., Madisonville, Ky.
READEY, HARVEY J.........
Cummins Diesel Sales Corp. of Mo., 3311 Washington, St. Louis 6, Mo.
REAK, BERNARD A., Sales Engr.........
Roberts & Schaefer Co., 2220 E. Michigan, Evansville, Ind.
REBSTOCK, JOE.........Coal Yard Supplies, 2550 W. Sullivan, St. Louis 7, Mo.
RECHSTEINER, FRED, Dist. Repr.........
Link-Belt Co., 317 N. 11th St., St. Louis 1, Mo.
REECE, CARL.........Consolidated Coal Co., Railway Exchange Bldg., St. Louis, Mo.
REED, FRANK H.........State Geological Survey, Urbana, Ill.
REED, R. E.........Hercules Powder Co., 511 S. 24th St., Terre Haute, Ind.
REES, ERNEST L.........Truax-Traer Coal Co., Pinckneyville, Ill.
REES, O. W., Chemist.........
Ill. State Geological Survey, Natural Resources Bldg., Urbana, Ill.
REESE, B. F., Pres.,.........Coal Dealers Sales Co., 175 Salisbury St., St. Louis 7, Mo.
REESE, C. A.........General Electric Co., 849 S. Clinton St., Chicago 80, Ill.
REHNQUIST, CLARENCE L., Advtg. Mgr.........
Nelson L. Davis Co., 343 S. Dearborn St., Chicago 4, Ill.
REIBER, J. LOUIS.........
Mt. Olive & Staunton Coal Co., 806 LaClede Bldg., St. Louis, Mo.
REICHLING, R. L., Sales Engr.........
The Tool Steel Gear & Pinion Co., Cincinnati, Ohio

REID, H. A., V. P. in Charge of Oper....
The United Electric Coal Companies, 307 N. Michigan Ave., Chicago 1, Ill.
REITHER, E. C....Timken Roller Bearing Co., 416 Craig St., Pittsburgh, Pa.
RETTIG, R. G., Supt....General Electric Co., 1115 East Road, St. Louis 10, Mo.
REUTER, WM., Constr. Engr....Peabody Coal Co., P. O. Box 311, Marion, Ill.
REUTER, WM. D....Peabody Coal Co., 829 S. Virginia, Marion, Ill.
REYNOLDS, DOYLE C....
Mack Motor Truck Co., 33rd & Wentworth, Chicago 16, Ill.
REYNOLDS, GEORGE J., Elec. Engr....
Morgan Mines, Inc., P. O. Box 128, Herrin, Ill.
REYNOLDS, HUGH M., Mgr., Mech. Sales....
U. S. Rubber Co., 305 S. Broadway, St. Louis 2, Mo.
RHINE, FRANK E....623 E. 17th St., Alton, Ill.
*RICHARDS, L. O....Paul Weir Co., 20 N. Wacker Dr., Chicago 6, Ill.
RICHARDS, P. L....5930 Walnut St., Pittsburgh 32, Penn.
RICHART, RALPH R., Ch. Elec'l Engr....C. W. & F. Coal Co., Benton, Ill.
RICHMOND, K. C., Editor....
Coal Heat Magazine, 20 West Jackson Blvd., Chicago 4, Ill.
RIEDLINGER, ARTHUR P., State Mine Inspector....
117 Amsler St., Bartonville, Ill.
RIEVLEY, R. L....Egyptian Powder Co., 217 S. Jackson, Harrisburg, Ill.
RIGG, HAROLD, Engr....C. W. & F. Coal Co., Orient No. 3, Waltonville, Ill.
RIHA, WILLIAM T., Sales-Serv....
Carboloy Co., Inc., 2226 Kessler Blvd., N. Dr., Indianapolis 22, Ind.
RILEY, FRED W....John Fabick Tractor Co., 700 W. Cherry, Carbondale, Ill
RIPPON, JOHN R., Vice Pres....
United Mine Workers of Amer., Dist. 12, Springfield, Ill.
‡RISI, ALFRED....Nason, Ill.
RITCHIE, R. J., Sales Engr....Chain Belt Co., 8001 Clayton, St. Louis, Mo.
RITTER, LEO J....Ritter Coal Co., Box 132, DuQuoin, Ill.
RIZOR, D. E....Marion Power Shovel Co., Marion, Ohio
ROBBINS, J. S., Cons. Engr....307 N. Michigan Ave., Chicago 1, Ill.
ROBERTS, ARTHUR L., Gen. Supt....Franklin County Coal Corp., Royalton, Ill.
ROBERTS, BEN F., Area Serv. Supvsr....
Shell Oil Co., Inc., 602 S. Court St., Marion, Ill.
ROBERTS, W. C....Ruby Globe Mng. Co., Box 31, Clarksville, Ark.
ROBERTSON, JACK F., Engr....Ecanleerf Engineering Service, Fairmount, Ill.
ROBERTSON, JAMES L., Lubr. Engr....
Industrial Sales, Cities Service Oil Co., 405 Washington, LeRoy, Ill.
ROBERTSON, S., Foreman....Superior Coal Co., Gillespie, Ill.
ROBINSON, A. W....R-J Bearings Corp., 3300 Lindell Blvd., St. Louis 3, Mo.
ROBINSON, W. F....
West Virginia Steel & Mfg. Co., Box 118, Huntington 6, West Va.
RODENBUSH, KENNETH....
C. W. & F. Coal Co., Orient No. 3, Waltonville, Ill.
ROE, WALTER B., Asst. Chief Engr....
Truax-Traer Coal Co., 230 N. Michigan Ave., Chicago 1, Ill.
ROE, WILSON, Engr....Pyramid Coal Corp., Pinckneyville, Ill.
ROECKER, EARL, Sls. Engr....Bethlehem Steel Co., Bethlehem, Pa.
ROEHRKASSE, ARTHUR, Treas....Cutler Coal Co., Cutler, Ill.
ROETS, FRANK W....Coal Age, Continental Bldg., St. Louis, Mo.

ROHRER, L. C., Sales Rep.......................................................
Jones & Laughlin Steel Corp., 135 S. La Salle St., Chicago 3, Ill.
ROLLINS, J. E., V. P.......................................................
Bituminous Casualty Corp., Bituminous Bldg., Rock Island, Ill.
ROLLO, JOHN C.......................................................
Bell & Zoller Coal Co., 307 N. Michigan Ave., Chicago 1, Illinois
*ROMAN, F. W.............Hercules Powder Co., 332 S. Michigan Ave., Chicago 4, Ill.
ROMIG, JOHN L.......................................................Atlas Powder Co., Wilmington, Del.
ROOME, C. O.......................................................
Goodyear Tire & Rubber Co., 4210 Forest Park Blvd., St. Louis 8, Mo.
ROSE, C. G., Prod. Mgr.....................Bixby-Zimmer Engineering Co., Galesburg, Ill.
ROSENQUIST, G. C., Wood Preserving Div.......................................................
Koppers Co., 122 S. Michigan Ave., Chicago 3, Ill.
*ROSING, BORGE, Vice Pres.......................................................
West Va. Steel & Mfg. Co., Box 118, Huntington 6, W. Va.
RUMFELT, HENRY.......................................................
Bucyrus-Erie Company, 105 West Adams St., Suite 3100, Chicago 3, Ill.
RUMMEL, D. M.......................................................
John A. Roebling's Sons Co., 5525 W. Roosevelt Rd., Chicago 50, Ill.
RUSSELL, FRANK.........Russell & Son, 100 W. St. Louis St., West Frankfort, Ill.
RUTLEDGE, J. J.......................................................621 St. John Road, Baltimore 10, Md.
RYAN, J. P.......Northern Illinois Coal Corp., 310 S. Michigan Ave., Chicago 4, Ill.
*RYAN, JOHN T., JR., Gen. Mgr.......................................................
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa.
SACKBAUER, L. A., Coal Traf. Mgr.......................................................
Missouri Pacific Railroad Co., St. Louis, Mo.
SADLER, WALTER, Supt.......................................................Sahara Coal Co., Harrisburg, Ill.
SAGE, SIDNEY B., Mng. Engr.........................Union Colliery Co., DuQuoin, Ill.
ST. CLAIR, WALT, Sales Mgr.....................Hyster Co., 208 E. State St., Peoria, Ill.
SALMONS, J. D.......................................................Peabody Coal Co., Taylorville, Ill.
SALMONS, PAUL.........................Peabody Coal Co., 215 E. Park St., Taylorville, Ill.
SALSICH, NEIL E., V. P..................................Jeffrey Mfg. Co., Columbus, Ohio
SAMUELS, EDWARD L., Prep. Mgr.......................................................
Walter Bledsoe & Co., Merchants Nat'l Bank Bldg., Terre Haute, Ind.
SANDTNER, EDW. E., Branch Mgr.......................................................
Cummins Diesel Sales Corp., 1800 S. Washington, Peoria, Ill.
SANFORD, J. H., Mgr.................Mining Division, Ohio Brass Co., Mansfield, Ohio
SAYERS, ROBERT P., Sales Engr.......................................................
Nelson L. Davis Co., 343 S. Dearborn St., Chicago 4, Ill.
SAYLOR, H. N., Pres.......................................................
H. N. Saylor Co., 2908-2910 Brannon Ave., St. Louis 9, Mo.
SAYLOR, LLOYD, Mech. Supvr.......................................................
C. W. & F. Coal Co., Orient No. 2, 706 E. Fifth St., West Frankfort, Ill.
SCHATTEL, K. F., Dist. Mgr.......................................................
National Cylinder Gas Co., 2110 N. Adams St. - Box 627, Peoria, Ill.
SCHAUB, HENRY W., Sales Engr.......................................................
Allis-Chalmers Mfg. Co., 135 S. La Salle St., Chicago 3, Ill.
‡SCHECK, DONALD EDWARD.........................................323 Tenth St., La Salle, Ill.
SCHIBER, R. R., State Mine Inspector.......................................................Glen Carbon, Ill.
SCHICKEDANZ, L. H., Mech. Engr.......................................................
United Electric Coal Co's., 505 N. Main St., Canton, Ill.
SCHILLINGER, E. J.......................................................
A. Leschen & Son Rope Co., 810 W. Washington Blvd., Chicago 7, Ill.

SCHINDLER, PAUL.....Underwriters Safety & Claims, Marion, Ill.
SCHLAPP, C. H., JR.....Perry Coal Co., O'Fallon, Ill.
SCHLEPER, G. J.....Union Colliery Co., Dowell, Ill.
SCHLINKMANN, P. E.....Mississippi Lime Co., Alton, Ill.
SCHLITT, T. J.....Schlitt Industrial Supply Co., 422 E. Adams St., Springfield, Ill.
SCHMEISSER, P. J.....
National Cylinder Gas Co., 216 Constantine St., Peoria Heights, Ill.
SCHMIDT, W. E.....Columbia Quarry Co., 107 S. Macoupin St., Gillespie, Ill.
SCHMOELLER, C. C., V. P. in Chge. of Sales.....Mississippi Lime Co., Alton, Ill.
†SCHONTHAL, B. E., Pres.....
B. E. Schonthal & Co., 28 E. Jackson Blvd., Chicago 4, Ill.
*SCHONTHAL, D. C.....West Va. Steel & Mfg. Co., Huntington 6, West Va.
*SCHONTHAL, JOSEPH, Sec.....
B. E. Schonthal & Co., 28 E. Jackson Blvd., Chicago 4, Ill.
SCHOOLER, D. R., Assoc. Prof. Mining.....Missouri School of Mines, Rolla, Mo.
SCHROEDER, FRED R., Pit Supt.....Truax-Traer Coal Co., Fiatt, Ill.
SCHROEDER, WALTER J.....
Dow Chemical Co., 135 S. La Salle St., Chicago 3, Ill.
*SCHUBERT, R. R., V. P. and Gen. Mgr.....
Greensburg Mach. Co., Greensburg, Pa.
SCHULER, FRED.....
Goodyear Tire & Rubber Co., 207 Hamilton Blvd., Peoria, Ill.
SCHULER, HARRY A., Sales Mgr. Cen. Div.....
Hewitt-Robins, Inc., Robins Conveyors Div., 402 W. Randolph St., Chicago 2, Ill.
*SCHULL, B. H., Pres.....Schull-Moake Coal Corp., 607 N. Market St., Marion, Ill.
SCHULZ, HOWARD.....
C. W. & F. Coal Co., Orient No. 1 Mine, West Frankfort, Ill.
SCHWALB, F. E., Dist. Mgr.....
Webster Mfg. Co., 343 S. Dearborn St., Chicago 4, Ill.
SCHWARTZ, H. L.....W. M. Hales Co., Hillsboro, Ill.
SCIRANKO, MIKE, State Mine Inspector.....204 W. Washington, Benton, Ill.
SCULLY, T. ALVIN.....U. S. Bureau of Mines, 625 E. C. St., Belleville, Ill.
SEE, FRED O., Vice Pres., Mining Div.....
Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.
SEEKAMP, HERMAN L.....Superior Coal Co., Gillespie, Ill.
SEIDEL, JEROME J., V. P. & Sls. Mgr.....
Seidel Coal & Coke Co., 3524 Washington Ave., St. Louis 3, Mo.
SEIDEL, MAURICE E., Pres.....
Seidel Coal & Coke Co., 3524 Washington Ave., St. Louis 3, Mo.
SELLEG, L. A., Mgr.....
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SEMONES, M. M., Tech. Repr.....
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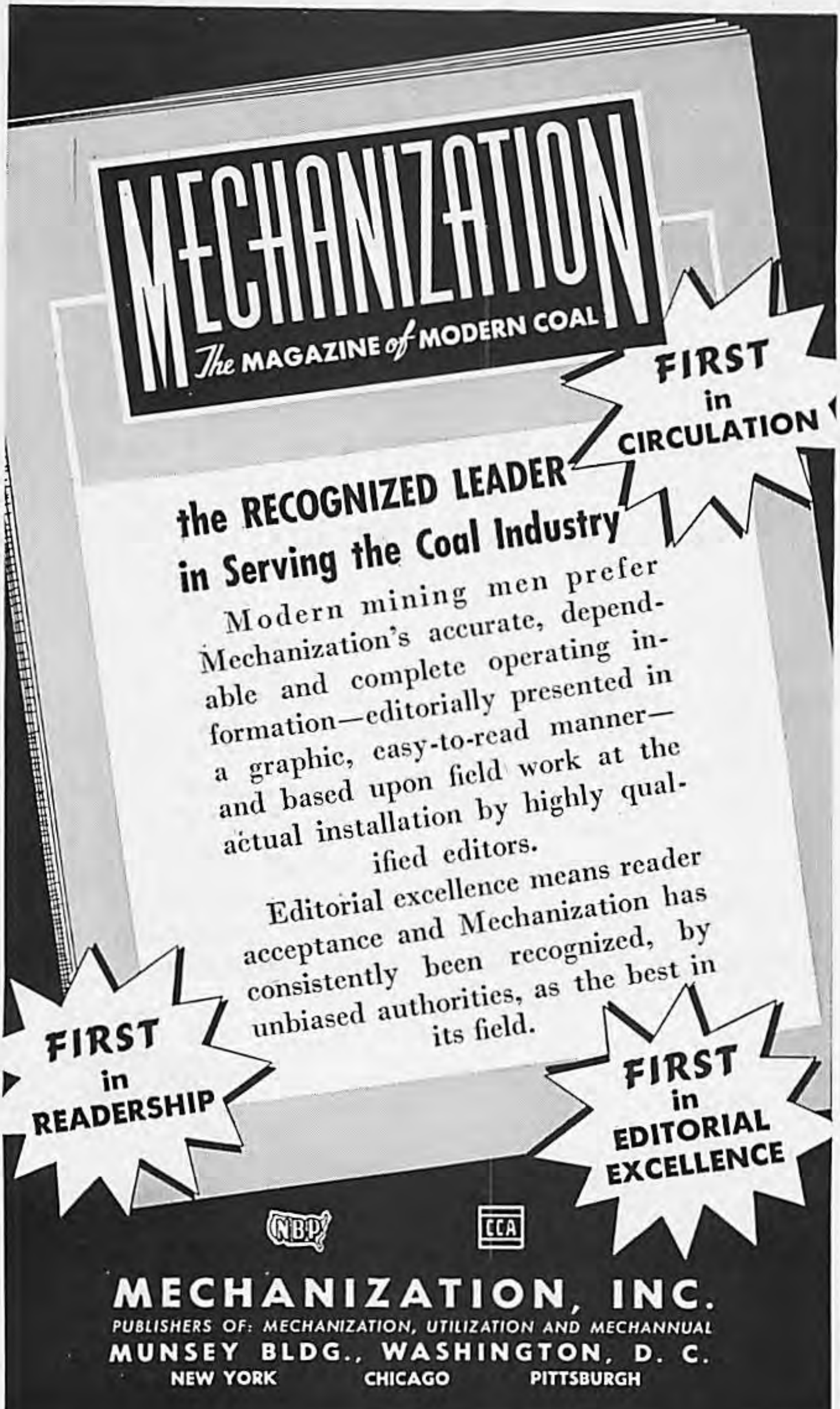
| W. D. Butts | R. J. Hepburn |
| C. S. De Witt | F. E. McEvoy |
| J. P. Donovan | M. M. Shepard |

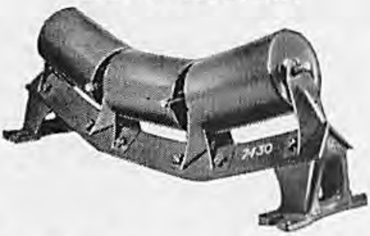
R. W. Webster

Their willingness and efficient cooperation have helped make this yearbook possible.


MECHANIZATION
The MAGAZINE of MODERN COAL
FIRST in CIRCULATION
the RECOGNIZED LEADER in Serving the Coal Industry
Modern mining men prefer Mechanization's accurate, dependable and complete operating information—editorially presented in a graphic, easy-to-read manner—and based upon field work at the actual installation by highly qualified editors.
Editorial excellence means reader acceptance and Mechanization has consistently been recognized, by unbiased authorities, as the best in its field.
FIRST in READERSHIP
FIRST in EDITORIAL EXCELLENCE
NBP
CCA
MECHANIZATION, INC.
PUBLISHERS OF: MECHANIZATION, UTILIZATION AND MECHANNUAL
MUNSEY BLDG., WASHINGTON, D. C.
NEW YORK CHICAGO PITTSBURGH

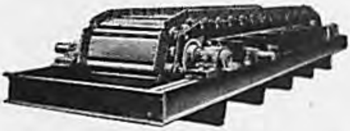
## *Stephens-Adamson* Conveyors

### BELT CONVEYORS



S-A belt conveyor equipment is available in all sizes and for varying degrees of service. S-A engineers design and equip complete conveyor installations for handling any required volume of coal. If you plan to modernize or expand your conveyor system, consult with S-A for a recommendation. Write us for a copy of belt conveyor catalog No. 146.

### PAN CONVEYORS



S-A pan conveyors for use as picking tables, feeders and lowering conveyors are available in any required size for any particular requirement. Write us for pan conveyor catalog data, which gives dimensions and engineering data on several styles.

### REDLER CONVEYORS

S-A REDLER Conveyor-Elevators are particularly well suited for handling fines at the mine as well as bulk chemicals. REDLERS convey and elevate in a single unit . . . . have compact enclosed casings and are available in sizes for handling practically any required number of tons per hour. Write fo- REDLER Catalog No. 140.

**STEPHENS-ADAMSON**
MFG. CO.

45 Ridgeway Ave.
Aurora, Illinois

20 N. Wacker Drive
Chicago, Illinois

# Use the wire rope that's cut out for today's jobs

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.

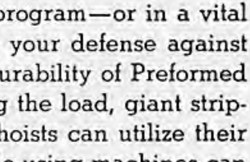
These gains result from pointing up Yellow Strand's stout, drawn-to-order steel wires with the limberness of preforming. The rope reeves easily . . . runs freely around small sheaves . . . spools evenly despite overloads. Still every length is as tough as ever—highly resistant to shock, abrasion and 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.

**Broderick & Bascom Rope Co., St. Louis**

***Branches:*** New York, Chicago, Houston, Portland, Seattle. ***Factories:*** St. Louis, Seattle, Peoria

**YELLOW STRAND**

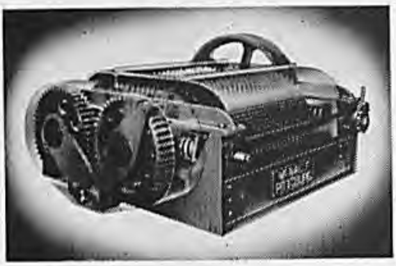
***PREFORMED*** **WIRE ROPE**



# McNALLY PITTSBURG EQUIPMENT CAN BE BOUGHT IN INDIVIDUAL UNITS *to meet your Requirements*

## McNALLY SCREENS

Efficient multiple screening sections combine with means for by-passing to lower decks for rescreening and mixing coals at low operating cost.

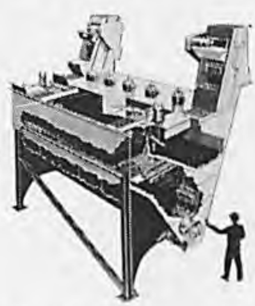


## McNALLY GEARMATIC DRIVE CRUSHER

New Gearmatic Crusher for economical reduction to screenings or stoker sizes. Light, Standard, Heavy-Duty Stoker Coal Crushers; seven sizes. Reduces egg and nut sizes to 1¼", 1", ¾". Gearmatic Primary Breakers also available.

## McNALLY-NORTON WASHER

McNally-Norton Washers are fully automatic, of the Baum jig type. They give positive separation of coal from refuse . . . assures maximum coal recovery. Wash sizes to 8". Operating control is simplified. Power consumption low. No constant attendant is required. Specific gravity of washed coal is adjustable to predetermined market requirements. McNally-Nortons are available in models from 25 to 450 tph per unit.



## McNALLY-CARPENTER DRYER

McNally-Carpenter is a flexible dryer of the centrifugal type that assures high water removal. With the McNally-Carpenter there is small loss of product in the effluent. Dryer has large capacity, low power cost per ton of dried material, and low maintenance cost. Especially efficient in minus ⅜" sizes.

**McNALLY PITTSBURG**

MANUFACTURERS OF EQUIPMENT TO MAKE COAL A BETTER FUEL

McNally Pittsburg Mfg. Corp. — Manufacturing Plants: Pittsburg, Kansas • Wellston, Ohio.

Engineering & Sales Offices:

Pittsburgh • Chicago • Rio de Janeiro • Pittsburg, Kansas • Wellston, Ohio

# BETHLEHEM PRODUCTS for the Mining Industry

### Prefabricated Track

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.

### Mine Roof Bolts

Bethlehem is in an excellent position to furnish a complete line of materials for mine roof bolting, including slotted or headed roof bolts, wedges, roof plates, roof ties, roof channels, angle washers, and roof bolt extensions. The latter allow roof bolts to be used in mining low seams.

These roof supports may be ordered in simple sets, each set consisting of a threaded and slotted bolt with nut, wedge, and roof plate; or sets may consist of a roof tie or channel with four roof bolts, four wedges, and four angle or plate washers.

### Wire Rope

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.

### Hollow Drill Steel

Fatigue-resisting drill steel — equally suitable for forged-on bits or threaded rods used with detachable bits. Easy to forge and heat-treat. The smooth, round, well-centered hole minimizes fatigue failure. Rigid inspection assures top quality. Available in standard sections and lengths.

### Solid Drill Steel

An all-purpose carbon tool steel for general blacksmithing tools, chisels, drills, pinch bars, etc.

★ ★ BETHLEHEM STEEL ★ ★

**OTHER BETHLEHEM PRODUCTS FOR MINES**

MINE CARS • WHEELS AND AXLES • TOOL STEELS • BOLTS, NUTS, RIVETS, AND SPIKES • WIRE NAILS • HOT-ROLLED SHEETS • GALVANIZED STEEL ROOFING AND SIDING • PIPE • FABRICATED STRUCTURES • PLATES
MAYARI R (HIGH-STRENGTH, LOW-ALLOY STEEL)


The world's largest shovel is now equipped with a 45 cu. yd. dipper. Its new front end design gives it increased range.

# THE MARION LINE

## STRIPPING MACHINES

| Type | Capacity | Type | Capacity |
|---|---|---|---|
| 33-M | ¾ cu. yds. | 4161 | 5 cu. yds. |
| 43-M | 1 cu. yd. | 151-M | 6½ cu. yds. |
| 362 | 1½ cu. yds. | 5323 | 18 cu. yds. |
| 372 | 1¾ cu. yds. | 5561 | 45 cu. yds. |
| * 93-M | 2½-3 cu. yds. | **7200 | 5-8 cu. yds. |
| 492 | 3 cu. yds. | **7400 | 8-13 cu. yds. |
| *111-M | 3½-4 cu. yds. | **7800 | 30 cu. yds. |

* Diesel Clutch type and Ward-Leonard electric.
** Size of bucket depends on length of boom.

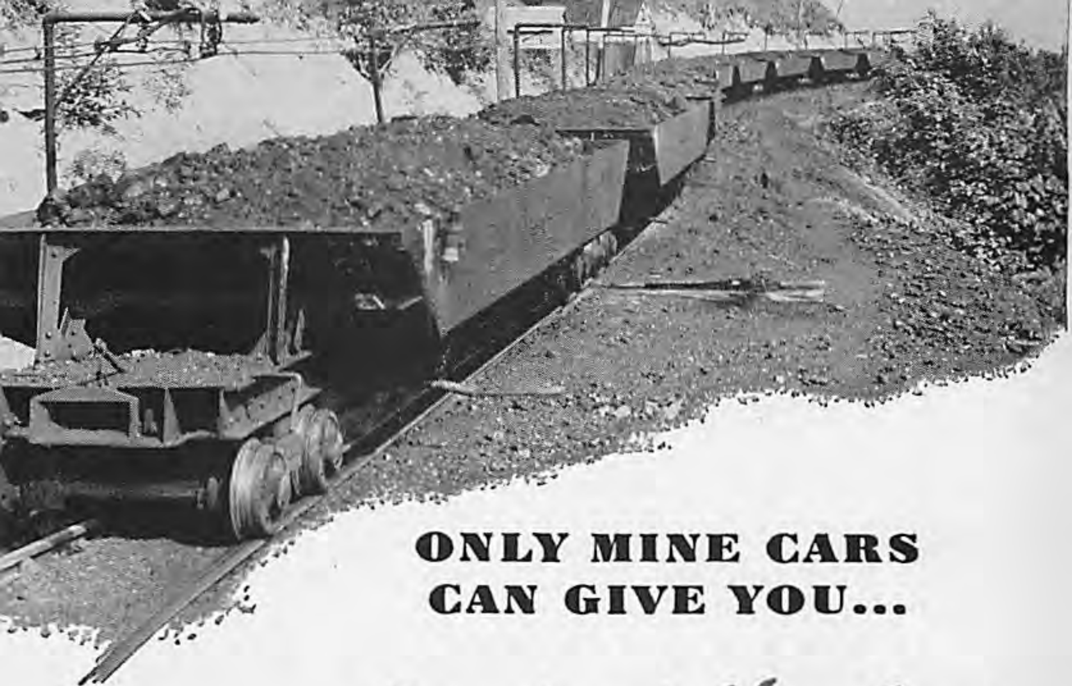
## COAL LOADERS

There is a MARION Coal Loader of the proper size and capacity to meet every requirement. Tell us your needs.

# MARION

## POWER SHOVEL COMPANY

**Marion, Ohio, U.S.A.**



## 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

**KOPPERS COMPANY, INC.**
**Pittsburgh 19, Pa.**

## PRESSURE-TREATED WOOD


**They're plenty tough wet or dry!**

Streamlining your blasting operations with Seal-Tite Tamping Bags saves labor, speeds up shooting and reduces cost. Supplies of dummies are made up quickly and easily and are stored underground under humid conditions — and they're always handy and ready for use.

We'll send you samples of Seal-Tite Tamping Bags to try out — in the sizes you need — or in an assortment. Yours for the asking.

Tamping Bag Co.

216 SO. THIRD ST.
MT. VERNON, ILL.

# CUMMINS® DIESELS
## Built Not Once But
## TWICE

**Eighty models** of Cummins Diesels provide an engine for your job in the 50 to 550 hp range, and compounded engines extend this range to 1440 hp. Optional equipment to match your specific operating requirements.

Cummins advantages: Engines, units and assemblies are interchangeable ... service and parts problems simplified ... replacement parts inventories reduced ... down-time is held to a minimum ... dependable, low-cost power in all your equipment.

**Dependable Power.** Cummins Diesels have established long records of proved performance and dependable operation in the tough, heavy-duty jobs.

Cummins do more work per day at lower cost in heavy-duty applications, and they have what it takes to stay on the job month-after-month without costly down-time.

**Lower Operating Costs.** Cummins Diesels reduce fuel bills because exclusive mechanical features of the Cummins Fuel System assure accurate metering of fuel, efficient preparation, and controlled injection. Designed and built for years of service on the toughest jobs, they last longer and reduce maintenance costs because of their inbuilt ruggedness.

On your job where dependable operation and low fuel and maintenance costs over long periods of uninterrupted operation determine the margin of profit, Cummins Diesels increase your profits.

**Continuous Operation.** Fully tested and proved under the most adverse operating conditions, on jobs where constant, uninterrupted operation is essential, Cummins Diesels have consistently demonstrated their unfailing reliability and flexibility in both constant and variable load operations.

**CUMMINS ENGINE COMPANY, INC., COLUMBUS, INDIANA**

**Diesel power by**
**CUMMINS**

CUMMINS Dependable DIESEL

TRADEMARK REG. U. S. PAT. OFF.

## CUMMINS DIESEL SALES CORPORATION

**1700 S. Indiana Ave. · Chicago 16, Illinois Tel. WAbash 2-5326**

*Branches*: 1921 *S. Highway* 100, *Milwaukee* 14, *Wisc., Tel. Glenview* 3-3187 1800 *S. Washington St., Peoria* 6, *Illinois, Tel.* 3-3748; *Maughs Street, Mauston, Wisconsin, Tel.* 397-*W*.

# JOY

"The World's Most Complete Line of Modern Mining Equipment"

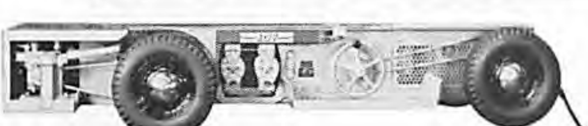
*Products for* ***THE COAL MINES***

## CONTINUOUS MINERS


JCM machines will handle split seams —can be used in any mine the machines will enter.

JOY Continuous Miners are built in two models, the 3-JCM for low coal and the 4-JCM for thick seams. Both are field-proved units, highly flexible and mobile—the greatest single advance in coal mine mechanization today for safety and high-tonnage, low-cost production. Continuous Miners can handle seams from 42″ to more than 100″ high, eliminating completely the former separate jobs of cutting, drilling, shooting, and loading away from the face.

## ROOF-BOLTING EQUIPMENT



### COMPLETE LINE OF DRILLS

Joy makes a complete line of hydraulic and pneumatic drills for roof-bolting. The standard SAE-91, the CFS chain-feed, and the new telescopic SAE-91 stopers do the entire job: drill the hole, drive and wedge the bolt, and tighten the nut. Where roof conditions permit the use of a rotary, the Joy RBD-1 self-propelled drill will bottom holes faster than any machine on the market.

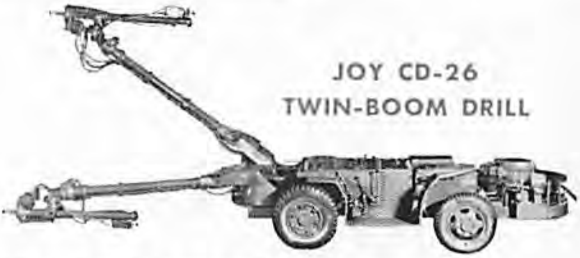
### PERMISSIBLE COMPRESSORS

JOY WK-82 and 83 Mine-Air Compressors are B of M-approved . . . highly efficient, heavy duty air-cooled units, available in rubber-tire or track models, either self-propelled or draw-bar type. Capacities range from 130 to 240 CFM, height from 30″ to 34″. JOY Roof-Bolting Equipment is backed by 50 years of compressor and drill-building experience.

# TONNAGE FAST . . . AT LOW COST

## COAL DRILLS

The CD-26 is a self-propelled, hydraulically controlled trackless coal drill that keeps ahead of any loader. Rotation speed is variable independent of feed, and the feed can be varied independent of speed, to suit drilling conditions. JOY Mobile Coal Drills are available in single or twin-boom models, with hydraulic or electric controls.



JOY CD-26
TWIN-BOOM DRILL

## AXIVANE VENTILATION FANS

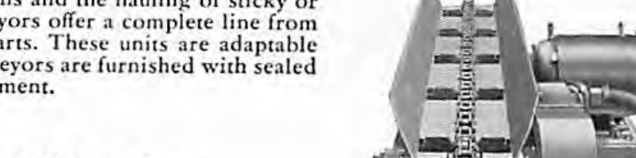
THE PIONEER VANEAXIAL FAN

JOY AXIVANE* Fans are designed for lower speed operation, which reduces noise, increases life and simplifies lubrication. Other features include wide range of blade adjustment and simultaneously adjustable blades, eliminating guesswork settings. JOY Fans are always at peak efficiency, even when air demand increases or decreases considerably.

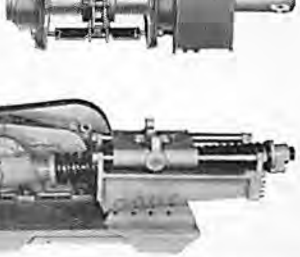
*Reg. U.S. Pat. Off.

## CONVEYORS

### Troughed Belt Conveyors



Three series of belt conveyor designs are available, each engineered for the particular type of job required. JOY Tandem Pulley Drive Belt Conveyors feature low belt tension and integral extended discharge suited to gathering and main haulage underground. JOY Single Pulley Drive Belt Conveyors are particularly adapted to slope-belt installations and the hauling of sticky or wet materials. JOY Type "C" Conveyors offer a complete line from 5 to 20 HP with interchangeable parts. These units are adaptable to multiple operations. All JOY Conveyors are furnished with sealed precision bearings as standard equipment.



### Chain Conveyors

For mechanical mining in thin seams, JOY Chain Conveyors are available in a variety of sizes for face loading, room and gathering work. The new Model FA is the most modern chain conveyor on the market—simpler, lighter, much more compact and efficient in every way, giving far longer service and requiring less maintenance.

### 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.

*"Complete Line of Modern Mining Equipment"*

LOADS OF SATISFACTION


# NO-KOL-DUST

✶ **COAL TREATING OIL** ✶

**IS:**

The "Tailor Made" Low Cold Test
Oil to suit INDIVIDUAL REQUIREMENTS

We can furnish ANY VISCOSITY from
100 @ 100 S. U. to 5000 @ 100 S. U.

★

(1)—Recognized and approved by the leading coal companies and equipment manufacturers.

(2)—Made strictly from Smackover Crude and is always uniform.

(3)—The high viscosity grades cling to the outer surfaces of porous coal and hold down the float dust.

(4)—Renders the coal practically impervious to water and seals in the inherent moisture.

(5)—EXCEPTIONALLY SWEET ODOR!

*Prompt shipment in tank car lots from our own refinery at Smackover, Ark.*

— WRITE TODAY FOR PRICES F. O. B. YOUR MINE —

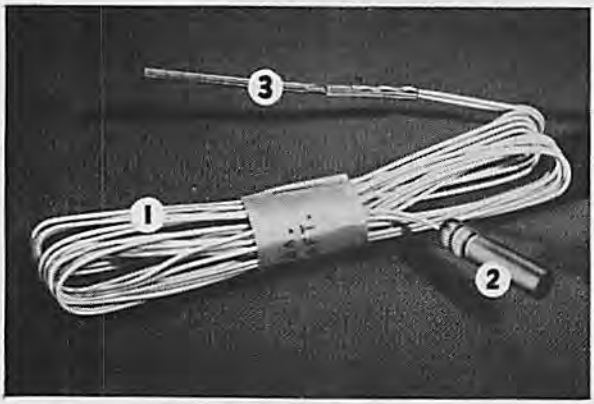
**» HENRY H. CROSS COMPANY «**

**REFINERS** **PETROLEUM**

122 South Michigan Ave.
Chicago, Illinois

Telephone:
WAbash 2-8728

# WHY COAL MINERS O.K. THESE CAPS




Du Pont Electric Blasting Caps are well known for their dependability. Three important reasons are that they embody the most advanced improvements in design and manufacture that have been made in over fifty years. For example:

**1 NYLON INSULATED WIRES.** They're tough. They resist abrasion, and yet the insulation can readily be removed when necessary. They're clean . . . easy to handle . . . nonkinking. And they're colored for maximum visibility in the mine.

**2 RUBBER PLUG CLOSURES.** Double crimping securely locks rubber plugs in cap shells and assures maximum resistance against water, dampness and the extremes of temperature. In addition, these closures permit the use of short length cap shells that make priming easier and safer.

**3 SHIELDED SHUNTS.** Cellophane-lined aluminum foil short-circuits the leg wires through the entire length of the bared ends and also shields the ends from contact with electric currents. This gives double protection against premature firing.

Du Pont Electric Blasting Caps are supplied with white insulated iron or red and yellow insulated copper wires. Both types are available in standard lengths ranging from four to twelve feet.

The Du Pont representative serving your vicinity will gladly give you complete information about these caps or any of the other Du Pont products designed to help make the job of mining coal easier, safer and more economical. Have a friendly talk with him whenever you can. E. I. du Pont de Nemours & Co. (Inc.), 332 South Michigan Avenue, Chicago, Illinois.

## DU PONT EXPLOSIVES

*BLASTING SUPPLIES AND ACCESSORIES*

## *These Du Pont Permissibles also widely approved*

**"MONOBEL" AA** because it is an economical producer of big lump coal.

**"LUMP COAL" C** because it has a characteristic heaving action that puts coal where it's easy to load.

**"GELOBEL" C** because it is ideal for hard rock and slate work . . . a gelatinous dynamite unaffected by wet conditions.

—and for stripping:

**DU PONT "NITRAMON"***

—the safest blasting agent—is steadily becoming more popular. Easy and safe to store, handle, load, hook up and fire. Packed in watertight containers. Non-headache-producing.

**DU PONT MULTIPLE-SHOT PERMISSIBLE BLASTING MACHINE**

Compact. Sturdy. Water-Resistant. A ten-cap unit of the twist type.

**DU PONT "DETECT-A-METER"**

New instrument is both a stray current detector and a blasting galvanometer. An inexpensive investment in greater safety.

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*New Edition—Du Pont Blasters' Handbook*

Contains over 470 pages of helpful information for every blaster. Profusely illustrated. It's a book you need and can use. Send for it now. $1.50 postpaid, including tax where applicable.

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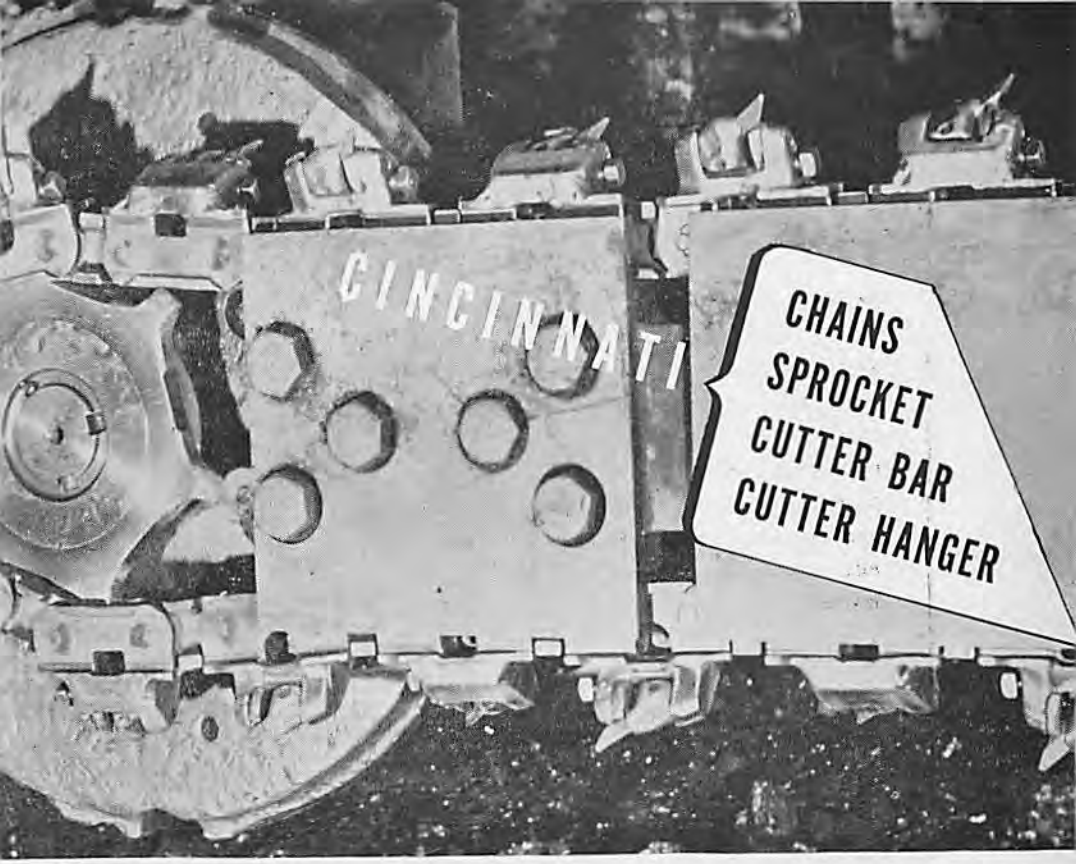
DU PONT

BETTER THINGS FOR BETTER LIVING ...THROUGH CHEMISTRY




Close-up view showing Cincinnati Cutting Equipment (Duplex Chain, Bit, Bar and Sprocket) mounted on Sullivan 7-AU machine ready to shear. The operation where this photograph was taken has many Sullivan 7-AU machines in use and has standardized on this type of Cincinnati Equipment.

# CINCINNATI COAL CUTTING EQUIPMENT MEANS LOWER CUTTING COSTS!

Deep down in thousands of American coal mines and in many foreign mines, Cincinnati Coal Cutting Equipment is performing with maximum efficiency and a minimum of servicing. If you are not now using Cincinnati Chains, Bits, Bars and Sprockets we suggest you talk to one of the Cincinnati Mine Representatives in your territory or write us direct. They will welcome the opportunity to prove to you that Cincinnati Chains, Bits and Bars will use less power . . . provide more tonnage at less cost and at the same time decrease maintenance costs. Cincinnati Chains are built to meet all cutting conditions . . . your problem is ours. Let us hear from you . . . there's no obligation.

## THE CINCINNATI MINE MACHINERY CO.

2988 SPRING GROVE AVENUE CINCINNAIT, OHIO

# FABICK
# HEADLINERS FOR MINERS

The lines of mining equipment — sold and serviced by Fabick — are the top producers of the industry. Each is proved-on-the-job — for production ability and low-cost, long-lived dependability.

Standardize with Fabick for the finest in equipment . . . the finest in service.

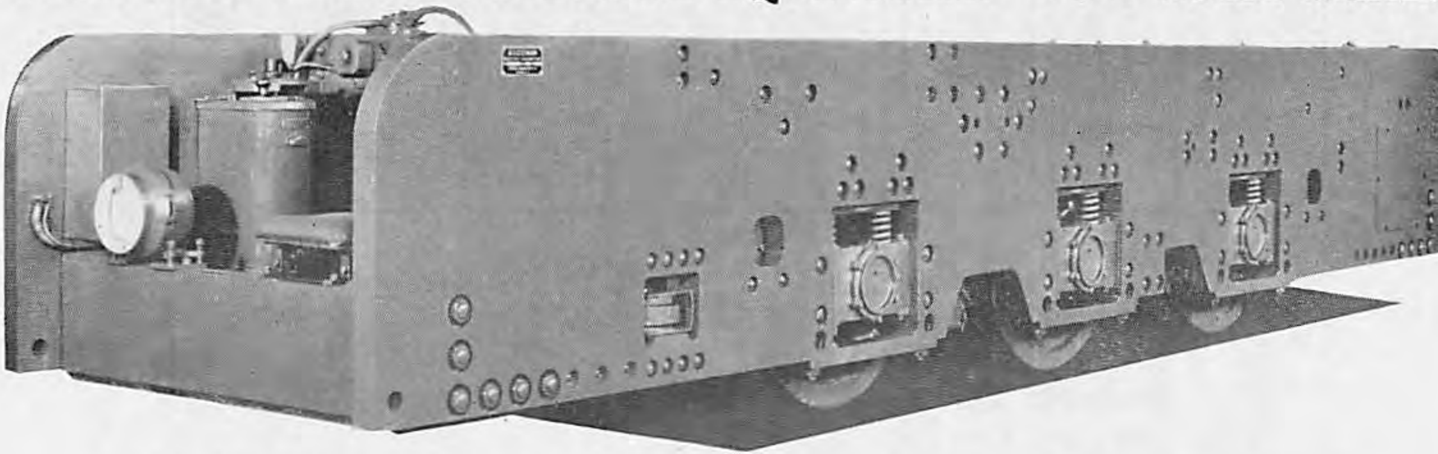
## *FABICK Features these Mine Lines . . .*

"Caterpillar" Diesel Engines — Electric Sets — Track-type and Rubber-tired Tractors — Motor Graders — Earthmoving Equipment • Athey Force-Feed Loaders — MobiLoaders — Portable Breakers — Rubber-Tired Hauling Trailers — Forged-Trak Wheels • Lorain Shovels — Cranes — Draglines • Trackson Traxcavators — Pipelaying Equipment • DoMor Elevating Graders • Hyster Winches — Hystaways • Fleco Landclearing Equipment • Joy Compressors — Air Tools Case Industrial Wheel-type Tractors — Industrial Engines • Bethlehem Wire Rope • Pioneer Crushing-Screening Plants — Conveyors • LaCrosse Trailers • Off-the-road Tires for Earthmoving Equipment . . . all backed by Famous Fabick Service!

# FABICK SERVICE

SALEM — MARION, ILLINOIS
ST. LOUIS, MISSOURI
JEFFERSON CITY, MISSOURI

# GOODMAN HEAVY HAULAGE EQUIPMENT FOR COAL MINES



A 20-ton locomotive powered by three 120 hp., 250 v. motors. It features semi-magnetic control, hydraulic brakes, and a pusher arm for moving cars on adjacent tracks at rotary dump.

Goodman locomotives in trolley, storage battery and combination types cover the entire range of haulage and gathering services. Let us help you make a selection to suit your conditions.

## GOODMAN MANUFACTURING COMPANY

HALSTED STREET AT 48TH • CHICAGO 9, ILLINOIS

***Cutting Machines • Loaders • Conveyors • Locomotives • Shuttle Cars***

# Rome 60 MINING CABLES

## NEOPRENE SHEATHED... MOLDED IN LEAD


P-105 BM molded in the Neoprene sheath assures full compliance with Federal and Penn. Safety Codes.

**Mine operators like Rome 60 Mining Cables for their rugged Neoprene protection, inside and out. For instance, in Rome 60 Flat Twin (Parallel Duplex) Type G, for shuttle car service, power conductors and grounding conductor are separated by Neoprene. Outside is a tough tear and abrasion resistant Neoprene sheath. Insulated for 75° C. continuous operation, Rome 60 Mining Cables are preferred for their durability and safety.**

***It Costs Less To Buy The Best***

**ROME CABLE**
*Corporation*
**ROME • NEW YORK**
From Bar to Finished Wire

ROME CABLE ROME, N.Y.

ENGINEERING

MANUFACTURING

CONSTRUCTION

# You Get More

## *In a Roberts and Schaefer Preparation Plant!*

In a coal preparation plant engineered and constructed by Roberts and Schaefer Company you get more than the materials involved, more than the visible structure and machinery.

The important *extras* you get are the priceless R&S experience in creating completely new plants and modernizing obsolete plants... and the broad R&S engineering, construction and manufacturing facilities. In Roberts and Schaefer Company you find an organization equipped to do the whole job or any part of it . . . any place in the world . . . any time you are ready.

Next time you have a coal preparation problem, remember that you get more for your investment when you get in touch with R&S.

# ROBERTS and SCHAEFER COMPANY

*130 N. Wells Street, Chicago 6, Illinois*

| | | |
|---|---|---|
| 254 West 54th Street | 1314 Henry W. Oliver Bldg. | P. O. Box 570 |
| NEW YORK 19, N. Y | PITTSBURGH 22, PA. | HUNTINGTON 10, W. VA. |

# Select your Wire Rope FROM THIS APPROVED LIST


These ropes tried and proved on hundreds of installations like yours are built of the finest steels and Internally Lubricated to resist corrosion.

Consider these laboratory tested and field proved ropes.

Select the correct rope for your equipment—save time and money.

You can get a Macwhyte recommendation by writing to Macwhyte Co. or a Macwhyte distributor.

MANUFACTURED BY MACWHYTE COMPANY
KENOSHA, WISCONSIN, MFRS. OF WIRE, WIRE ROPE, AND BRAIDED WIRE ROPE SLINGS

| USE | ROPE DESCRIPTION |
|---|---|
| Shaft Hoists | 6x19F or 6x16F Monarch Whyte Strand or Macwhyte Plow Steel—*PRE*formed preferred. |
| Incline or Slope | 6x7D; or 6x19G Monarch Whyte Strand or Macwhyte Plow Steel—*PRE*formed preferred. |
| Mining Machines and Loaders | 6x36G *PRE*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 *PRE*formed Lang Lay with I.W.R.C. |
| Shaft Sinking | 18x7 (non-rotating) Kilindo *PRE*formed Monarch Whyte Strand or Macwhyte Plow Steel. (Resists spinning of an unguided load.) |
| Blast Hole Drilling | 6x19 "Hi-Lastic" Macwhyte Mild Plow Steel Drilling Line.<br>6x7 Macwhyte Mild Plow Sand Line. |
| Car Puller Ropes | 6x19F; or 6x19G *PRE*formed Monarch Whyte Strand F. C. (fiber core) or I. W. R. C. (independent wire rope core). |
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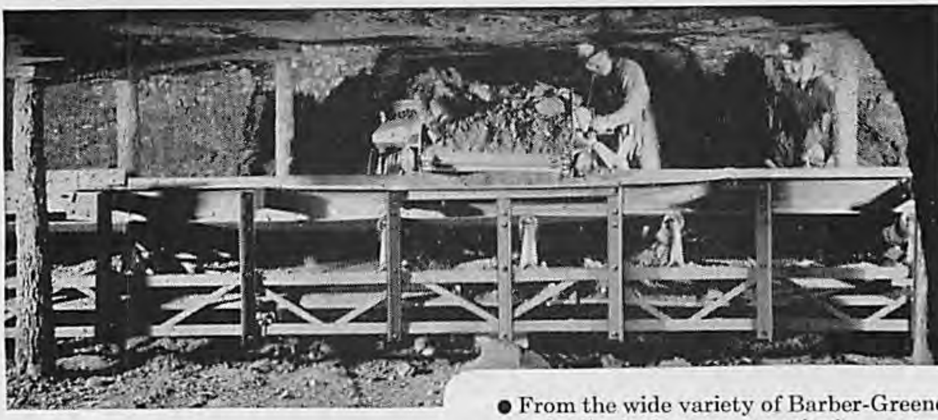

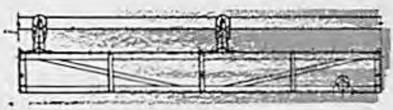

**Truss Conveyor Frame**
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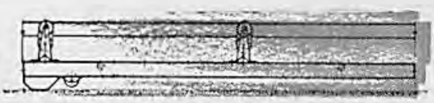
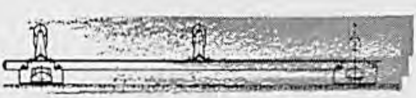


**Channel Conveyor Frame**
***Ideal for Low Headroom***



**Low Seam Conveyor Frame**
***Designed for Frequent Moving***

● From the wide variety of Barber-Greene *standardized* frames, terminals, power drives and take-ups, you can select those units best suited to the particular requirements of an underground conveying system in your mine.

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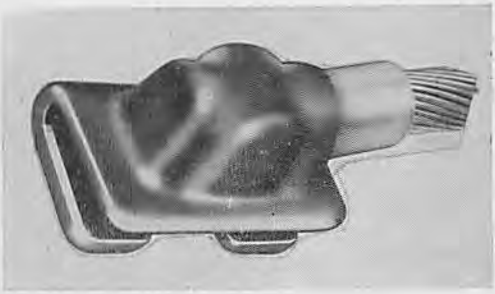

Mescoweld Rail Bonds feature our patented Flash-welding process for attaching terminals to cables—assuring an oxygen-free weld for maximum conductivity and long life. 20 different types permit you to select the Mescoweld Rail Bond best suited to your requirements. The popular universal type M8-F is illustrated.

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- Lower bit cost
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## COAL DRILLING

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- Lower maintenance cost
- Drills coal and rock
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- Reduced bit cost
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- Lower maintenance cost

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- Drills farther
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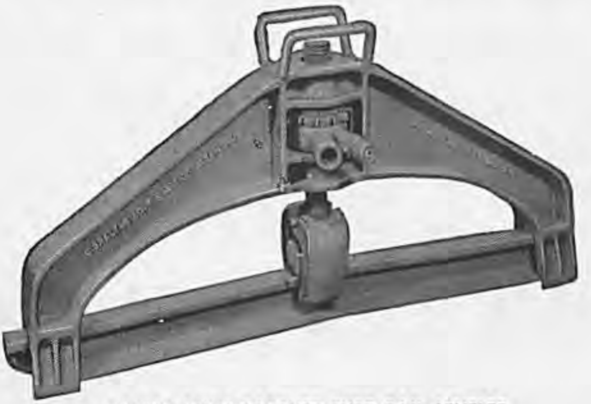

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