PROCEEDINGS

of the

ILLINOIS MINING INSTITUTE

FOUNDED FEBRUARY, 1892

Fifty-Ninth Year

1951

Annual Meeting
SPRINGFIELD, ILLINOIS
November 2nd, 1951

G. S. JENKINS

President, 1951

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
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

In Loving Remembrance

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
H. C. FREDERICKS, August 16, 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
CHARLES L. BOWMAN, Jan. 30, 1951
B. P. MELTON, February 22, 1951
A. F. KEENAN, March 18, 1951
GEORGE M. LOTT, April 12, 1951
D. F. McELHATTAN, April 12, 1951
M. J. CHOLLET, April 20, 1951
WILLIAM BURNETT, JR., June 14, 1951
E. J. COFFEY, July 20, 1951
A. C. CALLEN, July 30, 1951
F. E. WEISSENBORN, August 7, 1951
R. A. BARTLETT, November 26, 1951
D. D. WILCOX, November 30, 1951

* Killed in Action

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

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

OFFICERS 1952

PRESIDENT

Clayton G. Ball
Chicago, Illinois

VICE-PRESIDENT

William M. Bolt
Farmersville, Illinois

SECRETARY-TREASURER

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

EXECUTIVE BOARD

Walter Eadie*	Moss Patterson***
J. S. Forman***	H. A. Reid*
A. G. Gossard*	F. E. Snarr*
E. E. Green***	G. Don Sullivan*
Lawrence Kiss***	Frank L. White**
Rice W. Miller**	Henry C. Woods**

* Term expires 1952
** Term expires 1953
*** Term expires 1954

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.
1950-51	G. S. Jenkins, Consolidated Coal Co., St. Louis, Mo.

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FIFTY-NINTH ANNUAL MEETING

MORNING SESSION

PAPERS

AFTERNOON SESSION

The Entire Afternoon Session Was Prepared and Conducted by the ILLINOIS SOCIETY OF COAL PREPARATION ENGINEERS AND CHEMISTS. We are indebted to them.

EVENING SESSION

REPRINTS

REPRINTS from 1951 "Coal Mine Modernization" Yearbook, Through Courtesy of the American Mining Congress. Papers Presented at the American Mining Congress, Cleveland, Ohio, May 14-17, 1951

REPRINT from 1950 "Proceedings of the Coal Mining Institute of America" by Permission of the Author and the Coal Mining Institute of America

REPRINT from March-April 1951 Issue of "Occupational Trends" Through Courtesy of the Publication, the Author, and the Bellman Publishing Co., Inc., of Boston, Mass.

REPRINT from March 1951 Issue of Mining Congress Journal Through Courtesy of the American Mining Congress

PROCEEDINGS OF ILLINOIS MINING INSTITUTE
FIFTY-NINTH ANNUAL MEETING

Held in Springfield, Illinois

FRIDAY, NOVEMBER 2, 1951

MORNING SESSION

10 O'clock A.M.

The opening session of the 59th Annual Meeting was called to order at 10:10 A.M. November 2, 1951 by President G. S. Jenkins, at the Hotel Abraham Lincoln, Springfield, Illinois.

President Jenkins: Will the meeting please come to order. I now declare the 59th Annual Meeting of the Illinois Mining Institute in session. The first order of business is the reading of the minutes of the last Annual Meeting. In as much as these minutes are published in the Year Book, we usually dispense with this unless there is an objection. If there is no objection we will go on to the Report of the Secretary. Mr. Schonthal.

SECRETARY'S REPORT

At the beginning of this, our 59th Annual Meeting, your Institute had a membership of 1250 members. At the evening session today we will tell you how many new members have been added. This fine enrollment helps us maintain our position as one of the outstanding associations of its kind.

Our cash balance in the bank as of November first was $1126.97. We own $10,000 cash value of interest-bearing bonds.

During the year just ended, seven of our members passed away, including Fred Weissenborn, our oldest member and an Honorary Member of this Institute. The usual message of condolence were sent to the families of all.

You will hear a detailed report from Professor Walker about our scholarship program and the various students who are studying mining under scholarships administered through the Illinois Mining Institute. I want to add the Institute's special thanks to the Henry A. Petter Supply Company for their interest in this program by sponsoring one of this year's students. Your Institute is continuing this year also to sponsor a mining scholarship at the University of Missouri. At tonight's dinner we hope you will meet many of these scholarship students as well as some of the other students who are attending the Department of Mining and Metallurgical Engineering at the University of Illinois.

The 1951 Proceedings is now being compiled. Our special thanks go to the advertisers who have already renewed or intend to renew their advertisements in the publication. It is their support which makes the book possible. We hope this year's issue will be bigger and better than ever.

While this report is brief, I am sure you may realize the many, many details handled by your Secretary's Office. They could not be accomplished without the full cooperation of your officers, the executive board, committees, and all our members. My sincere thanks to you all.

Respectfully submitted,

B. E SCHONTHAL, *Secretary-Treasurer*

* * *

I should like to add this, that this past year our printing has cost us a lot. We are trying to keep the standard up to the peak it has been. I have occasion to get copies of many books from various organizations and, without patting ourselves on the back, I will say that ours, I think, is the finest by far of any I have seen, and it costs us considerably more than it ever did. The cost per copy is more than the $3.00 dues we get for membership, so the operating expenses of the organization are taken care of out of what we get from advertisers.

I am not telling you this with any thought of raising the dues. We do not need to do that. I want you to see, though, that the costs have been going up and our book as it is issued today costs us considerably more than the dues, but we are going to maintain the standard of it. Thank you.

President Jenkins: You heard the Secretary's Report. Are there any questions or suggestions? The dues of the Institute have been frozen here for about twenty years, and I believe we are still operating in the black, aren't we?

Mr. Schonthal: Yes, sir.

President Jenkins: I think I had better get the Executive Committee together and see if we cannot lend you to the administration in Washington!

Mr. Schonthal has some communications to present at this time.

Mr. Schonthal: I have a communication addressed to me, dated November 1, 1951. "Please present to President G. S. Jenkins and the Executive Board my resignation as a member of the Executive Board effective this date. Sincerely, William W. Bolt."

I move its acceptance.

President Jenkins: The acceptance of Mr. Bolt's resignation has been moved. May we have a second to the motion made by Mr. Schonthal?

The motion was seconded.

President Jenkins: All those in favor say "Aye." Opposed, "No." Mr. Bolt's resignation is approved.

The next report is the Report of the Nominating Committee. It will be presented by Mr. George C. McFadden, Chairman.

NOMINATING COMMITTEE REPORT

To the Membership of the Illinois Mining Institute:

As Chairman of the Nominating Committee of the Illinois Mining Institute, I wish to report that the Committee unanimously recommends to the membership the following nominations:

OFFICERS

PRESIDENT:

Clayton G. Ball
Paul Weir Company, Chicago, Ill.

VICE PRESIDENT:

William Bolt
Freeman Coal Mining Corporation, Farmersville, Ill.

SECRETARY-TREASURER:

B. E. Schonthal
Chicago, Illinois

EXECUTIVE BOARD

To serve on the Executive Board for a three-year term:

J. S. Forman
Mt. Olive & Stauton Coal Co., St. Louis, Mo.

E. E. Green
Old Ben Coal Corporation, West Frankfort, Ill.

Lawrence Kiss
Superior Coal Company, Gillespie, Ill.

Moss Patterson
West Kentucky Coal Co., Madisonville, Ky.

To serve on the Executive Board for a two-year term:

Rice W. Miller
Nokomis Coal Company, Nokomis, Ill.

Respectfully submitted,
George C. McFadden, Chairman
John E. Jones
Ben H. Schull

President Jenkins: Thank you. Are there any further nominations? If not, the Chair will entertain a motion to instruct the Secretary to cast a unanimous ballot in favor of the slate as presented.

Mr. Chedsey: I move the nominations cease and that the Secretary be instructed to cast one unanimous ballot for the slate as presented by the Nominating Committee.

President Jenkins: We have a motion to accept the slate as presented. Is there a second?

The motion was seconded.

President Jenkins: You have heard the motion and the second. All those in favor say "Aye." Opposed. The motion is carried.

Mr. Schonthal: The ballot is cast and the nominees are elected.

President Jenkins: The ballot has been cast and I declare them duly elected.

The next order of business is the Report of the Scholarship Committee. Prof. H. L. Walker.

SCHOLARSHIP REPORT

Student enrollment in our colleges and universities has been extremely cyclic in nature for the decade just past. We have experienced the lean years of the late war; this was followed by the tremendous influx in the post bellum days when our faculties were heavily overloaded, and our class rooms and laboratories were overcrowded; we have now entered another part of the cycle when numbers of students are again decreasing. The current decrease is undoubtedly the result of: (1) low birth rates during the depression of the thirties, (2) the demand for manpower in the "police action" (not a war?) of the far east (3) manpower needed to contain an "iron curtain" in Europe, and (4) poor publicity by our Federal Department of Labor which made public statements that engineering as a profession would be overcrowded by 1951.

Data collected by the American Society for Engineering Education show the total engineering student enrollment, udergraduate and graduate, in all branches of engineering for 1950-1951, to be 180,262. The total for mining engineering students was 1,607 of which 97 were graduate students. Mining engineers receiving their first degrees in June 1951 totaled 480 as compared to an approximate total of 41,700 for all branches of engineering. How should these data be interpreted when only 1.1% of all engineering degrees are in the great mining industry of this country? I know, of course, that the mining industry utilizes the talents of engineers in other fields.

It now appears that the industrial needs are for approximately 95,000 graduating engineers in 1951-1952 and our schools have in sight only an estimated 25,000 graduating engineers for this year, and sad to say, is the fact that a high percentage of these graduates will be drafted for military duty within a few weeks after receiving their degree.

SCHOLARSHIP STUDENTS

Names of Students in Picture:

Front Row—left to right

1) William M. Cazier, Decatur, Illinois
2) William H. Donley, West Frankfort, Illinois
3) Richard J. Trainor, Pontiac, Illinois
4) James P. Snider, Harrisburg, Illinois
5) Donald C. Simpson, Valier, Illinois
6) Charles E. Childers, Taylorville, Illinois

Back Row—left to right

1) Paul R. Penrod, Dongola, Illinois
2) Bruce W. Gilbert, Mattoon, Illinois
3) Daryl R. Gaumer, Sterling, Illinois
4) Warren E. Holland, Zion, Illinois
5) Robert L. Pounds, Taylorville, Illinois
6) Tommy S. Ullom, Benton, Illinois
7) Jack E. Tisdale, Benton, Illinois

Names of Students who could not meet for Picture:

1) Paul I. Hutchinson, Chicago, Illinois
2) Alfred Risi, Nason, Illinois
3) Donald E. Scheck, La Salle, Illinois
4) Robert J. Webster, Taylorville, Illinois

TABLE I. ENROLLMENT DATA (FIRST SEMESTER) 1945 to 1951
INCLUDES ALL BRANCHES OF UNIVERSITY

Year	Mining		Metallurgy		All Engineering		All University	
1945-46	10		26		908		11970	
1946-47	20	(+100.0)*	82	(+215.4)	4428	(+387.7)	28553	(+138.5)
1947-48	23	(+ 15.0)	102	(+ 24.3)	5150	(+ 16.3)	29944	(+ 4.9)
1948-49	57	(+147.8)	109	(+ 6.8)	4721	(− 8.3)	28929	(− 3.4)
1949-50	96	(+ 68.4)	116	(+ 6.4)	4144	(− 12.3)	28592	(− 1.2)
1950-51	79	(− 17.8)	106	(− 8.7)	3104	(− 25.1)	24394	(− 14.7)
1951-52	66	(− 16.5)	99	(− 6.6)	2736	(− 11.9)	22044	(− 9.7)

*Percentage change of previous years = $\frac{\text{(Current Year − Previous Year) x 100}}{\text{Previous Year}}$

Table I tabulates student enrollment at the University of Illinois for the period 1945 to 1951. I am showing the distribution according to University, College of Engineering, and Department of Mining and Metallurgical Engineering enrollment. I think you will be interested in studying the data.

I am happy to report a new scholarship has been added during the past year. The scholarship is known as the Henry A. Petter Supply Company Scholarship in Mining Engineering. In writing to Mr. B. E. Schonthal, Secretary of the Institute, Mr. Stanley D. Petter stated he was impressed by the work of the Illinois Mining Institute and that the Henry A. Petter Supply Company would be happy to participate if there were needy students. This scholarship is being administered by the Institute under the same plan and provisions as other scholarships. We are very grateful to Mr. Petter.

There are active, for this year, 17 scholarships in mining engineering at the University. The sponsoring agency, and the student and his home address are shown in Table II. From the inception of the scholarship plan by the Illinois Mining Institute there have been 43 students who have held scholarships. Of this number 11 have received degrees and entered the industry. Of the 17 scholarships active this year 8 students expect to receive their degrees during the current year.

In addition to the enrollment and scholarship data I should like to report on three other matters of interest to the Institute membership.

(1) In 1949 I reported we, of the University, were hopeful that an appropriation could be secured for the construction of a new building

TABLE II

SCHOLARSHIPS ACTIVE I SEMESTER 1951-1952

Sponsoring Agency	Name of Student	Home Address
Illinois Mining Institute	Warren E. Holland	Zion, Illinois
Old Ben Coal Corporation	William H. Donley	West Frankfort, Ill.
Old Ben Coal Corporation	Paul I. Hutchinson	Chicago, Illinois
Old Ben Coal Corporation	Alfred Risi	Nason, Illinois
Old Ben Coal Corporation	Donald C. Simpson	Valier, Illinois
Old Ben Coal Corporation	Jack E. Tisdale	Benton, Illinois
Peabody Coal Company	Charles E. Childers	Taylorville, Ill.
Peabody Coal Company	Daryl R. Gaumer	Sterling, Illinois
Peabody Coal Company	Paul R. Penrod	Dongola, Illinois
Peabody Coal Company	Robert L. Pounds	Taylorville, Ill.
Peabody Coal Company	James P. Snider	Harrisburg, Ill.
Peabody Coal Company	Richard J. Trainor	Pontiac, Illinois
Peabody Coal Company	Tommy S. Ullom	Benton, Illinois
Peabody Coal Company	Robert J. Webster	Taylorville, Ill.
Henry A. Petter Supply Co.	William M. Cazier	Decatur, Illinois
Alfred E. Pickard	Donald E. Scheck	La Salle, Illinois
Sahara Coal Company	Bruce W. Gilbert	Mattoon, Illinois

in 1951. I regret to report that we did not receive any consideration whatsoever. I therefore, can only report a further disappointment in this matter. There is, however, a possibility that we may be able to construct a new floor on the metallurgy laboratory building.

(2) In 1949 the membership of this Institute adopted a resolution for modifying the State Mining Laws which would permit substitution of years of formalized mining education for years of underground experience in qualifying for certificates of competency for employment in and about the mines. The 67th General Assembly in 1951 passed legislation in accordance with the Institute's resolution. The law with respect to a certificate of competency as mine examiner now reads: "That if he is a graduate mining engineer from an accredited mining college, two years of his college work will be accredited on the four years experience required." This is a step in the right direction and will be of

special interest to graduate mining engineers who wish to enter the production side of coal mining.

(3) In 1949 I also reported that the Department of Mining and Metallurgical Engineering, with the cooperaiton of the University Extension Division, had embarked upon a program of coal mining instruction and study through extension work in the local communities. The program was begun and there were four schools in operation, but the State Division of Vocational Education became interested in this type of instruction and started courses of study. There was no need for competing agencies within the State, so the University withdrew their program and made available their materials to the Division of Vocational Education. We are hopeful the program will be successful and that the mining industry of the State will support the program.

* * *

President Jenkins: Thank you very much, Prof. Walker. The Chair will entertain a motion that the Report of the Scholarship Committee as presented by Mr. Walker be accepted.

Mr. Schonthal: I so move.

Mr. Chedsey: I second the motion.

President Jenkins: All those in favor say "Aye." Opposed, "No." It is carried.

Next we have the Report by Mr. Maurice D. Cooper, Director of Mining Engineering Education of the National Coal Association, from Pittsburgh, Pennsylvania. Mr. Cooper.

Mr. Cooper: In a few words Professor Walker has given you an interesting and accurate survey of the present situation. In an equally few words I would like to comment on what he has said. The situation is not as good as it should be and not as bad as it might be.

There is a stirring around in the coal industry in regard to education. There is more active interest throughout the country, and the result is being shown in an improvement in regard to employment in the industry, but there again there is a chance for betterment.

A good many companies throughout the country are establishing scholarships. The total number is increasing constantly and there is an opportunity to add more. The greatest chance for help as far as education and its relation to the coal mining industry is in the early employment of those students who are about to graduate. There are thirty colleges teaching mining engineering and other industries are skimming off the boys pretty early in their senior year. If the coal industry would wake up to the fact that these boys are available and desirable and useful to the coal industry, its representatives would get onto the campuses as early as possible in the Fall, interview the students and make definite arrangements for their employment.

Too much emphasis cannot be placed on Summer employment. Those boys in the freshman, sophomore and junior years need employment during the summer to get money and experience, and the coal industry will serve its own interests if it will give temporary employment to the students. Not only will they be helping them, but they will be helping themselves in providing an opportunity for selecting future employees. I hope it may be possible in future years to take greater advantage of summer employment.

President Jenkins: Thank you very much, Mr. Cooper. I think in the coal industry has been a little bit lax in picking up the students about to be graduated, and that is probably the reason so many students have not selected mining as their calling in life, because they have not been properly approached. I am sure all of the country is now beginning to realize that with the modernization that has come along we are going to need more and more of these technically trained personnel, and now is the time to get in and make our wants known.

Prof. Walker: We are having a little difficulty with these scholarships, and Mr. Schonthal gets a little discouraged with me. We have people who come in and they are in the Naval Reserve and they are called to active duty and I report this to Mr. Schonthal and he has difficulty in keeping his records accurate; and then there is a report to be made to the sponsor that we have some money left over. Then we have the taking up of some 15,000 to 19,000 student records in 3 days. It takes a little time, even with I.B.M. machines, to do that. I hope you people will be somewhat understanding of the problems we do have.

Mr. Schonthal: You are not mad at me, are you?

Dr. Walker: No. (Laughter).

President Jenkins: I understand the difficulties Professor Walker is talking about. We had a student who was enrolled and, as Dr. Walker said, he came in and thanked us for his scholarship and said he was going to work for Uncle Sam.

The next order of business is Unfinished Business.

Mr. Schonthal: We have no Unfinished Business and no New Business.

President Jenkins: We now get to the business of the day, which is coal mining, and I would like to present Mr. Fred Miller. Fred was born in Southern Illinois and is now Superintendent of the C. W. & F. Coal Company, at Waltonville, Illinois. I give you Fred Miller.

Mr. Miller: Thank you, Mr. President.

Members of the Illinois Mining Institute and Guests: The first paper on your program this morning was intended to be presented by Mr. James Westfield, better known to most of us as Jimmy. However, Jimmy was unable to be here this morning and a very able associate, Mr. W. H. Tomlinson, better known as Tommy, from the Bureau of Mines at Vincennes, Indiana, will give his paper, which is entitled "Roof Drilling with Dust-Control Equipment." Mr. Tomlinson.

Mr. Tomlinson: Mr. Chairman and members of the Illinois Mining Institute: Mr. Westfield, whose paper I will read, asked me to express his regrets for his inability to be with us here today. Unfortunately, a mine catastrophe occurred in an eastern State a few days ago and his services are demanded there.

This is not the first time that I have had the pleasure of attending the Illinois Mining Institute, but it is the first time I have been privileged to address this group—I assure you gentlemen that it is a real privilege and a pleasure to be permitted to address you on this occasion. Now, to get on with the paper: one hundred copies of Mr. Westfield's paper were mailed to me here from Pittsburgh; however, they have not yet arrived. If the shipment gets here before the meeting adjourns a copy of the paper will be distributed to each of you.

As your chairman indicated, the subject of the paper is, "Roof Drilling with Dust-Control Equipment."

Gentlemen, I hesitate very much to even mention the subject of the effect of atmospheric dust on the human body because, as you know, we know so very little about this subject, even in this day and age. The subject is highly controversial. One expert will say that such-and-such is the case and another will disagree with him, so it is difficult to make conclusive and direct statements or deductions about dust. We say that in arithmetic 2 and 2 is 4 and we are reasonably sure our deduction is correct. We cannot be so positive when we talk about the effect of atmospheric dust upon the human body.

I might say, too, that the industry (coal) in this country has been dust conscious only during the last two decades; what made this so was principally the incidence of silicosis allegedly due to drilling of highly silaceous sandstone encountered in a tunnel being driven for water power in an eastern State. I happened to be within a few miles of the tunnel in question at the time and was privileged to see analyses of the strata through which part of the tunnel was driven, which was found to be around 96.6 per cent pure silica. You can readily understand that a very hazardous condition existed in that tunnel, the degree of which is not approached in coal mining.

However, I think you will also agree with me, that any dust, or extraneous material breathed into the lungs, is detrimental to health. I know this to be true from 16 years personal experience underground breathing coal and other dust, because at this moment I am suffering some impairment of lung capacity due to dust I got in coal mines.

There may be some questions after I have read this paper. I do not know that I will be able to answer them, however, I shall try.

ROOF DRILLING WITH DUST-CONTROL EQUIPMENT

By JAMES WESTFIELD
Chief, Accident Prevention and Health Division
Region VIII, Bureau of Mines
Pittsburgh, Pa.

INTRODUCTION

Drillings for roof bolting have created a new dust problem for the coal-mining industry. Drilling is inherently dusty, and control of the dust produced by drilling vertical, or nearly vertical, holes is much more difficult than control of that produced by drilling flat or down holes.[1] Moreover, the dust produced by roof drilling differs in composition from that produced by drilling or cutting the coal face, in that it contains a significantly greater amount of free silica and therefore presents a greater potential hazard of causing the lung disease, silicosis.

Roof bolting has been practiced successfully in the mines of the St. Joseph Lead Co. in southeastern Missouri for over 20 years, but it was not until 1947 and 1948 that large-scale roof-bolting experiments were first conducted in coal mines.[2] Although the need for dust control in conjunction with roof drilling was recognized from the beginning, the development and acceptance of roof bolting progressed so rapidly during 1949 and 1950 that solution of the dust problem lagged behind other engineering phases of the technique.

TYPE OF ROCK ENCOUNTERED IN ROOF DRILLING

The roof generally is bolted where the immediate roof is soft and in many instances where the roof bolts can be secured firmly into a harder or more substantial formation above. The types of strata found in drilling a roof are coal, shale, sandstone, limestone, and all the impure and intermediate variations of these materials. A comprehensive study of the geologic sections of the immediate roof of mines in Region VIII of the Bureau of Mines, where roof-bolting studies are in progress, reveals that 67.7 percent of the footage of all the holes drilled for roof bolts is in shale, 23.4 percent is in sandstone and sandy shale, 7.1 percent

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[1]Brown, Carlton E., and Schrenk, H. H., Effect of Angle Drilling on Dust Dissemination: Bureau of Mines Rept. of Inevestigations 3381, 1938, 7 pp.

[2]Thomas, Edward, Roof Bolting in the United States: Bureau of Mines Inf. Circ. 7583, 1950, p. 1-3.

is in coal and coaly shale, and 1.8 percent is in limestone. Shale consists chiefly of kaolin, muscovite, and quartz, with small amounts of many other minerals. Sandstone consists principally of quartz, with a cementing material of silica, calcite, or limonite. A limestone consists chiefly of calcite, with varying amounts of quartz. Even the coal may contain a small percentage of quartz. Thus, quartz is present in significant amounts in about 91 percent of all the rock drilling for roof bolting.

Free-Silica Content of Roof Strata and Its Relation to Air-Borne Dust

The free-silica content of a mineral material (quartz is the most abundant form of free silica) is determined most accurately by the X-ray diffraction method, which is based upon the specific diffractive properties of crystalline substances.[3] This method requires only a small sample, and the small size of industrial dusts does not affect the results adversely. Determination of free silica by this method was developed in part in the Bureau of Mines, where it is now used for quantitative analysis of samples of rock, rock dust, drill cuttings, and air-borne dust.

The free-silica content of the roof strata of 51 coal mines has been determined by X-ray diffraction analysis from roof rock, drill cuttings, and midget-impinger samples of air-borne dust collected in mines in 9 Eastern States. The average free-silica content of 80 samples from these mines is 31 percent, and it ranges from 7 to 88 percent. The free-silica content of the roof strata of 43 of the mines classified as having shale roof averages 26.5 percent and ranges from 7 to 62 percent. The free-silica content of the roof strata of 8 of the mines classified as having sandstone roof averages 55 percent and ranges from 31 to 88 percent. These results show that wide variation may exist in the composition of various roof strata and that the content of free silica encountered in drilling a shale roof may equal or exceed that found in drilling a so-called sandstone roof.

Although the composition of a mineral source material may not be considered an exact index of the composition of air-borne dust produced by mechanical disintegration of the material, some evidence on this subject is available. Unpublished data developed by the Bureau of Mines indicate that the quartz content of air-borne dust decreases as the time of settling increases, and direct comparison of analyses available in the Health Branch of the Bureau of Mines also indicates that the free-silica content of the air-borne dust produced by drilling is somewhat, but not significantly, less than the free-silica content of the material drilled. These results, though too limited to be conclusive, give some justification for using the analysis of the source material in evaluating the dust hazard, particularly since the error, if any, is on the side of safety. It may be pointed out also that Industrial Code 33 of the State of New York, Control of Silica Dust in Rock Drilling, bases its definition of "injurious silica-dust concentration" upon analysis of the source material drilled.

[3]Ballard, James W., Oshry, H. I., and Schrenk, H. H., Quantitative Analysis by X-ray Diffraction, I. Determination of Quartz: Bureau of Mines Rept. of Investigations 3520, 1940, 10 pp.

Allowable Dust Concentrations Applicable to Roof Drilling

Any dust breathed in large quantities over a long period can impair the health of a worker, and silica is recognized as definitely harmful when inhaled into the lungs. Coal dust is less harmful but should not be considered completely harmless.

The hazard of exposure to silica-bearing dust is commonly gaged by the number of dust particles found in a unit volume of air and the free-silica content of the dust. Limits for occupational exposure expressed in such terms have been suggested by evaluation of the results of numerous clinical and engineering studies.[4/5/6]

The Bureau of Mines has made the following tentative recommendations on allowable limits of air dustiness:

> "In bituminous and lignite mines, the average full-shift concentration of atmospheric dust, to which a workman may be exposed should not exceed 20 million particles per cubic foot of air, and a maximum concentration for any single operation should not exceed 40 million particles of dust per cubic foot of air. When the dust contains silica, not more than 5 million particles of silica dust per cubic foot of air should be present in the above limiting concentrations. The dust count may be multiplied by the percentage of silica concentration, and if the result is less than 5 million the dust concentration will be considered safe. The above limiting concentrations are based on impinger samples in which light-field counts[7] are made under a microscope."

To maintain these standards a dust concentration higher than 18.9 million particles per cubic foot of air would not be allowable when the average shale roof is drilled, and a dust concentration higher than 9.1 million would not be allowable when the average sandstone roof is drilled. A dust concentration no higher than 5.7 million would be required in some instances.

Roof-Drilling Dust-Control Practice, All Coal Mines, Region VIII

Table 1 lists the types of drilling equipment used for roof drilling, the number of mines using each type, and the number of mines using or not using a dust-control method with each type. It can be seen that at 71.1 percent of the mines roof is drilled with no dust-control equipment: contrary to the Bureau of Mines recommendation that "a dust respirator is not to be used as a permanent substitute for dust-control measures,"[8] reliance is placed upon the protection offered by respirators.

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[4]National Silicosis Conference, Report of Medical Control, Final Report of the Committee on the Prevention of Silicosis Through Medical Control: Dept. of Labor, Division of Labor Standards, Bull. 21, Part I, 1938, p. 34.

[5]Sayers, R. R., Bloomfield, J. J., Dallavalle, J. M., et al., Anthracosilicosis Among Hard Coal Miners: Public Health Service Bull. 221, 1936, 113 pp.

[6]Flinn, Robert H., Seifert, Harry E., Brinton, Hugh P., Jones, J. L., and Franks, R. N., Soft Coal Miners Health and Working Environment: U. S. Public Health Service Bull. 270, 1941, 113 pp.

[7]Brown, Carlton E., and Schrenk, H. H., A Technique for the Use of the Impinger Method: Bureau of Mines Inf. Circ. 7026, 1938, 20 pp.

[8]Pearce, S. J., The Use of Dust Respirators in Coal Mines: Bureau of Mines Inf. Circ. 7561, 1950, 6 pp.

TABLE 1. — ROOF-DRILLING DUST-CONTROL PRACTICE, ALL COAL MINES, REGION VIII

Drilling Equipment	Coal Mines: Total Number	Number Using Control Method	Number Not Using Control Method
Pneumatic Percussion	278	91	187
Electric rotary	57	2	55
Hydraulic rotary	8	3	5
Pneumatic percussion and electric rotary	6	5	1
Pneumatic percussion and hydraulic rotary	4	1	3
Total, all types	353	102	251
Percent, all types	100.0	28.9	71.1

TABLE 2. — DUST-CONTROL METHOD AND APPLICATION TO DRILLING EQUIPMENT, ALL COAL MINES, REGION VIII

Dust-Control method	Drilling Equipment: Pneumatic percussion	Electric rotary	Hydraulic rotary	Totals: Number	Percent
Application of water	46	......	3	49	13.5
Dust collector	51	7	1	59	16.3
None	191	56	8	255	70.2
Total applications				363[1]	100.0

[1]Includes 10 mines using 2 types of drilling equipment.

Dust-Control Method and Application to Drilling Equipment, All Coal Mines, Region, VIII

Table 2 shows what dust-control methods are used in conjunction with pneumatic percussion, electric rotary, and hydraulic rotary drills. Note that the applications of dust collectors outnumber the applications of water.

Dust Concentrations Produced by Roof Drilling Without Dust-Control Equipment

Dust concentrations recently observed in five mines where stoper-type pneumatic drills are used without dust-control equipment averages 607 million particles per cubic foot of air and ranged from 51 to 1,194 million particles per cubic foot. In six mines where electric rotary drills were used without dust-control equipment, the dust concentration averaged 313 million particles per cubic foot and ranged from 10 to 1,185 million particles per cubic foot. The dust concentrations cited are indicative of the dust exposure of the driller but were obtained under such variable conditions that they should not be used for direct comparison. For instance, the averages indicate that pneumatic drilling produces twice as much dust as electric rotary drilling; actually the ratio may be higher. The ranges indicate that either type of drill may produce dust concentrations higher than 1 billion particles per cubic foot of air. This amount of dust can pollute the air to such an extent as to constitute a serious menace to the health, not only of the drillers, but any persons working in the return air from the place where drilling is being done.

Dust-Control Methods Applicable to Roof Drilling

Dust produced by roof drilling must be arrested or collected at its source if it is to be controlled adequately. This can be done by water or a dust collector. Water can be used effectively with pneumatic percussion or hydraulic rotary drills. Dust collectors can be adapted to any type of drilling equipment.

Application of Water

Introduction of water to the bottom of the hole through the drill steel when drilling is done with pneumatic percussion drills has been accepted as standard practice in metal mines. This practice is applicable to roof drilling and complies with the Federal Mine Safety Code requirements. Successful control by this method[9] depends mainly upon maintaining the flow of enough water through the drill, using water continuously during the drill-operating period, and providing positive ventilation as needed. High dust concentrations can result if too little water is used, especially when vertical holes are drilled with a stoper-type drill. It is advisable to maintain adequate water pressure so that a full flow of water can be realized. Collaring dry—that is, drilling the first few inches of hole before opening water valve—can also cause high dust con-

[9]Williamson, W. C., and Shugert, J. L., Practical Dust Control: Mining Engineering, January 1950, pp. 86-90.

centrations and should not be allowed. During recently observed roof drilling with a wet stoper drill, dust concentrations averaged 13.3 million particles per cubic foot of air and doubtless would have been lower had not all the holes been collared dry, as conditions for maintaining low dust concentrations otherwise were excellent. Wet drilling must be supplemented by ventilation to obtain the desired control, as the water does not arrest the dust completely. Other conditions being favorable, normal ventilating currents should prove adequate but will have to be directed to the drilling operation. The most frequent objection to wet, pneumatic percussion drilling is that it is a disagreeable task. The splashing of the water and drill cuttings and the wetness underfoot are particularly objectionable to the driller when the headroom is limited, as in many coal mines.

Various hydraulic rotary drills have been developed, and the use of water to control the dust reportedly has been successfully applied to them. The Bureau of Mines has not as yet had opportunity to observe the results obtained.

The need for a water-distribution system or the use of inconvenient pressure tanks, the adverse effect upon some mine roof and floor, and the difficulty of using water with electric drills are other factors that limit the use of water to allay drilling dusts. Results of tests conducted with wetting agents, foam, and various types of water sprays, all with the hope of minimizing these factors, have been unfavorable. Satisfactory equipment for producing and applying foam has not been developed; water sprays have proved inefficient, [10] and thus far the performance of wetting agents has not justified their use.[11]

Dust Collectors

The operating principle of most dust collectors is application of exhaust ventilation near the source of the dust. Numerous dust-control systems based upon this principle have been devised for controlling dust produced by all types of pneumatic rock drills. Some of these have demonstrated that, by proper application of this principle, successful results could be obtained, even under the most difficult conditions. Regardless of results, unfavorable operating features restricted their complete development. With the advent of roof drilling, the possibility that their use here might overcome the serious objections to wet drilling and the fact that they were applicable to electric rotary drilling again stimulated their further development. To meet this need, several types of dust collectors now have been made available commercially, and others have been developed and used locally.

In 1950, the Bureau of Mines inaugurated a program at the Experimental Mine, Bruceton, Pa., for testing dust-collecting devices developed commercially for roof drilling in coal mines. The reasons for conducting these tests were (1) to assist the designers of the equipment by evaluating the effectiveness of the devices under controlled test condi-

[10] Johnson, John A., and Agnew, Wing G., Dust Produced by Drilling Where Water is Sprayed on the Outside of the Drill Steel: Bureau of Mines Rept. of Investigations 3478, 1939, 6 pp.

[11] Johnson, John A., Use of Wetting Agents in Reducing Dust Produced by Wet Drilling in Basalt: Bureau of Mines Rept. of Investigations 3678, 1943, 27 pp.

tions and (2) to enable the Bureau of Mines to obtain information on dissemination of dust during roof drilling, and on methods of controlling it, that will be beneficial to the mining industry.

Under this program, performance tests were conducted for six different types of dust-collecting systems. Each design has included a collecting head, an exhaust ventilating system, and means for removing the entrained dust load from the air passing through the system before releasing it to the mine atmosphere. The design of the hood is most important because it affects the dust-collecting efficiency directly and dictates the performance required of the other parts of the collector. Drilling in hard roof produces fine, readily transported particles, whereas drilling in soft roof, such as occurs above the Pittsburgh seam, produces large, scalelike particles that tend to plug a dust collector unless it is designed to accommodate their transport. The collectors apparently most successful have overcome this difficulty by avoiding restrictions and using the effect of gravity to full advantage in moving the drill cuttings from the hole. The provisions for a tight seal where the drill steel passes through the hood are more critical than the provision for a seal where the hood contacts the roof. Unfavorable results caused by an ineffective drill-rod seal cannot be overcome by any reasonable amount of exhaust ventilation. Either positive-pressure exhausters or air injectors can provide an adequate rate of exhaust ventilation if the previously mentioned difficulties are avoided. Removal of the dust load from air passing through the system has been no problem, being accomplished either by gravity separation of the large particles and mechanical filtration of the fine particles or, more simply, by mechanical filtration alone. Two collectors have been designed for removing the dust load by a washing action.

No attempt has been made to evaluate the features of the various collectors other than their collecting efficiencies. It is obvious that size, weight, and portability should be given more consideration. It is noteworthy that one of the most successful dust collectors is so compact that one man alone can move it about and set it up with ease.

The results of some performance tests have shown that it is possible to reduce roof-drilling dust concentrations to 5 million particles per cubic foot of air with dry-dust collectors and that a dust collector can perform satisfactorily with either pneumatic percussion or electric rotary drills. The favorable results obtained under severe test conditions indicate that dust produced by pneumatic roof drilling can be controlled more effectively by the use of an efficient dry dust collector than by the application of water.

The performance tests are not to be construed as approval tests, such as are conducted by the Bureau of Mines on other types of equipment under provisions of appropriate published schedules. Such a schedule, establishing permissibility tests, is being prepared and upon completion will allow the Bureau of Mines to grant formal approval to equipment passing the prescribed tests. Approval-schedule procedure tests have demonstrated the ability of dry-dust-collecting equipment to control dust in accordance with the tentative Bureau of Mines Recommendations previously discussed.

Federal Mine Safety Code as Related to Rock Drilling

Article IX, Section 1b, of the Federal Mine Safety Code is specific in requiring the use of water for controlling dust where roof or other rock is being drilled with percussion drills. This precludes the use of dry-dust collectors, successfully or otherwise, and the Federal coal-mine inspector has no alternative but to cite a violation of the Code where this practice is observed. The citation is not capitalized, as normally would be done when a serious hazard to health exists, if, in the inspector's opinion, the dust collector is doing a good job. Statements of the facts of the case are included in the report under the heading "General Information." The Bureau of Mines recognizes the situation of an operator thus cited and suggests that he appeal from the citation to the Joint Industry Safety Committee.

Acceptable dry-dust collectors have been developed, and the Bureau of Mines has proposed to the Joint Industry Safety Committee a revision of Article IX, Section 1b, to permit the use of dry-dust collectors with pneumatic drills.

Article XI, Section 7g, of the Code states that men exposed to gas, dust, fume, and mist inhalation for short periods shall wear permissible respiratory equipment. Rock drilling, other than roof drilling, has been excepted from dust-control provisions, in many instances, under this section. A comprehensive study of the airborne dust resulting from rock drilling in coal mines has been undertaken by the Bureau of Mines; and data obtained from this survey indicate that, in some instances, rock drillers and other workmen are being exposed to injurious concentrations of dust. The application of dust control to roof drilling will stimulate the application of dust control to other rock-drilling tasks. Rock drilling without dust control cannot be justified if and when suitable control methods can be applied.

Summary

1. In Region VIII, 353 coal mines are using roof bolting, and 63 million square feet of roof area are being supported by roof bolts.

2. The roof strata drilled for roof bolting contain significant amounts of free silica. The samples taken from 51 mines in Region VIII show that the free-silica content averages 31 percent.

3. Roof drilling without provisions for dust control results in a serious health hazard, as drillers and other workmen in the return air from the place where drilling is being done are exposed to dangerously high concentrations of silica-bearing dusts.

4. Dust-control methods are not used in conjunction with roof drilling at 71 percent of all the mines in Region VIII where roof bolting is being practiced.

5. Wet pneumatic roof drilling, if properly conducted, results in favorable dust concentrations, but it can affect the mine roof and floor

adversely, is a disagreeable task (particularly in low coal), and requires a water-distribution system or use of pressure tanks.

6. The development of dust collectors has been stimulated by the need for overcoming the objectionable features that accompany wet pneumatic roof drilling and by the fact that they can be adapted to electric rotary drills.

7. The Bureau of Mines inaugurated a program for testing the efficiency of dust-collecting devices developed commercially for application to roof drilling in coal mines, and the test work proved that the principles applied in these dust collectors are adequate.

8. In inspecting mines the Federal inspector is forced to cite a violation of the Federal Mine Safety Code when roof drilling is done with a pneumatic drill, even if a dry-dust collector is used successfully; as a result, the Bureau of Mines has asked the Joint Industry Safety Committee to revise the Code to permit the use of dry-dust collectors in connection with roof drilling.

9. Control of the dust produced by roof drilling is difficult but must be accomplished. The effort being expended toward proper application of wet methods and newly developed supplementary devices should result in a high degree of success.

10. Rock drilling other than roof drilling has been excepted from dust-control provisions in many instances by the Federal Mine Safety Code. This exception has resulted in rock drillers and other workmen being exposed to injurious concentrations of dust. Development and application of dust control to roof drilling will stimulate application of dust control to other rock drilling tasks. Rock drilling without dust control cannot be justified if and when suitable control methods can be applied.

* * *

Chairman Miller: Thank you very much, sir.

Before we get into a discussion of this paper, those of you in the back of the room, won't you avail yourselves of the seats in the room?

This fast growing youngster of roof bolting has had a truly amazing growth. The industry, I believe, is indebted to Jimmy Conway and Dave Neal, formerly of the Consolidated Coal Company, for the application and early development of roof bolting. At that time I know, too, that dust creation by drilling for roof bolting was recognized but that, like many other things in development work, first things had to come first. We were primarily interested then in learning whether or not the idea was qualified and how effective it could become. As a result, even though the dust hazard was recognized it had to be by-passed in the interest of other first things which must come first.

Now I think there are many of you who have had experiences with roof bolting and roof drilling and I know there must be questions on this in your minds as a result of the things which Mr. Westfield has written and the things Mr. Tomlinson has told us about this, so we will now open the meeting for discussion, and those of you who would like to ask questions, for the record, we would appreciate it very much if you would stand, give your name and affiliation, so that the man keeping the record here can keep them straight.

Mr. Fletcher: Can you tell me if there is any way your graphs can show the size of the particles? Some of the particles are larger and possibly are more injurious than the smaller ones. There is a difference in the size of particles of dust.

Mr. Tomlinson: I am sorry the graph does not show it, Mr. Fletcher, but when we speak of dust which affects the human body we generally limit ourselves to the dust particles of the size of 10 microns or less. Now I do not know whether there are size tests made. In connection with these studies I assume there were. Generally the more difficult dusts to get out of the air are the small ones more injurious to us so for that reason the larger particles of dust do not stay in the air as long and are not breathed with the same ease as the smaller particles. It is the fine dust particles of 10 microns or less that we deal with when we speak of injurious dust.

Chairman Miller: Does that answer your question, Bob?

Mr. Fletcher: Yes, thank you.

Chairman Miller: Are there any other questions? Does anybody have an experience that they would like to relate?

Thank you again, Mr. Tomlinson. We are indebted to you and to Jimmy for a fine presentation of this subject.

Our next paper is entitled "Engineering and Applications of Steel Cable Conveyor Belting for Slopes." This paper will be presented by Mr. J. L. Thornton, Manager of the Coal Division – Belting Sales Mechanical Goods Division of the Goodyear Tire and Rubber Company of Akron, Ohio. Mr. Thornton.

Mr. Thornton: Mr. Chairman, Members of the Illinois Mining Institute:

Our time is rather limited so I will start right in with the presentation of this topic now. It was originally planned for me to give this extemporaneously. However, in order to stick pretty close to the script it will be necessary for me to refer continuously to the paper.

This discussion would have been considerably clarified had we been able to take the time to draw some charts and project them on the screen, but later if there are any questions in regard to this I will attempt to elucidate and elaborate.

ENGINEERING AND APPLICATION OF STEEL CABLE CONVEYOR BELTING FOR SLOPES

By Development and Engineering Depts.
of the Goodyear Tire & Rubber Co.
and presented by

J. L. THORNTON
Manager of Coal Sales, Belting Dept., Mechanical Goods Division
Goodyear Tire & Rubber Co.
Akron, Ohio

Although the use of small steel cables in the carcass of rubber conveyor belting has only recently come to the attention of many engineers, its use is not new. Patent files reveal that steel cables sewed into leather belting were first used about 55 years ago. Great strength and very small elongation of steel cables were even then attractive to designers attempting to handle very high tensions in excess of cotton and leather constructions.

In 1925 a coal mining company using several miles of rubber and cotton conveyor belting investigated the use of the small steel cables then available to obtain higher tensions in the belting. They asked for bids requesting 1600 feet of 48 inch belting to handle 1500 tons per hour of R O M coal. The cables specified were 3/16" 6 x 7 cotton center sash cord placed in the belt on ⅜" pitch.

One company tested belting of the specified construction and found many limitations preventing the use of such design. After numerous trials a satisfactory cable was found but the cost of the belt was prohibitive. The idea was abandoned at that time.

The study of steel cables was revived by the development of small, very strong steel cables intended for tires. These proved so successful in Flat and V-Transmission belting that production of these items progressed much more rapidly than the application to tires.

The application of steel cable V-Belts early in World War II to replace the inadequate cotton construction for fans, generators and water pumps on motor vehicles produced an outstanding job and some 1,000,000 belts were delivered for that purpose.

At the same time, flat transmission belts incorporating steel cables, were establishing a place in industry handling drives that were beyond the range of conventional belts.

The first commercial application of steel cable conveyor belting late in 1942, nearly nine years ago, was in a long inclined conveyor transporting ore from the Morris Mine, an open pit type in Minnesota Mesabi Range. Its excellent performance resulted in the use of similar belts at two other open pit mines for the same company.

At the time steel cable went into production on various kinds of belting, there was no other choice for very strong belts beyond the range of cotton.

Now other fibers such as rayon, nylon, glass and treated cotton of possibilities of strength beyond that of ordinary cotton, may overlap into the high strength field primarily held by steel. Within the past few years there have been three installations of plasticized cotton and nylon combination belting but there has not been time enough yet to evaluate the advisability of using such construction universally.

If the trend in the price increase of cotton fabric continues at a high rate and steel proceeds at a slower rate of increase, the overlap may even allow steel to invade the present position held by heavy cotton belts.

About the only impression left by the initial effort to use the 3/16″ 6 x 7 cotton center sash cord was that the diameter of the cable was excessive for the little additional strength obtained.

The steel cable that revived belt development in this direction was 0.036″ diameter and by properly relating cable tension to pulley diameter it was possible to eliminate flex failure as a cause of belt failure. It was possible with this cable to operate belts with pulley diameter as small as 3 inches.

In conveyor belting, where frequency and severity of cable bending is much less it was apparent that such small diameter cables of very fine wire were not necessary, so larger cables and coarser wire are used.

High carbon steel rods are used for making the cable and its strength is obtained partly through continued cold work of the drawing operations. Very small wires attain a strength up to 350,000 psi. An analysis of one of the rods was specified as follows:

Carbon—0.070 Mangenese 0.035 Phosphorous 0.010 or less sulphur 0.04 Silicon 0.02.

The steel cables are treated mainly to obtain adhesion between the steel and surrounding rubber portions of the belt and to protect the wires from corrosion. An electroplated brass was used extensively from an adhesive standpoint. With a brass adhesive bond small steel cables such as those used in V-Belts develop a bond strength equal to the cable strength when embedded in rubber for a length of approximately 3 inches, and then pulled parallel to the cable axis. One or two metal to rubber cements were used with some success in addition to brass adhesion.

Protection of these cables from corrosion has always been recognized as necessity. The cables are embedded and well bonded to the rubber and there is, apparently, no severe corrosion problem if we may judge from exposure test and actual performance when the cables are exposed by accidental damage to the belt. The use of plating such as tin, prior to brass plating was investigated, but such coatings are so thin and so easily damaged that their use is of doubtful value. The use of stainless steel cables follows naturally but cost and certain process problems discourage the idea. Fortunately, users of large conveyors are aware of the importance and value even in cotton belts of early repair in accidental damage. Thus, it is not impractical to provide such maintenance to prevent exposure of the steel cables. Also, the location of the steel cables in conveyor belts is such that they are much less likely to be exposed by usual operating hazards than are the plies of a cotton belt.

Methods of Manufacture

Transmission belts incorporating steel cables are almost universally manufactured as Endless belts. In these circumstances the steel cable is wound in a helix with an advance each revolution depending upon the size cable and the strength required in the belt. In all cases the cable diameter is so small relative to the belt length that the angle of helix is almost imperceptible. In a few cases where the installation of Endless Transmission belts became impractical straight lengths have been manufactured and made endless in the field with vulcanized joints. The nature of joints in steel cable belts will be discussed later.

Conveyor belting, because of its much greater length, is almost invariably manufactured in long rolls and spliced endless on the job.

Several methods of placing steel cables in the carcass of the roll of belt have been used. Pre-assembly of the steel cables into a woven fabric with sufficient transverse members to hold the assemby in shape were used in early manufacture. This procedure simplifies subsequent assembly operations in belt manufacture but carries with it some inherent defects of the weaving operation which are much more serious in steel fabrications than in cotton.

In other cases this pre-assembly of the steel cables is made in a matrix of rubber compound. In still others there is no pre-assembly and the operation of placing steel cables becomes a part of the belt assembly. In any of these examples control of as many as 600 spools of steel cables being fed into the belt is a rather complicated process.

In both transmission V-Belts, flat belts and conveyor belts the steel cables are embedded in a layer of rubber or synthetic compound designed to adhere to the brass plated cables, and to provide support for the cable under the radial forces on the pulleys. The cables themselves must be placed so they distribute the tension in the belt uniformly or in some predetermined pattern.

Fabric envelopes usually of cotton are provided to give transverse strength and stiffness in both transmission and conveyor belting and as a wearing surface in transmission belts. In conveyor belts, of course, rubber covers are provided for protection against abrasion and cutting by the material carried.

Strength of steel cable belts can be varied both by size of cable and by pitch of the cable in the belt. Thus, in any belt strength from range of 3500 pounds per inch of width where untreated cotton belts leave off, up to 25,000 pounds per inch of width is possible. The strongest such belt made so far is one using $\frac{5}{32}$″ 7 x 7 aircraft cable which has a strength of approximately 17,000 lbs per inch width.

The tension at which such belts can be operated depends upon the frequency and severity of bending around pulleys. Under ordinary conditions of conveyor operation, maximum operating tensions in the range of 15 to 20 percent of the ultimate strength are used. As pulleys become smaller and belt speeds greater in transmission use relatively lower operating tensions are necessary to assure normal belt life.

It is frequently true that the limit of operating tension which can be assigned to a steel cable belt is not dictated by strength or bending of the cable itself but rather by other components of the belt.

Advanages of steel cable belt are:

A. Strength.

The outstanding advantage of steel cable conveyor belting is of strength beyond that of any textile reinforced belt of practical proportion. In conventional belts of ply type construction the thickness and stiffness builds up almost directly with strength. There is a definite limit on strength for each belt width in conventional plied belts since the thickness must be kept in proportion to width to permit transverse flexibility for troughing. In steel cable belts longitudinal strength and transverse flexibility can be controlled independently in belt design, thus removing a limitation on strength. This greater strength permits longer centers and higher lifts eliminating the hazard and cost of transferring material from one flight to another. Lifts up to 400 feet vertically on inclined conveyors handling relatively light material such as coal are now about the limit for untreated cotton constructoin. Steel cable belts have immediately doubled this lift and are handling still more difficult slopes.

B. Length Stability

Fabric belts change length with tension and moisture content and gradually grow or permanently elongate. In most cases the net result is a lengthening belt but in some cases, due to increased moisture content, a belt will diminish in length or shrink. It is is not always possible to predict which will occur. Length changes of 2% or 40 feet of belt in a 1000 foot C C convyeor are not an impossibility.

Steel belts change so little in length due to change in tension, moisture or temperature that stretch or shrink is negligible. The steel cable conveyor belt at the Morris Mine elongated only 0.05 of 1% in 6 years of operation.

C. Tension Induced by Bending

Belts built up of plies of textile material such as cotton puts the designer in the middle. He wants a high modulus material to minimize length changes in the belt as tension changes occur. When a section of the belt approaches the head pulley under high tension its outer plies must elongate with respect to the inner plies and in so doing build up tensions in themselves which are greater as the modulus of the ply fabric is made higher. Thus, the fabric or tire cord plies are a compromise and become an increasingly difficult compromise as stronger belts of greater number of plies are required.

Cotton belts in which the load is carried in a single layer of large ropes provided a way out by practically eliminating tensions due to bending, but the strength of such a belt is limited by the loss of tensile efficiency in unusually large textile ropes.

The steel cable belt takes over this single layer principle. In fact, such a high modulus material could not possibly be made on the multiple ply principle and extends the tension capacity far beyond the strongest cotton belts.

D. Inspection

Inspection of cotton belts in service depends upon more or less expert interpretation of surface indications of what is taking place in the carcass. This can be a very revealing method of inspection when practiced by conveyor operators of long experience. One conveyor operation has repair men who can actually spot incipient ply separation by cover appearance before deterioration has become an actual separation. As a general thing, however, users of conveyor belts are not able to determine the condition of a belt carcass with much certainty.

The steel cable belt lends itself to more precise examination by means of a fluoroscope. With this apparatus the X-Ray shadow of each steel cable is visible on a screen and can be photographed. Thus, any damage or breaks in cables can be detected and repaired.

Splicing of steel cable transmission and conveyor belting in the field is practical and successful. Early efforts were mainly in the direction of socketing cable ends in various fittings or in making the usual short cable splice in the individual cables. With the present small cables and the large number of them placed in wide belts both of these methods are usually impractical. With larger cables a modified cable splice in individual cables was used in at least one case.

The most practical splice is one devised for single layer cotton rope belts and is now adapted to steel cables. In this splice the ropes or cables themselves are not joined but simply lie side by side when mating ends are meshed. The tension in one cable end is transferred to an adjacent group of cables through a thin layer of rubber compound in shear, and in a zone further along the belt transferred back again to the opposite end of the original cable. Each of the cables in the transfer group is handled the same way at a separate zone in the splice. Thus, all the cable ends are dispersed through the region of the splice in a calculated manner. The extent of this disposal of ends determines the strength of the splice. It can be carried to almost any extreme but usually a splice length of 6 to 8 feet providing a strength of 80% of the balance of the belt proved satisfactory. This splice is stronger than splices in plied belts. In addition it is much more durable in bending since all of its joints are in a single plane and are relieved of tensions due to bending which are destructive to plied belt splices.

E. Design Features

One of the most frequent questions proposed in a discussion of steel cable belts is that the cables may not stand the repeated bending around the pulleys. This was thoroughly investigated, but even without that, it is obvious the cables running over pulleys 500 to 100 times the cable diameter at intervals exceeding 5 minutes does not present a serious problem. Of course, cables running over pulleys 100 times their own diameter or less and at belt speeds of 8000 feet per minute as in the case of transmission belting are another problem. Even so by adjusting allowable tension used in designing to compensate for pulley diameter reduction such drives can be handled. Cable tension has a very rapid effect on life on a pulley of given diameter. Another question stems from the belief that steel cables will cut down through the supporting rubber compound. This will happen if the bond between rubber and steel fails and if radial pressure is high enough. With good bonding and proper relation between cable tension and pulley diameter this is no problem.

Conditions which require vertical curves and transition from troughed to flat in conveyor or those requiring edges of a belt to be longer than the center or vice versa must be more precisely engineered than in cotton belts because the high modulus of the steel cable belt makes uneven distribution of tension across belt width more serious.

By using a more conservative curve length, however, and by more gradually flattening the belt approach to the pulleys the maldistribution of tension can be kept within allowable limits.

The appication which gave the steel conveyor its start is an installation such as at the Morris Mine. Underground coal mining, quarries and open pit mines have very large quantities of bulk material to raise to the surface. Belts were long recognized as a most reliable, safe and economical means of transport here. But with very high belts and particularly with heavy material such as iron ore the tension in the belt built up so rapidly that it was necessary to design the conveyor into several units or flights. The transfer of material from one unit to another adds cost in the form of terminal machinery. In many cases an attendant is required at the transfer point. The tension capacity of the steel cable conveyor belt makes it possible to handle almost any slope or a single conveyor without transfer, attendants, and hazard to the belt from pit to loading pocket.

Steel cable elevator belts also are being operated successfully and in many instances are replacing the steel link type especially in connection with Chance-Cone equipment.

The economics of belt design long fixed by the unique position of cotton are now astir under the influence of increasing cotton cost, and high production with lowering cost of other fibers such as rayon. Now with cotton being disturbed for the first time comes an opportunity for steel cable to establish itself with the lower cost per unit of belt strength in addition to its other advantages and take a substantial place in the expanding production of conveyor and other belting.

The outstanding steel cable slope conveyor belt installation in this country is that of the Chicago, Wilmington and Franklin Coal Company at the Orient No. 3 Mine and details of this installation follow:

The highest belt conveyor in the world is at the Chicago, Wilmington & Franklin's Orient No. 3 Mine at Waltonville, Illinois. This belt conveyor which carries 1200 tons of coal per hour is the means of escape for a mine located over 800 feet below the surface. In fact, the actual lift of the conveyor, that is, the vertical distance from the tail pulley to the head pulley, is 868′ 7¼″, over ten stories higher than the Golden Gate Bridge Tower. To accomplish this high lift, the material on the belt must travel 3,290 feet along the slope carrying the coal at a speed of 625 feet per minute. The belt will thus completely unload itself in 5¼ minutes if it weren't being continuously loaded down in the mine.

To give an idea of how tremendous a production 1200 tons per hours is, it would take 24 gondola cars fully loaded every hour to equate to this capacity. When this huge tonnage is added to the fact that the coal has to be lifted as high as it does, it can readily be seen why this belt conveyor is one of the transportation marvels of our time.

To master this enormous lift and to successfully carry such a large tonnage continuously was a problem which most normal belt materials could not handle. (Over 40 plies untreated 42 oz. cotton duck would be needed.) This belt had to be designed in steel to handle the tensions created by the big lift and the design load is approximately 90,000 pounds of tension.

The conveyor belt is the strongest 42″ belt in the world. No other 42″ belt in operation today could successfully climb this steep slope.

A belt with the same strength, carrying the same tonnage, and traveling at the same speed, could carry its material a distance of 4.18 miles if the conveyor were on level terrain. The longest single conveyor belt in the world today travels a distance of 2.06 miles.

While designing a belt to carry huge tensions over a long distance (there are actually 6563 feet of belt in this one conveyor) the problem of stretch is very important.

The allowance made for take-up on this long length of belt is only 25 feet of counterweight travel and only a small portion of this 25 feet will ever be utilized.

Since the steel cables are laid side by side, they do not have enough traverse rigidity in themselves to produce a belt with the proper troughing characteristics. Therefore, 10,510 sq. yards of fabric had to be included to supply this transverse stiffness, and also to act as a protective covering around the steel cables. This is 23,648 pounds of fabric, or almost 12 tons of the belt's weight. The covers of the belt are composed of 75,292 pounds of rubber. The balance of the belt's weight is created by the steel cables and the neoprene bonding agent. There are 240 cables $\frac{5}{32}$″ in diameter in the cross section.

If these cables were laid end to end, there would be one continuous cable reaching 303 miles, or the distance from the mine itself through Chicago and up into Kenosha, Wisconsin. If the cable were broken down into its finer wires, they could be stretched over half way around the world, a distance of 14,847 miles.

The total weight of the belt is 89½ tons, and there are 105 tons of coal on the belt at any time when it is fully loaded. This entire load is moved 625 feet per minute by a 1500 horsepower synchronous motor driving the belt through an eddy current clutch.

A notable design feature in a belt of this size is the choice of a head pulley. The usual belt conveyor has a head pulley large enough to allow the loss of life of the belt's carcass due to flexing to become so small it is negligible. This is not the case in a steel cable belt. Here, a much smaller head pulley than the 72" pulley being used would still be large enough to be sure the belt does not lose any life due to flexing. The size of this pulley is determined by the pressure of the belt against the pulley face. If the face pressure of the the strength carrying members were too large, the steel cables could pull through the belt. Therefore, a 72" head pulley which gives an adequate safety factor in the face pressure is used.

In comparison, if an attempt had been made to use the 40 plies of 42 oz. duck, there would be required a head puley 262" in diameter in order not to limit the belt's life by flexing.

Some interesting information regarding the actual installation is included here.

There were 8 rolls of the belting approximately or averaging 843 feet each. The shipping weight of each roll was about 22,000 pounds or 11 tons.

The handling of the belting was materially facilitated by the use of the company's 100 ton crane. Although larger than actually required the operation was not slowed down by its use.

Four rolls of the belting were run in on the return side of the conveyor and 4 rolls on the top side. Five sets of specially designed clamps were used to regulate the feed the belting into the slope and to hold in place for vucanizing.

All splices except one were made on the outside about 100 feet from and in line with the slope mouth. The last splice was made at the bottom of the slope near the tail pulley.

Approximately two hours were required for handling, mounting on the shaft and uncrating each roll.

It took a little less than one hour to feed each roll into the conveyor structure.

Preparing the belt ends for the splice, removing top cover, buffing and readying for the cementing required approximately 18 hours.

Each splice is over 12 feet long and 6 heats were required for each one. The time used was about 11 hours each.

A Summary of the time required is given in the table below.

Handling and uncrating belt	2 hours
Feeding into slope	1 hour
Preparing belt ends	18 hours
Vulcanizing	11 hours
Total	32 hours

per length or less than 200 hours for completing the project.

The number of men required would vary of course with each operation but there were from 2 to 12 men required for various periods depending upon the particular work being done.

So much for the formal presentation of the paper. I have gathered that there are to be some questions asked – probably it will be a cross examination, and I will remain here until I can attempt to answer any questions which you might have in regard to the installation of the C. W. & F. belt.

Chairman Miller: Thank you, Mr. Thornton. I am sure there must be some questions on this one. Now we are ready for them. Again, please state your name and affiliation when you ask a question.

Mr. Read: I would like to know whether the head pulley on this belt conveyor is rubber covered or not.

Mr. Thornton: It is lagged, yes.

Chairman Miller: Are there any other questions?

Well, there are at least two things I believe you might like to know about this particuar installation, at C. W. & F., Number 3. First of all, the take-up moves from 6 to 8 inches, when the belt is started either under load or empty, in the total length of the belt of the conveyor.

The second thing, a couple of weeks ago the belt technician fluoroscoped the splices and found them to be just as they were originally.

Mr. Thornton: Certainly it has been a privilege to appear before you today and I hope that you have gotten something from this presentation.

* * *

Chairman Miller: Thank you again, Mr. Thornton.

I do not know how many of you feel about the question that is presented in the next paper about to be given, but I frankly admit that in a few times past when we were sitting up with a sick loading machine or something else about the property, or even a wildcat, we wondered what our years of study at the university meant to us. Mr. Rodney D. Caudle, Graduate Student in Mining Engineering of the University of Illinois will now tell you what they mean to him, that is, "What My Years of Study at the University Mean to Me." Mr. Caudle.

WHAT MY YEARS OF STUDY AT THE UNIVERSITY MEAN TO ME

By RODNEY D. CAUDLE
Graduate Student, Mining Engineering
University of Illinois
Urbana, Illinois

Mr. Chairman, Gentlemen: It gives me great pleasure to be able to speak before so distinguished a body. I might go so far as to say that it gives me great pleasure to talk anywhere, any time, any place, about anything, as anyone who has ever had to bear with me will readily tell you. I suppose college education is the one subject which I enjoy talking about most.

I don't quite understand why I have been chosen to reveal the profound secrets of my college education. Surely not just because I'm gabby, and certainly not because of any tremendous professional drive such as has been evidenced by some of the University's recent graduates. I give you as an example, one of our recent graduates who has stepped into an important position in a rather unusual industry. He is at present working in a bloomer factory, pulling down three thousand a year. I believe that is just about the ultimate in professional initiative. I really don't know why he isn't here today, probably tied up in his work.

Unfortunately, I can't speak to you about my accomplishments in the professional world and heap credit upon my former instructors. Instead I will have to moan about my failures in research for which I blame everything under the sun. Instead of going out into the world as every other wide-awake young hero had done before me, I decided to stay behind for awhile and see just what goes with this teaching and research racket. That's how I became a graduate student. I suppose you all recognize a graduate student when you see one. He's a hunchbacked introvert with specs, a stack of books, who's ready to rattle off statistics on any subject at a moment's notice. As further means of identification, you'll find that his wife is his sole means of support. As far as I can determine, a graduate student remains such until death separates him from his textbooks.

In general, I believe that college means about the same thing to me that it means to 95 out of a 100 other college graduates. There are always a few people who discover at the last moment that college was not meant for them, and then there is at least one character, who, if he's truthful, will tell you that college didn't mean *anything at all* to him.

What he really means is that he doesn't remember anything at all about college, and rightfully not, he was probably unconscious from the date of entrance exams until the commencement day exercises.

I think that the four years I spent at the University preparing for a degree in Mining Engineering were the most worthwhile years of my life. I might add that I believe they were also the most enjoyable years too. They certainly seemed to fly by the fastest.

I believe that college training has helped me immeasurely by forcing me to extract capabilities from the old grey matter. The first axiom of present college training, or so educators say, is: "The University teaches you to think!" I agree with the sentiment, but it does seem they went a bit overboard. If that is true, just what was I doing in those years before I came to college? What about all of those poor innocents out in government and industry who never had the benefit of college training? I think I woud go right along with the educator if he would say, "College training may improve your thinking," and let it go at that. I certainly feel that four years of college study have sharpened me up a bit.

People repeatedly remark that college is as different from high school as night and day. It was certainly so in my case. In high school, good grades were not too hard to come by, and the teacher's main concern was in keeping the number of failures at a minimum. In college, a different situation was found. Competition was fierce, grades were given strictly according to abilities, and the whole training program had an impersonal coloring. Class room time added up to slightly less than in high school, but preparation for classes took more than was dreamed of in high school. The tempo was much faster, and the work increasingly more difficult. It seemed that a whole lifetime of studies had been packed in four short years. There is no wonder a student's speed of thinking, accuracy of thinking, and orderliness of thinking were all improved. It was either this or be left by the wayside. These changes all helped to improve the utilization of the grey matter.

It must be granted that all of these improvements could have occurred in people who had never gone to college, usually as a result of the rigorous demands of their work upon their mental capacities. However, the majority of people are employed in physical labor, and their greatest mental exertion of the day comes when they try to think of a name vile enough to call the guy who creased their fender in the parking lot. It is fairly clear that such an occupation is not likely to lead to mental dexterity. Offhand, we might say that the physical laborer should be quite contented with his lot. He makes a good salary, that is as good as a large number of the college graduates themselves. But such is not the case. The fact that he sends his children to college, if he is able, should be an indication of the light in which the laborer considers college training. The man in industry realizes that although it is possible for him to rise to the heights of his profession by advancing from the ranks, the road is often much shorter for the college graduate. I believe one of the reasons is that the student is forced by his studies to extend himself mentally, whereas a worker struggling to get ahead too often finds himself stagnating because his work does not tax his mental capabilities.

College taught me the one thing which is taken for granted in grade schools from the fourth grade up. That is, the ability to read. No, I don't mean French, German, or any of the Dead Languages. I mean just plain old textbook English. When I entered college I was in the same boat with the majority of others. Dick Tracy was my favorite light reading, and as for technical articles, I had never gotten beyond Ripley's corner. New developments and research were obtained from a subscription to Popular Mechanics. Oh, I was quite secure, or so I thought, in my ability to read. But I soon learned differently. Every day study in college involves reading textbooks of a technical nature, often with print of uncomfortable size, cluttered up with fantastic mathematical formulae, in obtaining a concept of what is going on. College study also involves at various times the review of large volumes of highly technical works, and condensation of the same. This requires that the student develop the knack of reading at high speed, discarding the extraneous material and retaining the important facts.

I soon found that success in college does not come merely with speed of thought. Those two old standbys, accuracy and orderliness of thought, are necessary also to get the right answers in the least amount of time.

Lastly, college study packed the old grey matter with all kinds of facts. A lot of them seeped right out again, and I suspect myself of possessing a slow leak, but the down-to-earth basic facts are still there, and I hope they are there to stay. I mean the basic mathematics and physics which we have pounded into us in different courses— those items which are used quite commonly by engineers in their everyday work. When I stowed away all of that material, I stashed information on how to use it and where to find more, in the same place. It is for this reason that most college graduates display confidence in their ability to solve problems unlike any they have previously encountered. They know the fundamental principles underlying the problem, or they know where to go to find them, and they know how to take these basic facts and from them derive the solution.

It has long been the feeling of engineering educators that these basic mathematical and physical principles can be used to build a firm foundation for all of the problems of the engineering phases. In the case of mining engineering it has not been easy to do this. I have seen many of the basic components of mining explained by simple physical laws and related by exact mathematical formulae. This means that mining can be expressed (only to a limted extent at present) as an exact science, taking the place of the old mysterious principles of mining based upon proven practice, without a true insight as to why they worked. The actual mining engineering instruction to me meant a throwing together of the material from three other engineering groups, civil, mechanical, and electrical, and the application of that material to mining problems. In general, this did not mean the teaching of a definite mining practice such as found in one certain mine, but the principles underlying all mining practices. It was felt that specific mining practices could be best taught to the student upon graduation, at the mine of his employment. I feel that this stage of my college training furnished me with the equipment for solving problems in mining engineering by the use of engineering principles. Where problems are not easily solvable by the accepted basic principles, I have the necessary information to locate similar cases and determine what a proven method of solution has been.

I think the crowning addition to the store of knowledge I accumulated during my four years in college came during the summer months when I was employed by mining companies. It enabled me to learn the so-called practical side of mining. It showed me the limitations of my college training. It let me recognize some of the things which I knew previously only from books, and it made me familiar with that one quantity which is impossible to describe in literature, manpower. It brought home to me the vast difference which exists between a Mining Engineer and any other form of engineering.

As I have said previously, I think my four years of college training was worth every minute of it. I believe that once having entered industry, my college training will help me move ahead of the fellow who went directly from high school into industry, even though he will have four years more practical experience than I. No matter what my position, however, I fear that even more important than my college training will be my ability to do the job, and that's why I went to college in the first place.

* * *

Chairman Miller: Thank you very much, Mr. Caudle, for those very refreshing remarks. I think you have developed a philosophy that will carry you along the way to success, without any doubt. There is one thing that I think might be helpful to you if you recognize it now, and that is, when you go out into industry you have something to trade, which is essential. You have technical training, and if you are willing to trade that technical training with the fellow next to you who has not had the benefit of such training but who has had the experience, the two of you will make a good team and you will both get along just swell. Best of luck to you, Mr. Caudle.

Does anyone have any questions he would like to ask Mr. Caudle? If not, we will proceed to our next paper which is labeled "Flash! A Representative of the Defense Solid Fuels Administration will make a special trip from Washington to attend our meeting and address our members on timely problems."

We are fortunate indeed this morning to have with us Mr. Charles Connor, Director of the Defense Solid Fuels Administration, who will address our membership at this time. Mr. Connor.

Mr. Connor: I am happy to be with you on this occasion. I have read for years of the excellent accomplishments of this Institute, and as I know some of the members here, I am not surprised that that is the result of your labor.

Many of you who know me know that ostensibly I retired on July 10th, 1950, and succeeded in making that retirement effective for about two months. Then the coal industry requested me to take over the direction of the Defense Soid Fuels Administration, which I was very glad to do because I felt that it was in the interest of the defense effort and it was within my capabilities to do a good job and I was willing to offer my services.

I am often asked, "How do you like Washington?" and I never fail to tell the story about the fellow driving to his office every morning who had occasion to pass by the insane asylum, and as he went by through the fence that surrounded the grounds he could see a fellow in there going through all of the motions of a baseball pitcher. He would bend over and pick up the signal and pull his pants up and pull his cap down and rub the invisible ball in the palm of his hand and he would wind up and deliver a terrific throw to a catcher who was not there.

A friend of this man's asked him, "Why do you stop there for five or ten minutes every morning to watch that nut going through his antics?" and the reply was, "Well, if things go on the way they have recently, it won't be long before I'll be down here catching for that guy and I want to get on to his curves."

As a bureaucrat I am only an amateur and have no desire to become a professional. I think the majority of the people in our administration feel the same way about it and the sooner we can wind up our jobs and get back to our usual work the better satisfied we will be, and I hope that will not be in the too far distant future.

I think we have lined up a very efficient organization. I think the men we have at the head of our different divisions are experts in their lines, and I believe that we have done for the industry a good job according to our abilities and the materials which we have been accorded to do it with.

Today I am not going to talk to you about the detail of the work that the Defense Solid Fuels Administration is doing; I am going to revert a little bit towards some matters which might be considered policy. I do have with me today a couple of gentlemen who are prepared and I am sure can answer any questions you would care to ask them and I would like to introduce them. Mr. William Hahman, Deputy Administrator of the Solid Fuels Administration, and a gentleman who I think is known to most of you, the head of our Equipment and Materials Division, Mr. Clyde Woosley. Thank you.

IMPORTANT ASPECTS OF DEFENSE MOBILIZATION OF SOLID FUELS

By CHARLES W. CONNOR
Administrator, Defense Solid Fuels Administration
Washington, D. C.

I am happy to have this opportunity to discuss with you some of the vital aspects of our defense mobilization of solid fuels. I am particularly happy to talk to the members of the Illinois Mining Institute at this 59th annual meeting since as forward-looking representatives of the mining industry you are in a position to aid us directly in reaching our important defense goals. The mining industry in Illinois has already been called upon for many contributions to our new, and growing defense needs, in solid fuels as well as other mining fieds. Just as I am sure that you will be called upon for many additional contributions, I am also confident that you will respond with the same alert cooperation that you have demonstrated in the past.

Today, I should like to discuss two aspects of our defense requirements for solid fuels which are of rapidly increasing significance. First, I should like to outline for you the expanding demand for coal being created by the need to maintain an effective balance between energy fuel resources and their use. Second, I should like to outline the potential role of coal in the new program for synthetic fuel production which is being currently developed.

I believe that today we are witnessing a broadening recognition throughout Government as well as private industry that coal is becoming more and more important in meeting our defense demands for energy and power.

The importance of promoting the use of coal in order to conserve the supplies of other fuels has been increasingly recognized in this emergency period because while our reserves of other fuels have limitations, coal is in abundant reserve. Coal, in fact, constitutes about 98 per cent of the Nation's mineral fuel reserves.

Paradoxically, the trend in fuel consumption has been advancing with the greatest rapidity in those fields in which our reserve position is relatively weak in terms of sustained productivity. The continuation of this accelerating trend poses a dangerous situation in this period of defense mobilization. The fundamental philosophy of our entire rearmament effort demands that we be prepared for any emergency. It also demands that we be prepared to supply the tremendous fuel requirements of all-out mobilization over a sustained period. The limited nature of our domestic petroleum reserves, together with the uncertainty as to the availability of oil imports under emergency conditions, underline the importance of coal as our largest fuel resource. Today, as a matter of fact, it is clear that, even under the present mobilization program the United States requires oil imports of from 850,000 to 930,000 barrels a day.

It is also important to recognize that the production of coal can be expanded quickly and at a relatively small cost in terms of the amounts of scarce materials and equipment which would be needed.

Many agencies of Government concerned with the defense effort have recognized the urgency of giving first consideration to coal in meeting new defense needs. Early in June, for example, the Office of Price Stabilization declared that with the prospect of an acute supply situation developing this winter for residual fuel oil, it is desirable and urgent that industrial establishments, which are equipped to use coal through existing stand-by facilities, maximize such use. The OPS estimated that more than twenty-million barrels of residual fuel oil a year might be saved through such conversions. Similarly, in recognition of the fact that coal is the Nation's largest fuel resource, the munitions board has urged that coal be employed as far as practicable at all military facilities—both command and industrial.

A critical shortage of natural gas supplies also looms in some regions which has resulted in action by the Petroleum Administration for Defense barring distributors in some areas from supplying new space heating customers and new large volume consumers. Ironically, however, much of our natural gas fuel reserve is being shipped to areas where an abundant coal supply is readily available.

The gravity of the fuel situation has already resulted in such widespread concern for the national welfare that the Senate Committee on Interior and Insular Affairs is making a searching study of our national energy needs. This study includes consideration of the establishment of national fuels policy. There is no question of the need for collaboration of all concerned toward the development and maintenance of an effective balance between our energy fuel resources and their use.

If our national heritage in the field of energy resources is to be protected during this period of defense mobilization, we must establish a policy of wise use of our fuel resources, rather than one of short-term exploitation without regard for either the demands of all-out war or of long-term needs.

We must not endanger the future of our country by unwise policies which would lead to the rapid exhaustion of those fuels of which we have only limited reserves. For this reason, I believe it is in the public interest to expand the use of coal wherever practicable since our reserves of coal are relatively unlimited, comprising well over a 1,000 years supply.

It is with these same considerations in mind that the Defense Solid Fuels Administration is supporting the program for synthetic fuels production which has been proposed by Secretary of the Interior Oscar L. Chapman.

The Department of the Interior has been authorized by Congress to conduct extensive tests into the production of critically needed chemicals and liquid fuels from coal, lignite, and shale.

Very recently an experimental run was completed at the coal hydrogenation demonstration plant of the Bureau of Mines at Louisiana, Mo., at which more than 44 railroad-car loads of Illinois coal were converted to synthetic oil. This operation, characterized as highly successful by Bureau of Mines officials, resulted in the yield of 8,000 barrels of synthetic oil, or 3.15 barrels of oil for each ton of moisture free coal processed. More than 300,000 gallons of high quality liquid fuels produced at the plant have met severe military tests.

The studies of the Bureau of Mines over nearly a three-year period have brought out one point of major importance in the present emergency. The amount of steel required for initial construction per barrel per day of gasoline is about the same for coal hydrogenation as for petroleum. Also, if the coal hydrogenation plant is used for 20 years, the actual amount of steel consumed per barrel of product made is less than that required for petroleum.

On the basis of sustained production over a period of years steel requirements for coal hydrogenation, including the coal mine requirements, are about 2.8 pounds of steel for each barrel of product made, whereas for petroleum, including crude production as well as refining, about 4.6 pounds of steel are required per barrel of product.

Favorable economic conditions for the construction and operation of coal hydrogenation plants are increased by the fact that along with gasoline these plants can produce a high percentage of aromatic chemicals, most of which are in short supply and critically needed in our defense effort. As Secretary Chapman has pointed out, a total hydrogenation capacity of 30,000 barrels a day would increase the country's benzene production by about 20 per cent, its phenol output by about 11 per cent, and provide substantial amounts of toluene and xylenes for aviation fuels, as well as a new source of motor gasoline and liquified petroleum gas.

As you gentlemen may know, the Department has received one tentative proposal for the establishment of a synthetic fuel plant which calls for the use of Illinois coal. I understand that some negotiations have already been held between the individuals planning this synthetic fuel plant and Illinois coal interests with a view to working out feasible coal supply arrangements. According to surveys available, recoverable coal deposits in Illinois, suitable for conversion, are equivalent to 34 billion barrels of synthetic liquid fuels. The extent of the contribution which coal can make to the liquid fuels program is graphically illustrated by the fact that this amount is substantially larger than our total currently estimated domestic crude oil reserves of about 25 billion barrels.

An important step toward the commercial production of critical aromatic chemicals and gasoline by the hydrogenation of coal may result from the commercial pilot plant for coal hydrogenation being constructed by the Union Carbide and Carbon Corporation of New York City at Institute, West Virginia.

The Union Carbide and Carbon Corporation submitted an application for a certificate of accelerated tax amortization of the plant which was reviewed by the Defense Solid Fuels Administration. After an intensive investigation of the company's application by technicians of DSFA and the Bureau of Mines, I recommended to Secretary Chapman that the application be approved. He agreed with my recommendation as did DPA which recently issued a tax amortization certificate for the plant.

The new plant, estimated to cost about $11,000,000, will be the only one of its kind in the United States. Operation of the plant will result in increased production of such critical materials as pitch coke, napthalene, solvent naptha, coal tars, tar acids, special carbons, light oils, benzene toluene, and, at the same time, research and development will continue.

Various types of coal will be used in the research and development phase of the operation. The result of this work should broaden the technical knowledge of the coal hydrogenation process which is of great importance to the development of a synthetic fuels industry. The rise of a synthetic fuels industry making use of the coal hydrogenation process will, of course, greatly broaden the uses of bituminous coal. I believe, as a matter of fact, that we should all realize that as the need for synthetic fuels grows—and it may grow with great rapidity in a relatively short time—that a greatly increased demand for coal will result, not in one, but in virtually all coal producing areas.

Representatives of the coal industry have asserted that, coal production from existing mines can be readily expanded to meet the needs of new synthetic fuel plants using the coal hydrogenation process.

They believe that the new synthetic plants can be strategically located in representative sections of the coal producing areas of the United States where coal in all types, sizes, and grades can be made available for continued research.

Another proposal of interest in the over-all fuels picture has been made by Frederic O. Hess, former president of the Gas Appliance Manufacturers Association. Mr. Hess has pointed out that at present the gas industry is unabe to meet the demands for gas heating in millions of projected new homes. The solution, he indicates, could lie in the building of conversion plants to extract from coal a gas to be mixed with natural gas. Mr. Hess believes this would augment supply, improve combustion performance, and provide an interchange stand-by gas that would perform uniformly throughout a large area.

The Defense Solid Fuels Administration is keenly interested in the increased demand for coal which may result from the proposed construction of fuel-fired electric plants in the Pacific Northwest to help overcome the critical power shortage in that area. The House Committee on Public Works has recommended approval of legislation which would authorize construction of three steam-electric plants having a capacity of 100,000 kilowatts each, as well as five gas turbine electric plants.

The Committee reported that considerable attention was given in the course of the hearings to fuel supply problems in the Pacific Northwest during periods of emergency. The Bonneville Power Administration has already undertaken preliminary study of the possibility of using local coals. In any event, the Committee reported, it is clear that the plants will be designed with a view to the possible use of solid fuels from local or other sources.

Another important coal development which looms on the horizon involves the use of coal in the production of hydrogen for use in the manufacture of ammonia. The Department of Agriculture is currently discussing with the Department of the Interior a proposal for interdepartmental investigation in this field. Future use of nitrogen fertilizer is calculated in terms of hundreds of thousands of tons, and possibly within a few decades in millions of tons, so that the development of facilities using coal as the raw material to produce ammonia is being actively considered. This is particularly true since at the present time the production of nitrogen fixation for fertilizer is limited to the southern natural gas area, from which shipping costs to grain growing areas are high in terms of the greatly increased use expected.

I believe that the amazing growth of the electric power industry will increasingly lead to augmented use of coal to turn the dynamos of the country's utilities. In the TVA area, for example, the need for electricity on a huge scale in connection with atomic energy projects, plus heavily increasing demands resulting from the expanding industrialization of the TVA area, has led to a vast program for steam-generated power. It is reported that when all the new proposed TVA plants are completed, TVA's annual coal consumption may reach close to ten million tons annually. In 1954, for example, it is estimated that TVA's coal requirements will total over eight million tons, as compared to the current annual average of about 900,000 tons.

Similar developments may be expected in other areas of the country as the Nation's utilities expand over the next 15 years.

In this connection, the coal-burning gas turbine offers great promise as a driving unit for electric generators to supply power for firming hydroelectric power, and for operation in arid or semiarid areas, where there are nearby sources of coal. The only water requirement in the entire fuel-to-electricity cycle with the gas turbine is cooling water for the lubricating oils, and since this small amount of water can be recirculated and cooled in spray-ponds, the actual water consumption is negligible. Use of this equipment in arid regions of the West would conserve water for irrigation and other uses while supplying additional needed generating capacity.

Up to the present time, the major development work in connection with the use of coal as fuel for the gas turbine has been the work of the Locomotive Development Committee of Bituminous Coal Research, Incorporated. This group now has under test a 4,250-horsepower gas turbine designed and built especially for locomotive use. As part of this development the Locomotive Development Committee has investigated and has built for use with this locomotive turbine the necessary special auxiliary equipment. This includes coal drying and pulverizing equipment, special pumps to pump the coal under pressure to the combustors, and specially designed combustors, and the necessary ash-removal facilities to permit feeding of clean hot products of combustion to the turbine.

Although the efforts of the Locomotive Development Committee are directed to the development of a coal-burning gas turbine locomotive, the results of their research would be equally applicable to use of the coal-burning gas turbine for stationary power generation in areas where coal is readily available. The application of the coal-burning turbine for this purpose should be easier than its use on locomotives because of the severe space limitations in the locomotive application.

Two other possible methods of using coal as fuel for gas turbines are under investigation. One of these contemplates the use of producer-gas generated under pressure. The gas is cleaned and burned in combustors ahead of the turbine when using the open-cycle turbine, or burned without cleaning in heat exchangers when used with the closed-cycle turbine. The second possibility is the use of the gas from the underground gasification of coal as tested by the Bureau of Mines in connection with its experiment on the underground gasification of coal at Gorgas, Ala.

It will be interesting to see, as these various research programs progress, which of the three possible methods of using coal as fuel for the gas turbine appears to be the best for stationary power generation. However, sufficient progress has been made to indicate that the coal-burning gas turbine offers real promise as a prime mover for electric-power generation, particularly in arid regions and where relatively small units can be used advantageously. At the present time, gas-turbine manufacturers in this country are working in the range of from about 3,500 to 7,500-kw. capacity, but one large manufacturer predicts that units will eventually range in size up to possibly 55,000 kw., which with multiple units would provide any range of power generating capacity desired.

The vital and strategic importance of solid fuels to the health, economic welfare, and security of our Nation is unquestioned. Indispensable in the maintenance of a normal economy, solid fuels are one of the main keys to success in a defense program.

As I have indicated, the problems of maintaining adequate fuel supplies in times of emergency are numerous and complex. Accordingly, we welcome and earnestly seek the cooperation and assistance of all concerned in helping us to foresee, understand, and cope with these problems. Our primary objective is to prevent problems from arising or from becoming more serious, if at all possible, rather than to institute extensive controls.

I feel sure that we can look forward to a continued close working relationship between your institute and its members and the Defense Solid Fuels Administration.

I have greatly enjoyed this opportunity to discuss with you some of the important aspects of the emergency requirements for solid fuels. Our resources of coal and coke alone cannot guarantee victory for democracy in the long struggle ahead for peace and freedom. But lack of them could mean defeat for our cause. It is with this thought in mind that I say that the continued cooperation of all of us in reaching our defense needs for Solid Fuels' production and distribution is of urgent importance.

Chairman Miller: Thank you, Mr. Connor.

I have been asked to make an announcement. Purchasing agents and their assistants are requested to lunch with Mr. Connor and his associates, and they are supposed to meet outside this room immediately after this meeting has adjourned.

Mr. Connor, your address certainly precludes any remarks from this Chairman. However, there may be others who would like to ask Mr. Connor some questions, and I am sure he would be glad to answer them.

If there are no further questions, does anyone else have anything he would like to say about anything that has transpired at this meeting this morning? If not, I will turn the meeting over now to President Stuart Jenkins.

President Jenkins: Thank you, Fred, for your very capable handling of the meeting. I would like to thank all of those who have participated in this program this morning. We will resume the meeting at 2:00 o'clock this afternoon.

(Recessed at 12:30 P.M.)

AFTERNOON SESSION

November 2, 1951

The Friday afternoon session was called to order at 2:10 P.M. by Mr. Robert N. Morris, Chairman.

Chairman Morris: Gentlemen, as President Jenkins is not here, I will open the meeting and we will start the program. I know he will be here shortly. My name is Bob Morris and I am with the Sahara Coal Company and I will serve as Chairman of this afternoon's session. The Illinois Society of Coal Preparation Engineers and Chemists was asked to help in the preparation of this Illinois Mining Institute meeting and we are very happy to contribute to the program.

Our Society is a society of those interested in the control of coal cleaning plants and coal preparation. We meet at the Benton Country Club the third Friday of every month. Our membership is by no means closed and we invite all of you to attend all of our meetings. I think we can give you an interesting program.

This afternoon we are bringing you several papers which I hope will be of interest to you. The first paper on this program is "Heavy Media Coal Preparation Plant Design and Performance," by Mr. R. C. Woodhead of the McNally-Pittsburg Manufacturing Corporation, Pittsburg, Kansas. Mr. Woodhead.

Mr. Woodhead: This topic of heavy media coal preparation plant design and performance is a vast topic. It is almost impossible for me today to go into all of the details involved in the design of such a coal preparation plant. I am going to try to condense this and get down to the basis of the design and that, of course, is the medium which the condensed media processes depend upon. If there are any questions after this meeting I will attempt to answer them. I cannot promise you I can answer all of them, because this is a definitely technical subject and almost requires specialists on each detail and machine in the process itself.

HEAVY MEDIA COAL PREPARATION PLANT DESIGN AND PERFORMANCE

By R. C. WOODHEAD
McNally-Pittsburg Mfg. Corp.
Pittsburg, Kansas

The purpose of my paper is to discuss heavy media coal preparation plant design and to state some of the principals involved in operating characteristics and their application to practice.

The Dense Media separating process is indeed not a new idea. It was tried more than a century ago and has been constantly improved since the first, or nearly first dense media process experiment by Sir Henry Bessemer. In its infancy, the process was used in the preparation of metallic ores more than in coal preparation. It was, however, constantly in front of the coal preparation engineers in their own testing laboratories. It might be stated that economical dense media application has only been successful, particularly in Europe, during the last 15 or 20 years. Here in the United States it is more or less in its infancy, however great strides have been made by American preparation engineers who have designed and successfully operated some very excellent plants. The development of dense media plant design, its process and application, is well known and most of the machinery units involved have probably been used in different ways of mineral dressing for some time during the past. A study of past records of the early plants show that the separating performance and efficiency of these plants is inferior to those of today, and were much more mechanically complicated. All dense media plant designs of today indicate a trend toward simplicity. It is much less complicated than it was in the early days and progress has been rapid.

The development of the simplified and efficient plant is more likely due to extensive study and the application of sound engineering principles than to experimental scientific discovery. A dense media plant is simply a single machine, compromising not only the separating vessel, but the cleaning system for the liquid medium, which entails screening, pumping, thickening, purifying, densimetric control and other smaller details. Each of these problems is a study in itself. No one of them separately is impossible or too difficult to solve, but it is safe to say, the improper assembly of them would surely lead to a very inefficient plant.

The engineers and manufacturers of the United States are all working toward a common end. Whenever a plant of this sort is studied and designed by men of this profession or specialists in the field, they are sure to conclude with an improved and a more efficient plant.

It is possible to design and build a very complicated plant, and it is also possible to make that plant operate efficiently with the aid of the expert who was responsible for its design. However, with the widely varying coal mining methods in use in the United States today, a complicated plant is very likely to fail and require the expert's service to re-adjust it. The plants of today are designed to operate more simply and under a great number of variable conditions with a minimum of supervision and maintenance.

One of the main objects is the selection of suitable equipment for each process stage, to serve as an integral part of the whole circuit. Basically, each of these stages is as important to a dense media plant as the separating vessel itself.

In the design of a heavy media coal preparation plant, we should first consider the separating vessel which is best adapted to handle the feed to be separated. The primary problem of the dense media separating process is to simulate, as nearly as possible, results obtained by laboratory sink-and-float methods. At first it would seem the best process is one in which a separation is made in a quiescent bath by means of a salt solution or organic compound. With a properly designed separating vessel, the medium then becomes the separator and if properly controlled, can be very efficient. Unfortunately, we encounter many difficulties in the use of such media. A true solution or organic compound would result in a high cost of medium recovery losses due to evaporation and absorption of the medium by coal and refuse and corrosion of equipment. The use of inorganic compounds, such as salt solution, present difficulties such as high cost of solution recovery, limitation to low density separations and corrosion of equipment. The accuracy of separation is also reduced by the increased viscosity due to dust pollution and the dissolving of refuse, fire clays and slates.

If these drawbacks are enough to warrant the use of other material, and they are, then we are confronted with other problems. An artificial medium can be prepared by using a suspension of finely ground heavy materials. The application of this medium presents problems both in the separation and the recovery of the medium solids. Finely ground heavy material such as magnetite, spathic iron ore, mill scale ferrocilica, limestone, flue dust and sand must be handled in such a manner that they will not hinder separation by settling out too fast or become excessively viscous.

Some processes use a meduim composed of barytes and clay. In other words, the suspension must remain stable in the bath long enough to permit a density separation. This type of material definitely increases the cost of the medium recovery circuit and also demands a finely ground product for a suspended material.

Other processes, in order to reduce the cost of the medium recovery system, and at the same time keep the viscosity down, have attempted the use of unstable medium materials in a suspension with water. The application of this material involves still more complications, particularly when that medium is left in a quiescent state for any length of time. A certain segregation of medium must take place between the upper and lower areas of the separating vessel. In other words, if the material to be separated contains a near product or near gravity material, it would collect at an intermediate level in the vessel and prevent the rise or fall of the separating material. When this occurs, mechanical means must be employed to remove the near gravity accumulated material. It is sometimes attempted by hydraulic currents. These mechanical methods cause agitation and tend to depart from a true gravity separation.

Most inventors are aware of this fact and concentrate on reducing the settling rates of the heavy medium and still reduce the amount of agitation. The settling rate of the heavy medium can be reduced by (a) increasing the viscosity of the heavy medium, (b) reducing the particle size of the suspension material, and (c) reducing the density of the suspension material. It is obvious that any increase of medium viscosity would reduce the separating precision. Whenever the particle size of the suspension material is reduced, then the medium recovery circuit becomes more costly and less effective. Therefore, by reducing the degree of agitation and turbulence, we increase the cost of recovery of the heavy medium as well as the viscosity of the bath. The high viscosity reduces the settling rate of the heavy medium and at the same time reduces the velocity, or free fall of the migrated material and so impairs the accuracy of separation.

From the above it is then obvious that the design of the dense media plant must revolve itself about, not only the vessel, but the medium recovery circuit and, if it is properly handled, the only control necessary for a high efficiency separation is the control of the density of the medium. We must therefore, design a plant with a degree of accuracy and control almost impossible in other types of washers. For instance, in jigs and launder washers, the separating factors are mechanical and the density of the separation is controlled by many different mechanical empirical adjustments. A good dense media plant is one in which the separating material is passed through a dense or heavy medium without disturbing its normal characteristics.

The suspension itself is a complex fluid. Contained in this medium are finely divided solids of different characteristics, size ranges and densities. The main constituent is, of course, the medium selected for the separation, such as magnetite, mill scale, flue dust, etc., but all these suspensions contain fine coal, fire clay, shale, pyrite and other impurities which are washed off of the coal as it leaves the separating vessel. In the various coal preparation plant design problems, the properties of any one suspension material remain relatively constant, but the contamination of the medium varies considerably with the location. In other words, we must design a regenerating system to control the constituents of the medium.

There are two distinct types of regenerative systems employed in the United States today. They both operate satisfactorily. One is the system of magnetic recovery of the medium, and the other is the gravity, or free settling. The magnetic process is more applicable to processes involving the use of finely ground medium. Gravity, or the free settling process, is applied more frequently in the use of more coarsely ground mediums.

Most of the dense media plants today are used on the coarser fractions of the raw coal feed and generally specify 1/4" for the bottom size. This does not mean it cannot go lower, but the difficulties of medium recovery are increased with the decreasing sizes.

It has been established that the cost of dense media plants is largely dependent upon the amount of equipment used in the regenerative system. This will vary according to the size consist of the coal to be treated. We have learned during the past few years that with proper engineering of regenerative systems, the cost of this part of the process can be considerably reduced. It stands to reason that the amount of equipment involved in the regenerative system would depend upon the volume of material in that system. In other words, it would be the amount of dilute medium coming from all the rinsing screens.

Coal or refuse that has been separated in the bath or vessel, must be sprayed and its adhering medium removed. The degree of removal of this medium is naturally dependent upon the amount and type of spray water used. If the volume of this dilute medium is due to the amount of fresh water used, then it would naturally mean a large overflow out of the plant. This overflow will of course, carry away medium material. We can, however, control the rate of flow away from the plant by using not only fresh water as a spray, but by returning a portion of the dilute medium and another portion of the clarified water from a thickener or settling cone. The best suggested method is then to use a primary wash of a great deal of water, which could very well be dilute medium and should remove the greatest portion of the adhering medium. To further remove medium, we could employ a wash of clarified water. We have not yet added fresh water to the plant. We can then, on our last spray line, use a high pressure spray water system and remove the final traces of adhering medium. This medium collected in a sump, compromises the dilute medium in the dense media plant. It may be recovered, as stated before, either by free settling or by magnetic means.

The medium required for separation in any one vessel is generally of such volume that the greater portion of the medium in the circuit must be recirculated through the separating vessel. The means of recirculation varies with the process, however all of them employ a drainage screen from which the medium is drained from the sinks or floats through some small screen opening, such as 3/4 mm, and that medium recirculated through the bath or separating vessel without any dilution.

If the recirculation of medium is accomplished by pumping it must be done so that no dilution occurs as a result of seal water.

It is obvious that any recirculated medium must be densimetrically controlled. There are several ways in which the recirculated medium may be out of balance. The first cause would be the entrance of water in the vessel with the incoming feed. The second would be improper density of the make-up or return medium, and the third through mechanical devices such as pump seals, etc.

If we are presented with the problem of pre-screening ahead of the separating vessels, we generally use a wet screening method. With this method we have a dilution of the medium in the bath due to the water adhering to the coal. Several processes have a means of density control of this medium. One in particular employs a system in which a portion of the recirculated medium is sent to a small secondary medium classifying cone. This cone will effect a partial thickening. The overflow, while not completely clarified, is very much diluted as compared with the thickened underflow and is delivered to a special mechanism which, through a control apparatus, directs a portion of the diluted material away from the bath circuit. It is possible to visualize a situation where the make-up medium to the bath would be of a density great enough to increase the specific gravity of the recirculated medium. When this happens, the control apparatus, as explained above, instead of removing diluted medium from the classifying cone, will direct clarified water into the bath medium circuit to dilute it.

The above has been mentioned because of the cost of the medium circuit. We must remember that in the design of the plant, not only should it be flexible enough to handle a condition requiring cleaning of the medium, but must also be relatively simple, easily controlled and not too expensive.

Due to the physical and chemical characteristics of magnetite, it is one of the best and most widely used mediums. Since it can be made magnetic, it presents itself for the magnetic recovery circuit, and since its specific gravity is so high, it can be used efficiently in the free settling circuits. Due to the flexibility provided by the high density solid, it has been most generally used, but some progress has been made in the use of cheaper materials of lower density, and we expect more developments in the next few years. The comparisons of high density solids has not yet been made too clear, but should show in the relative cost of medium loss processing and the flexibility of control.

There is a lot of discussion concerning the amount of medium losses and a great deal of study is being applied to reduce these losses. In the amount of medium lost, we should not only be concerned with the efficiency of recovery, but also with the durability of the medium. Supposing there was no loss in the circuit, the degradation of medium solids would ultimately change the character of the suspension to such a degree that the separating vessel would become non-workable. It is, therefore, necessary to reject a very small portion of these degraded solids. From this standpoint it would appear that there is a definite minimum of medium loss and it will be entirely different for different media. In the relatively hard magnetic suspension materials, such as magnetite and ferrosilicon, the rate of sliming and degradation is correspondingly low. Some of the non-magnetic suspension materials used are more friable, but they are necessarily recovered by gravity settling methods which provide continuous purge of the system by permitting the finest slimes to escape with the final plant effluent. It would probably be safe to say the tendency today is to rely, not so much upon the physical type and characteristic of a particular medium solid to produce a given type of liquid medium, but rather to adjust a regenerative system to suit the cricuit in which it is used. It is obvious then, the type of medium selected governs the design of the medium recovery circuit.

We must, of course, consider the type of bath to be used. The bath, or separating vessels, fall into two classes. The deep class, which contains a large body of liquid in which the separation occurs in a central zone more or less vertical, and the effects of displacement smoothed out in the large space available. The small volume vessels are designed for a more effective horizontal separation occuring progressively as the coal advances and tends to use a given volume of medium more effectively. There are many different factors of the two types apart from the actual size, including different methods of handling middlings and sink and float products. The capacities for nearly all types of bath are based upon the surface area provided for the floats. We know that, in float and sink tests, a piece of shale can become trapped in a layer of floats when this layer has a thickness of several particles. We refer to this as mechanical entanglement. If a large size range is to be treated, we see a big difference in the density between the coal and the top liquid.

Another important factor is the introduction of the coal into the bath. If we place raw coal carefully on top of a layer of floating coal, the fine shale particles and all sizes of light shale will have little opportunity to become disengaged from the upper portion of the floats. It is important then for the coal to be placed where no material is being floated. The capacity for any one machine varies, depending upon the velocity of the removal of float coal and the amount of medium in the circuit.

The selection of pumps, or other means of handling fluid containing large or small portions of the medium must be considered. The quantity of heavy medium circulating through the baths varies considerably and the pumping of such quantities of abrasive material presents a problem of wear and tear. Centrifugal pumps of the Wilfley type are used successfully in the recirculation of the heavy medium because of their mechanical seal gland. A great number of dense media plant designers use air lifts wherever possible. It is, of course, not possible to use them on all of the medium handling circuits, since they are more suitable for large quantities and low heads due to the head room requirements. The arrangement of the pumps should be considered to avoid a waste of power. Dense media, of course, required more power than water, under equal conditions.

It is then necessary to go into the problem of bath location to reduce the amount of equipment to suit pump arrangement. The pipe lines in the plant coming from all machines and pumps, particularly those handling heavy medium, must always be installed on a slope in order that the medium will not settle out and plug the pipe. Any valves used in these pump lines or pipes should be selected to give as nearly as possible, a straight, through passage, such as the rubber diaphram or pinch type valve.

It is impossible to discuss in a short time all the factors dealing with dense media plant design, but in short, we might say the character of the medium influences the bath design and dictates the design of the medium purification system. It should be remembered the dense media plant is being installed to simulate actual laboratory sink float processes and do so efficiently and economically. The medium, when properly controlled, is of course a perfect separator, and if the plant is well designed, a high efficiency of performance can be expected.

* * *

Chairman Morris: Are there any questions that you gentlemen would like to ask Mr. Woodhead? If not, thank you very much, Mr. Woodhead.

Proceeding to the next part of the program, we have a series of papers discussing the methods and economics in the recovery of marketable materials from cleaning plant rejects. The first one in this series is a paper entitled "Control of Air and Stream Pollution by Fine Coal and Sulphur Recovery," and it will be presented by Mr. Louis C. McCabe of the U. S. Bureau of Mines, Washington, D. C. Mr. McCabe.

CONTROL OF AIR AND STREAM POLLUTION BY RECOVERY OF FINE COAL AND SULFUR

By LOUIS C. McCABE
Chief, Fuels and Explosives Division, Bureau of Mines
United States Department of the Interior
Washington, D. C.

Increasing attention is being given to problems of air and stream pollution arising from coal-mine wastes. Coal and pyrites discarded in gob piles or in washery refuse may be the source of air and stream polution or both. Finely divided clay from mining or washery operations also may be an additional source of stream pollution.

Sulfur in coal occurs as a sulfide of iron, known as pyrite, marcasite, iron pyrites, "fool's gold," or sulfur balls. In the presence of water and oxygen, the sulfur is oxidized[1] and, still in combination with iron, dissolves in the water as ferrous sulfate or copperas. Under certain conditions the ferrous sulfate is further oxidized to ferric sulfate. The iron is then partly separated as a brownish-yellow sediment, and sulfuric acid remains in the water. Where there is enough limestone in a region, the acid is neutralized almost as rapidly as it is formed, and the water flowing from a mine or the gob pile is neutral or alkaline. Where clays, sandstones, and shales predominate, the waters are usually acid and have no neutralizing effect on pyrite found associated with the mine refuse. Under these conditions, sulfuric acid will be discharged to the stream. When enough sulfuric acid is present to make the stream strongly acid, fish cannot utilize the oxygen from the water and die of suffocation, and plants and microscopic forms of life cannot survive in such water. When the microscopic forms are lost, a stream loses its power of self-purification. Unless treated, acid waters cause corrosion of piping, pumps, boats, bridges, and industrial plants, and domestic and industrial water supply may require additional treatment.

Mine refuse containing pyrite and coal is susceptible to spontaneous combustion, particularly when it is stored on the surface in a manner that permits segregation. When firing occurs, sulfur in the pyrite is oxidized to sulfur dioxide. In the atmosphere some of the sulfur dioxide may be further oxidized to sulfur trioxide, which combines with moisture in the atmosphere to form sulfuric acid. The acid particles form the fog that at times arises from gob piles or refuse banks. The

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[1] "Pilot Plant Study of Neutralization of Acid Drainage from Bituminous Coal Mines," Commonwealth of Pennsylvania, Dept. of Health, Apr. 1951

air-pollution problem in mine waste fires is then one of sulfur dioxide, sulfuric acid, and, when the coal present is burning, smoke.

In Allegheny County and throughout the Appalachian coal mining area generally, gob-pile fires are receiving considerable attention. Between 20 and 25 fires are burning throughout the area, and hundreds of others take fire from time to time. There are numerous records of refuse piles that have been dormant for 20 years, suddenly igniting. Considerable success has been experienced by some mining companies in depositing mine waste horizontally and then compacting it with a bulldozer or trucks. In such cases the edges of the piles are sealed from exposure to the atmosphere by earth. This materially reduces acid release to streams and effectively prevents spontaneous firing of the deposit.

Tom Wurts, Air Pollution Officer of Allegheny County, sent questionnaires to coal-mining companies throughout the United States. The returned questionnaires from companies in Pennsylvania reporting on 383 piles showed that 41 percent were burning and 22 percent had burned out. Only 37 percent were not burning at the present time. The questionnaires from out of the State reporting on 419 gob piles showed that 26 percent were burning, 18 percent had burned out, and 56 percent were not burning.

More attention has been devoted to controlling the flow of silt from the mine to streams in the anthracite region than anywhere else, because it was far more serious there than elsewhere. The problem now appears to be well under control in the anthracite region, and attention is being given to the bituminous-coal silt problem.

Air pollution is generally considered a local problem and subject to such regulations as the local authorities may adopt. Pennsylvania now has State-wide legislation for controlling atmospheric pollution, but this is the exception. Stream pollution is controlled through a number of interstate agreements, each compact embracing a river and its tributaries. The Ohio River compact is one with which you are familiar.

Since June 1948, the Federal Government has been in the water-pollution-control picture.[2] Public Law 845, passed by the 80th Congress is an act to provide for water-pollution-control activities in the Public Health Service of the Federal Security Agency.

This law emphasizes the primary responsibility of the State governments in regulating stream pollution, but it also recognizes the interstate scope of many pollution problems and the need for financial and technical aid in many parts of the country.

Basically the law contains provision for:

(1) The development of comprehensive programs to prevent or abate pollution.

(2) Research in the whole field of water-pollution control.

(3) Construction of sewage and industrial treatment plants.

(4) Financial and technical aid to States, interstate agencies and municipalities, and technical aid to industry; and

[2]Feller, G. and Newman, J., "Industrial Waste Treatment," Industry and Power, June, 1951

(5) Abatement of pollution in interstate waters through legal processes where needed.

The law also empowers the Federal Government to order the abatement of pollution in interstate waters when it creates a nuisance or health hazard in the adjoining State and to support that order with legal action if the occasion arises. The State's authority in this field is carefully protected, and no action can be taken without the consent of the proper State authorities.

The coal-mining industry is thus confronted with the air-and-stream-pollution problems. Where control measures are required, they are certainly less onerous if they can be made to pay their way or at least a part of their way. The only possibility of attaining this – so far as the coal industry is concerned – is by the recovery of pyrite, which may be utilized as a source of sulfur, and through the recovery of fine coal.

The United States consumed about 4,741,000 long tons of sulfur in 1951.[3] In the form of sulfuric acid it was primarily used for fertilizers, chemicals, petroleum refining, paints and pigments, rayon and film, dyes, and iron and steel. In the nonacid uses, it was consumed by the pulp and paper industry, industrial explosives, rubber, chemical, and in miscellaneous categories. A recent projection of sulfur demand to 1975 shows an increase to an annual consumption of 9,872,000 long tons. This forecast supposes a 150-percent increase in the use of sulfuric acid in fertilizers, 200 percent in chemicals, 100 percent in rayon and films, 100 percent in rubber, and 100 percent in chemical and allied uses.

Native sulfur and pyrites supply most of the sulfur used in the world today. The remainder is obtained from fumes of zinc, copper, lead, and nickel smelters, from sour natural gas (containing hydrogen sulfide), from industrial gases (at oil refineries, coke ovens, etc.), and in Europe from anhydrite. Pyrites are recovered not only from pyrite deposits that consist mostly of iron sufide minerals, but are also recovered as a by-product from different types of metalliferous deposits and from washing coal.

It is generally agreed that there are ample reserves of sulfur-bearing minerals in the United States and the rest of the world to supply any probable future demand. However, the bulk of these reserves is contained in deposits that have not been economically workable owing to availability of cheaper high-grade sulfur. Various processes for treating the marginal sulfur sources are available, and further technologic improvements are in progress. The problem therefore is primarily economic, as ample supplies can be obtained if prices advance sufficiently to allow profitable operation of the marginal sources.

Mine or washery refuse may contain 5 to 15 percent sulfur. It occurs as organic sulfur, which is combined with the coal substance, sulfate sulfur and pyrite. The pyrite may be present as nodules (sulfur balls) which can be hand-picked from the refuse relatively free of coal and shale, or it may occur as plates or disseminated through the coal as microscopic particles. The sulfur market requires that pyrite be essentially free of foreign material–for sulfuric acid manufacture the carbon content may not exceed 5 percent.

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[3]Sulfur and Pyrites, U. S. Bureau of Mines, 1950.

Sulfate sulfur most commonly occurs as calcium sulfate or gypsum plates or as crystals in the solid coal. Most freshly mined coal contains only small amounts of sulfate. Pyrite sulfur is the most common form, although organic sulfur predominates in some coals. In mechanical concentration of pyrite, the sulfate and organic sulfur are discarded. Thus it is possible that half or more of the total sulfur is not available in this method of recovery.

Until a few years ago the Midland Electric Coal Co. was using a small Vissac jig at Atkinson, Ill., to recover pyrite. When the new cleaning plant was put in operation in 1949, the equipment for pyrite recovery was removed.

Before the war, the Peabody Coal Co. recovered nodular pyrite from mine refuse at Taylorville. The refuse was run through 1¼-inch trommel screen, and the pyrite was then picked from the oversize material as it passed along a belt.

Early in 1951 a froth-flotation plant was placed in operation by the Island Creek Coal Co. at Holden, W. Va., to recover the minus-28-mesh coal that formerly had been discharged into the creek. About 250 gallons of slurry per minute, containing 19-20 percent solids, is processed in six 44-inch-square cells. The froth is dried in a vacuum filter and the filter cake added to the coarser coal. The tailings from the froth flotation machine may be discharged into the creek or the water recovered in a settling pond. About 7½ tons per hour of metallurgical coal is being recovered that heretofore had been wasted.

The sulfur in coal may be converted in properly designed furnaces to hydrogen sulfide, as is done in coke-oven practice or in a reduction furnace to elemental sulfur. Some experimental work is being done from the chemical-engineering approach at this time. It is expected that, when the refuse is crushed to a size that may be kept in suspension in a fluidized bed and burned, the coal present will supply the hydrogen and heat for the production of hydrogen sulfide. The H_2S may then be processed further to sulfur or sulfuric acid.

There is considerable interest in the recovery of sulfur dioxide from power-plant stacks by ammonia scrubbing to produce ammonium sulfate, sulfur dioxide, or sulfuric acid. With the control equipment now available, this process may be economical for large coal-burning plants. In that case, high-sulfur coals might conceivably be in demand.

The economics of fine coal recovery is more easily assessed where silting of waterways is involved. Spiral concentrators, flotation units, hydroseparators, and other types of equipment have been used successfully in recovery. The reclaimed coal may be dewatered in dewatering basins by stockpiling with vibrating screens, centrifuges, or heat drying.

The economics of sulfur recovery from coal is determined by freight rates and the going price of native sulfur on the Gulf coast. If a mine is so situated with relation to a community that air-and-stream-pollution control is necessary, every possible means available should be employed to make treatment pay its way. At this time it is possible only to recommend a thorough investigaion of the raw materials and the technology available to provide a reliable cost estimate of any air or stream-pollution program.

Some of the other authors on this Symposium will go into these methods of extracting the coal and pyrites. I think methods of one sort or other are available to us when we come to the problem of air and stream pollution but, as I said in the paper, the economics of the matter is rather complicated. At the present time sulphur is selling at $26.00 a ton on the Gulf Coast, and then added to that you have the freight rate. For instance, in California the freight rate is $8.00, so that gives them a $34.00 sulphur price to work against, so then it becomes a matter of assessing whether or not there is a going price in the given market area. It is one that needs evaluation for any particular spot, and obviously if you are near the centers of big sulphur areas it is going to be more important to you than if you are removed from the sulphur market. Thank you.

Chairman Morris: Does anyone here have any questions he might wish to ask Mr. McCabe at this time? If not, we will proceed to the next paper on this Symposium which is entitled "Fine Coal Recovery by Tabling and Flotation." It will be presented by Mr. Raymond Kloepper of the United Electric Coal Companies, DuQuoin, Illinois. Mr. Kloepper.

RECOVERY OF FINE COAL BY FLOTATION AND TABLING

By RAYMOND P. KLOEPPER
United Electric Coal Companies
Fidelity Mine
DuQuoin, Ill.

Froth flotation is commonly described as the separation of mineral particles from each other in a liquid pulp by means of air bubbles. This science of flotation has been practiced for less than fifty years. Coal flotation for recovery of fines had its infancy in European countries with plants in the United States being developed during the last 10-15 years. The post-war period has seen a tremendous expansion of coal flotation not only in the United States but world-wide.

The purpose of my paper is to give you a resume of the coal flotation plant located at the United Electric Coal Companies' Fidelity Mine, DuQuoin, Illinois — to our knowledge, the only one in the North Central States.

During the course of 17 years of washery operation, some two million tons of slurry have accumulated. Sludge disposal area became a problem as well as the possible economy involved in recovering a waste product. A thorough sample of the entire slurry pond was taken and sent to "The Denver Equipment Company," who did the original pilot plant testing; following which a contract was let to the Western Knapp Engineering Company for construction of a froth flotation plant.

Our installation consists of a floating dredge located some 1200′ from the mine washery, the flotation pant itself — adjacent to the washery and a filter plant for processing the clean product located at a stockpile area beyond the washery. A second source of feed being tried at this time is a direct current washery sludge pumped to the flotation plant as the underflow of an 80 foot Dorr Thickener. Future plans for a 24 hour operation include a direct washery feed on the first shift and pond reclamation with the dredge on the second and third shifts.

An eighth inch Morris pump is mounted on the 12′ x 34′ dredge for pumping 60-70 t.p.h. of slurry at 15-20% solids through 1200′ of 8″ cast iron pipe — the vertical lift to the plant being 30′. Pontoons support a lighter spiral steel pipe with flexible hose connections from the bank to the dredge. These same pontoons also support a 4400 volt cable which powers the dredge. A Friday winch provides power for mobility as well as control of the cutting boom with its five-bladed, two foot, rotating cutter. Winch cables anchored to stations to the right and left of the

The Dredge—The 8" discharge line can be seen floating on pontoons on the extreme left—part of the cutter blades can be seen just above the water level in the foreground.

dredge make the swing or dredging arc possible. After a 3-4' arc has been cut to a depth of 8-9' feet, two 8" spuds, mounted at the stern of the dredge, raised and lowered alternately, "Walk" the dredge into the next arc of slurry.

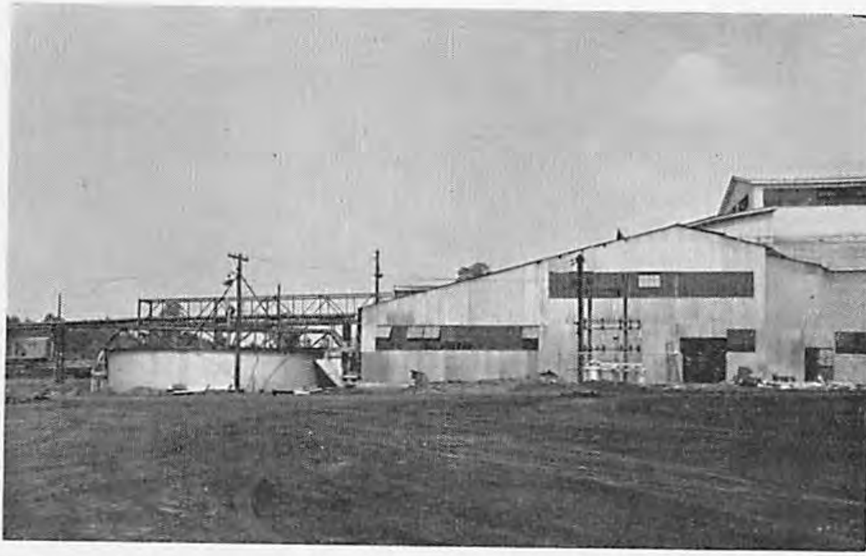
"The Flotation Plant"

The size consist of our slurry necessitated tables in addition to our flotation cells, for preparing a complete product. A representative size consist of the entire slurry pond is as follows: plus 10 Mesh—32%; 10 x 48 Mesh—45%; and minus 48 Mesh—23%. As the 35% ash feed enters the plant it first passes over a 5' x 10' Robins, double deck, gyrex vibrator. The oversize, plus 3/8", goes to an American Ring pulverizer in closed circuit with an elevator and the gyrex screen. The oversize on the lower deck, 3/8" x 2 mm, is sent direct to one 68' x 14' Wilfley concentrating table.

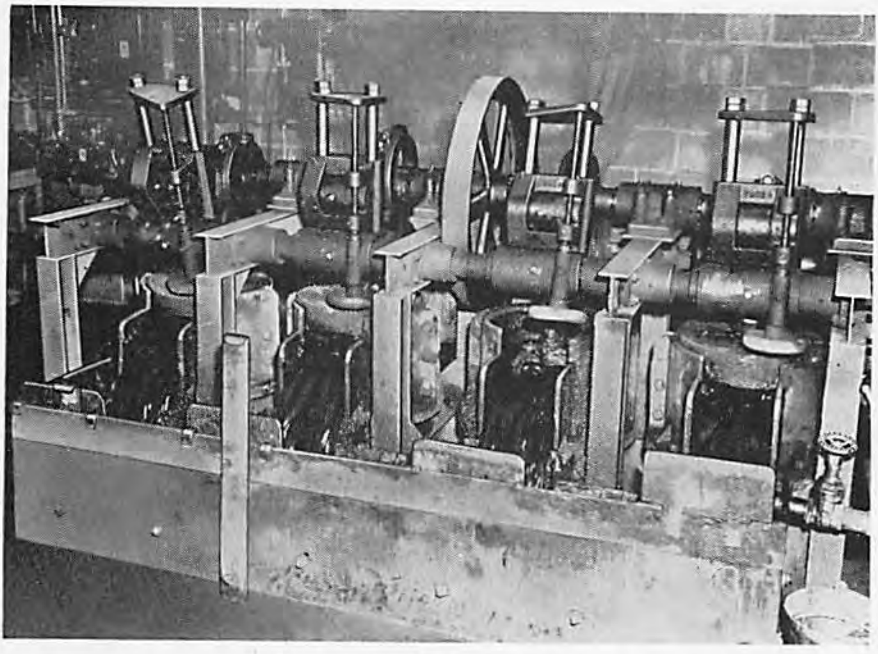
Diaphragm Pumps

All the minus two millimeter material is sluiced to a 50' Wemco thickener. Two Denver duplex diaphragm pumps remove the thickener underflow at 35-40% solids, while some slimes are removed in the overflow and go direct to final tailings. A 6" Wemco pump sends the pulp to a splitter box for feeding two parallel cleaning circuits of jigs, conditioners and flotation cells.

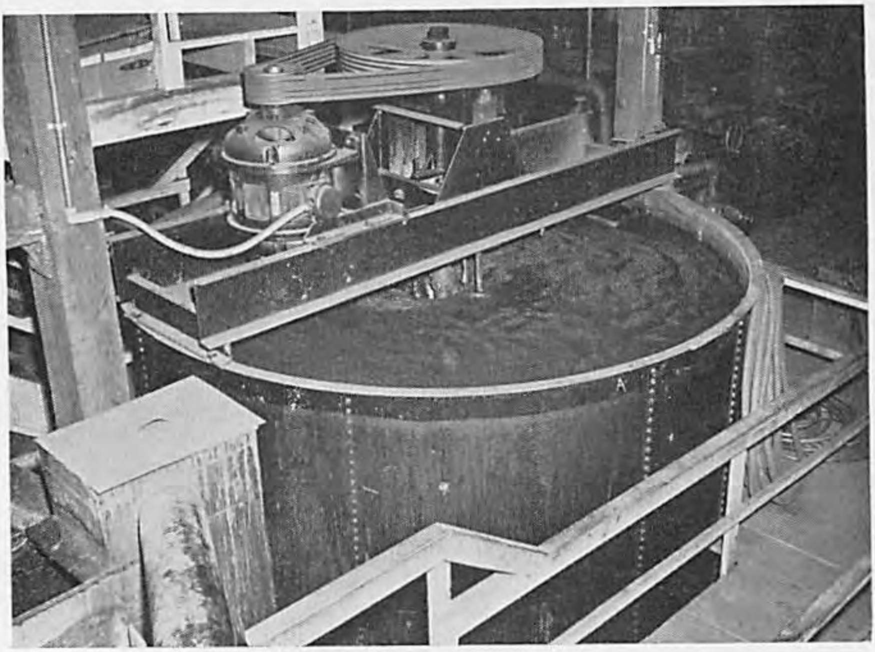
In each parallel cleaning circuit a 24" x 36" Denver duplex mineral jig removes much of the calcite, sand and pyrite and is in reality the first major cleaning unit.



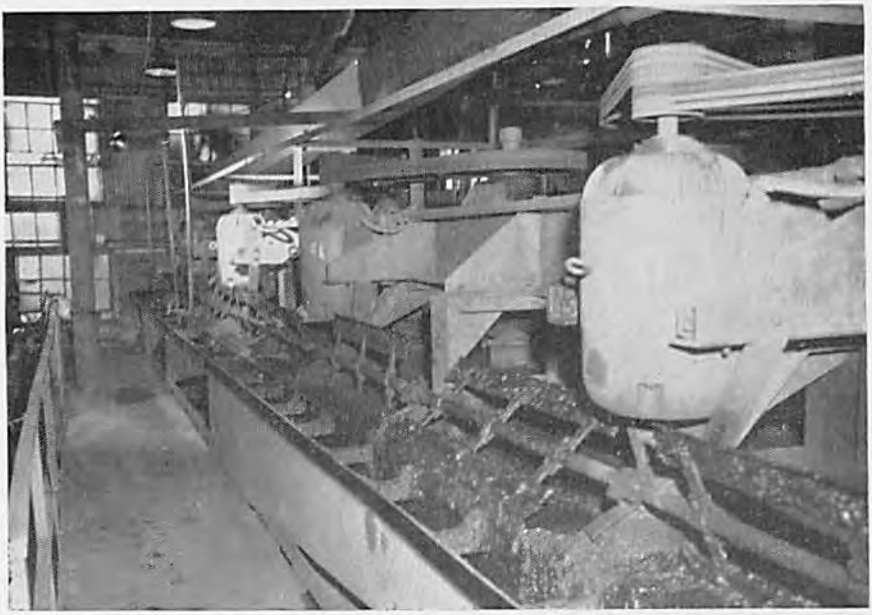
The Flotation Plant—the elevated line on the extreme left is the feed line from the dredge as it comes into the plant. The tank on the left is the 50′ thickener mentioned in the text.



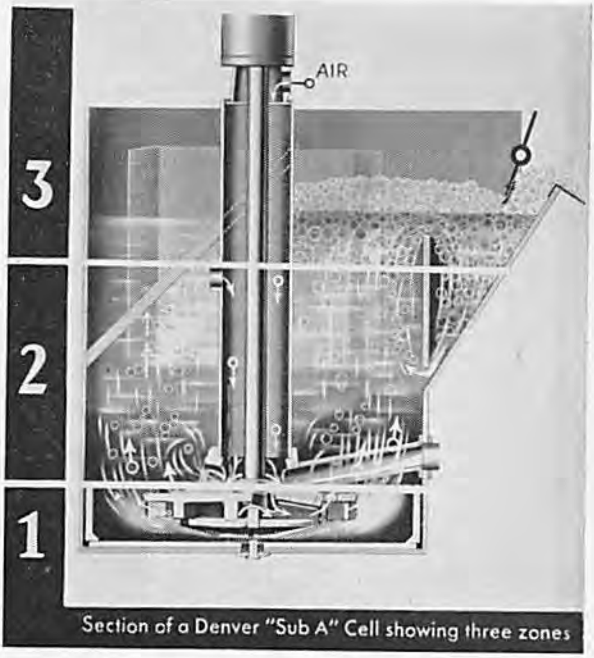
A 6″ quadruplex Denver Adjustable Stroke Diaphragm Pump in Action″



"Agitator and Conditioner"—note the layer of froth on the surface.



The West Bank of Eight Denver No. 30 Sub-A Cells in action at the United Electric Coal Companies, Fidelity Mine, Du Quoin, Ill.



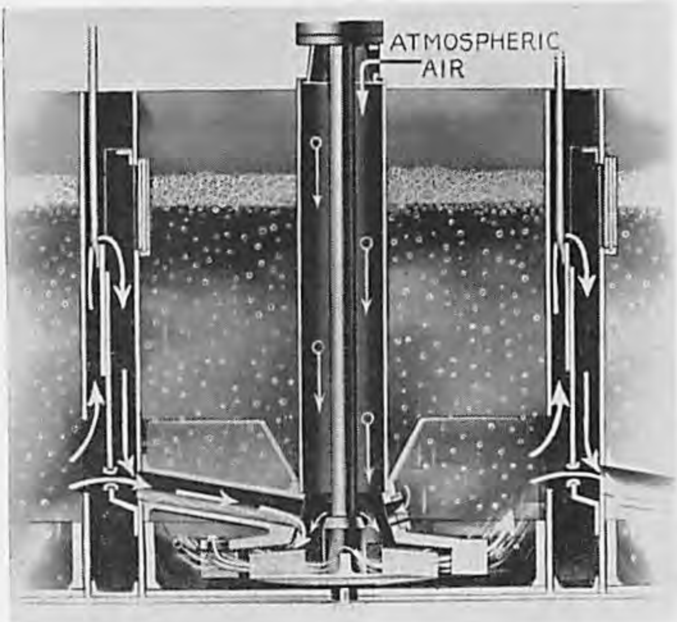
A cross-section of a Denver Sub-A Cell in action. Note the impeller with the hood plate immediately above it in Zone I, the Agitation Zone. The feed or middling return pipe may be seen in the lower right corner of Zone II, the Separation Zone. The Concentrate Zone is where the coal-laden froth collects and is removed by the paddle located in the upper right corner.

The Conditioner

The jig overflow discharges into a 10′ Wemco agitator for conditioning the feed prior to its entrance into the flotation cells. Before effective flotation can take place a difference must be established between the coal and the gangue. Nature has provided a difference in that coal has a greater affinity for the conditioning agent than the gangue. This difference of wettability leaves each particle of coal filmed with kerosene after thorough conditioning and the gangue merely wet with water. Some frother, a mixture of pine oil and methyl amyl alcohol, is also added in the conditioners.

Fidelity Flotation Cells

Each flotation bank consists of eight No. 30 Denver-Sub-A cells of 100 cu. ft. capacity per cell. The pulp, from the conditioners, enters cell No. 7 and flows in succession to cell No. 1 where the tails are discharged. The cell mechanism consists of an impeller and hood plate which set the entire pulp, reagents and forced air into motion.



Cross Section of a Denver "Sub-A" Machine showing the pulp flow between cells and aeration. Sand, pyrite, calcite, etc. remain in the bottom section of the cell while the conditioned coal particles rise to the surface.

Thousands of small air bubbles, filmed with the frothing agent, rise to the surface with the fine coal attached. The theory — "a relatively large air bubble picks up a relatively small piece of coal" has been changed to—" a relatively large piece of coal is picked up by many relatively small air bubbles."

The final concentrate from cell No. 7 is raked off by paddles into a launder for transfer to our filter plant for drying. The concentrates from cells No. 5 and No. 6 are recleaned in No. 8, the concentrate of which is also final product. Cell No. 6 receives the concentrates from Nos. 4, 3, 2 and 1 for recleaning. Additional frother and collector are added at various points in the cleaning circuit since "Stage addition of reagents" has proven more effective.

Final cell tails, including some clay, fine pyrite, sand and coarse coal are dewatered and then washed with sprays on a 4′ x 16′ Robins Eliptex Dewaterizer equipped with a 28 mesh wedge wire screen. Extremely fine sand, pyrite and clay go to final tails in the underflow from this unit. Fresh water is added to the oversize (2mm x 28M) thence to a pulp distributor for distribution to three 6′ x 14′ Wilfley concentrating tables.

The concentrate from these three tables joins the concentrate from

Photo of a single coal-laden bubble magnified 83 times—taken by R. H. Spedden of M.I.T.

the primary table which cleans the 3/8" x 2mm size and is pumped with a 4" Morris pump to our filter plant.

The Filter Plant

In the filter plant a 5' x 16' Allis Chalmers low-head vibrator, equipped with 28 mesh screen, receives the table concentrate for de-waterizing and discharging product to the stacker conveyor for stock-piling.

The cell concentrate comes through a separate pipe to a splitter for feed to two 6' eight-sector Eimco disc filters. When a vacuum of 20" is maintained, a cake of cell concentrate with 15% surface moisture results. Further moisture reduction takes place upon stockpiling. Finding desirable filter media has been quite a problem but we have found a combination of duck twill and saran effective and are currently experimenting with nylon and orlon.

The vacuum system for each filter consists of a (9" x 22") Ingersoll-Rand vacuum pump and snubber, a filtrate tank, moisture trap and a 2" Jennings filtrate pump. A Roots Blower in circuit wtih the filter provides air pressure for inflating the filter bags just prior to discharge of the dried cake. Colloidal material and water are drawn through the filter bags into the filtrate tank for removal to final waste by the Jennings pump.

The Filter Plant—The stacking conveyor and stockpile of cleaned slurry appear at the left. The "Bomb-like" units above the building are moisture traps for the vacuum system.

The dewaterized table concentrate and filtered cell concentrate both discharge into a common conveyor for removal to a stockpile or either direct loading to the washery. A two yard Sauerman Drag moves any stockpiled material to a loading hopper which discharges onto a Merrick Feed-O-Weight with variable loading rate of 15-175 t.p.h. A second flight conveyor transports the weighed slurry to the washery for loading, at approximately 40 tph average – the ash being 10-11%.

Constant feed control is provided by a Gagetron mounted on the dredge. It consists of electronic instruments, including a Geiger Counter, actuated by the gamma rays emitted from a radium source mounted on the dredge discharge line. The variations of solids in the line limit the amount of gamma ray penetration which variation is indicated on a dial mounted near the operator.

The cleaning costs per ton of slurry exceeds somewhat the cost of cleaning the coarser sizes in the main preparation plant but the absence of drilling, shooting, overburden removal, loading and transportation costs well overcome this difference. Special customers using pulverized fuel provide the main outlet for the flotation plant product.

Coal flotation is yet in its infancy in the American coal fields but there is little doubt that it has great potentialities. A consistently clean, low-ash, fine coal is gradually overcoming the former sales resistance to finer sizes.

Chairman Morris: Is there any question that anyone would like to ask Mr. Kloepper? If not, we will go on to the next paper, which is entitled "Recovery of Pyrite from Coal Cleaning Plant Rejects." This will be presented by Mr. Elmer Citron, Pittsburg & Midway Coal Mining Company, Pittsburg, Kansas. Mr. Citron.

Mr. Citron: Mr. Chairman, Members of the Illinois Mining Institute, and Visitors: This too is pretty much of a technical paper and I do not intend to go into all of the phases of this particular problem. What I am going to cover here is just going to be the processing equipment that we used in recovery of pyrites from our operations plant.

Now, I do not intend to go into the chemical phases of the recovery of pyrites at all because time does not permit us to carry on the long discussion that would be necessary and I am not capable of going into the chemical phase of it. I am mostly interested in the processing equipment end of it anyway.

THE RECOVERY OF FINISHED PYRITE FROM MINE REFUSE

By ELMER H. CITRON
Pittsburg & Midway Coal Mining Company
Pittsburg, Kansas

The Pittsburg & Midway Coal Mining Co. started their experiments some time back in the year of 1926. They, as well as probably every other coal operator, was aware of the general problem of *"Refuse Disposal"* and of the fact that valuable materials, *pyrite* and *coal* were contained in the refuse.

They were likewise aware of the desirability of devising some means whereby these valuable substances could be recoverd, which would solve "if realized," the refuse disposal problem at least to some extent.

A small pilot plant was constructed during he year of 1933 and was operated over a period of more than one year. This test or pilot plant included experimenal jigging and concentrating means that permitted the application of previously acquired experience. The testing included studies of the refuse and pyrite at several major producing mines; studies of various types of equipment for concentrating the pyrite; and finally to handle fifty tons of mine refuse per hour, in which all the experience of years of research, study, and developing was incorporated.

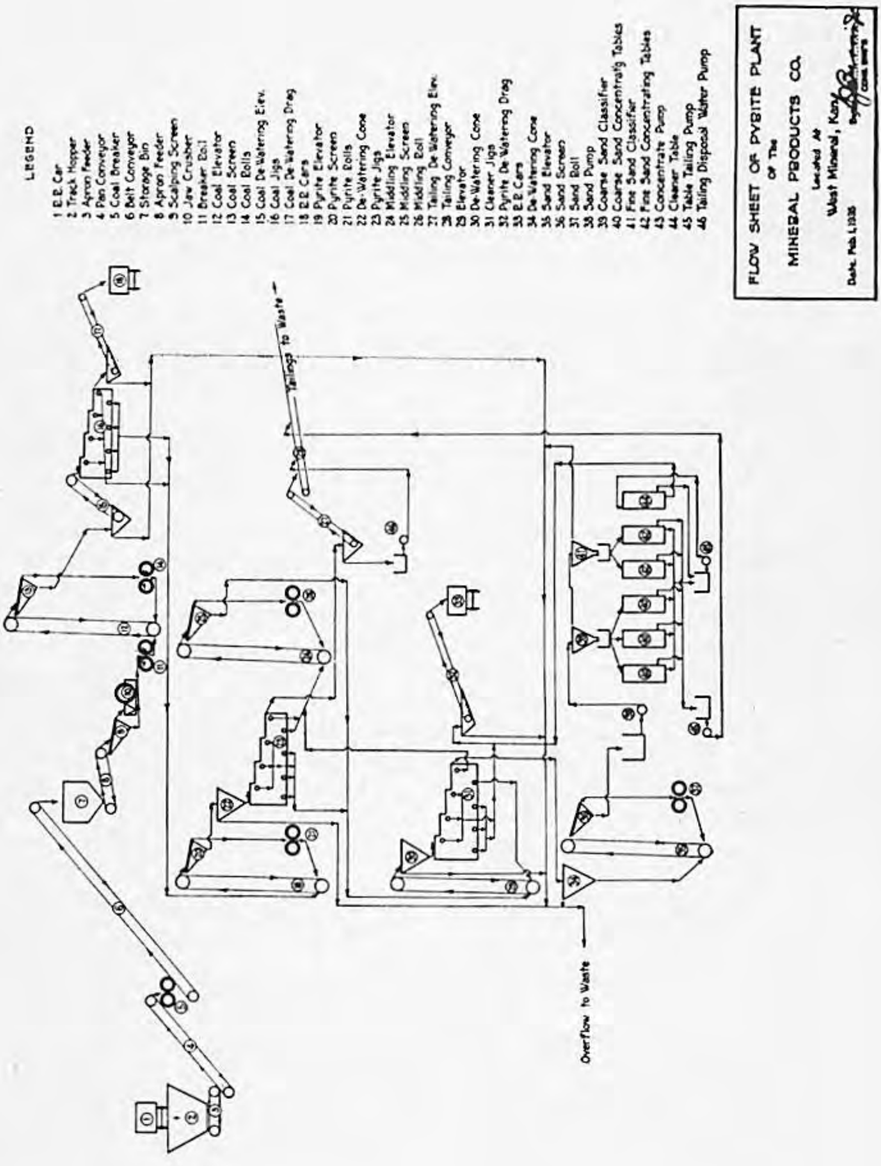
A plant was then designed and built to treat coal mine refuse and to recovrer therefrom marketable coal and a *high grade finished pyrite,* which was put into operation in the middle part of the year of 1936.

This plant furnished a good grade of coal and *high grade pyrite,* the pyrite being sold to the Monsanto Chemical Company, located in east St. Louis, Missouri, producers of sulphuric acid.

The plant was in continuous operation from 1936 till December of 1939 when the plant was practically shut down in order to discontinue temporarily the shipment of pyrite to the customer, the Monsanto Chemical Company, who had to make major repairs to their plant equipment.

This plant received coal mine refuse resulting from hand-picked mined coal and other treatments in a great variety of sizes, some of which were quite large and more or less intimately associated with valuable pyrites and other impurities which are valueless, such as stone, slate, clay, and the like, as well as some very fine powdered coal which is of little or no commercial value.

The mine refuse was first crushed (rather than ground) in a series of crushers which progressively reduced the larger lumps of material,


LEGEND
1 R.R. Car
2 Track Hopper
3 Apron Feeder
4 Pan Conveyor
5 Coal Breaker
6 Belt Conveyor
7 Storage Bin
8 Apron Feeder
9 Scalping Screen
10 Jaw Crusher
11 Breaker Roll
12 Coal Elevator
13 Coal Screen
14 Coal Rolls
15 Coal De-Watering Elev.
16 Coal Jigs
17 Coal De-Watering Drag
18 R.R. Cars
19 Pyrite Elevator
20 Pyrite Screen
21 Pyrite Rolls
22 De-Watering Cone
23 Pyrite Jigs
24 Middling Elevator
25 Middling Screen
26 Middling Roll
27 Tailing De-Watering Elev.
28 Tailing Conveyor
29 Elevator
30 De-Watering Cone
31 Cleaner Jigs
32 Pyrite De-Watering Drag
33 R.R. Cars
34 De-Watering Cone
35 Sand Elevator
36 Sand Screen
37 Sand Roll
38 Sand Pump
39 Coarse Sand Classifier
40 Coarse Sand Concentrat'g Tables
41 Fine Sand Classifier
42 Fine Sand Concentrating Tables
43 Concentrate Pump
44 Cleaner Table
45 Table Tailing Pump
46 Tailing Disposal Water Pump
Tailings to Waste
Overflow to Waste
FLOW SHEET OF PYRITE PLANT
Of The
MINERAL PRODUCTS CO.
Located At
West Mineral, Kan.

first to approximately *four* inches in size, then to approximately *two* inches in size, then preferably to *one and one-half* inches, then to *one* inch, and finally to approximately *three-eights* of an inch. This exact graduation is not essential but it is important to gradually and progressively reduce the size of the larger particles in the refuse to approximately three-eights of an inch.

By thus crushing rather than grinding the materials, the amount of finely pulverized coal is held to a minimum.

When the refuse has been crushed to pass an approximately three-eights of an inch screen, the refuse is washed and dewatered, and subjected to any suitable gravity separating means whereby the coal is separated from the refuse. There was thus obtained a commercial coal superior to, and on the market successfully competing with, bituminous coals.

The gravity separating equipment used was that of a well known coal jigs, from which the coal was discharged from the jigs as tailing. The remainder of the material from the coal jig constitutes bed draws and hutch of the coal jig.

Such bed draws and hutch materials was then passed to a screen having a screen cloth of approximately three-eights inch opening and all of the over-size from the screen was ground and again passed over the same screen in a close circuit.

All of the through or under-size material from the screen was conveyed to an automatic dewatering cone, the overflow material from the cone was passed to waste and the underflow material was fed to a well-known "rougher" pre-jig.

The tailings from this jig was conveyed to waste, while the hutch and bed draws from the last cell of the rougher jigs, which is commonly known as a middling product, will ordinarily require finer grinding to enable any intimately associated coal and pyrite to be separated.

This reground hutch and bed draws from the last cell of the rougher jigs, together with the bed draws and hutch from the other cells of the same rougher jigs, were then passed to an automatic dewatering cone, the overflow from this cone is passed to waste and the underflow is fed to cleaner jigs.

The products thus fed to the cleaner jigs from the dewatering cone consists essentially of pyrite, and the cleaner jigs serves to concentrate this pyrite.

It was generally found that the bed draws and hutch from all but the last cell of the cleaner jigs were a high-grade pyrite, and the product from these cells was passed to storage.

The hutch from the last cleaner jig cells was returned to the automatic washing cone and then again fed to the cleaner jigs while the bed draws of the cleaner jigs were too coarse and was reground to insure that the product be approximately three millimeters in size, and then likewise returned to the automatic dewatering cone and from the cone was again fed to the cleaner jigs.

The tailing from the cleaner jigs was then conveyed to still another dewatering cone, and the overflow from the cone was passed to waste while the underflow from the cone was fed to an elevator which discharged onto a screen having a screen cloth of approximately 2 mm. opening.

You will note that the cleaner jig cells produce three products:

1. Finished pyrite concentrates from the first three cells.
2. A middling product from the bed draws of the last cell which was reground and repassed to the cleaner jig cells.
3. A tailing product which was reground to a table size. This table size, reground product consists very largely of a fine pyrite.

The thrus or undersize material from the screen mentioned above was sluiced to a pump sump, and then pumped to a hydraulic classifying cone and from the cone to a distributor which split the fed to a series of coarse sand concentrating tables, three in number. The overflow from this last mentioned hydraulic cone classifier passed to a second hydraulic cone classifier, and from this cone to a distributor which in turn split the fed to a series of fine sand concentrating tables—two in number. The overflow from this last mentioned hydraulic classifier cone is passed to waste. It will be seen that these two sets of tables, five in number, produce two products:

1. A tailing which is passed to waste.
2. A more-or-less dirty pyrite concentrate or middlings.

This dirty pyrite was delivered to a cleaner table which produced a fine finished pyrite concentrate which was preferably delivered to storage along with the pyrite concentrate from the cleaner jig cells mentioned above.

The diagrammatic flow sheets that are being passed out will show in more detail the steps employed in separating the coal and the pyrite from the coal mine refuse.

Referring to the diagrammatic flow sheet, we will begin at the upper left-hand corner which shows the coal mine refuse, of large, small, and intermediate sizes, delivered from the railway car No. 1 to a hopper No. 2; from this hopper No. 2 the refuse is withdrawn by an apron feeder No. 3, which is driven through a variable speed transmission so as to permit regulation of the tonnage feed to a pan conveyor, No. 4. This conveyor, No. 4, discharges into a single roll coal crusher, No. 5, by which the material here is crushed to a size of approximately three and one-half or four inches. From this crusher, No. 5, the material is delivered to a belt conveyor, No. 6, which transports the product to a storage bin, No. 7. The product is withdrawn from the storage bin, No. 7, by an apron feeder, with a vari-speed drive, No. 8, which discharges the product onto a scalping screen, No. 9, having a two and one-half inch opening screen jacket. The oversize from the screen, No. 9, passes to a jaw crusher, No. 10, set to produce a product approximately two and one-half inches in size.

The undersize or thrus from the screen, No. 9, joins the thrus of the jaw crusher, No. 10, and they pass to a spaced crushing roll, No. 11, set to crush the material to approximately one and one-quarter inch in size. The thrus from this spaced crusher roll, No. 11, are taken by an elevator, No. 12, and delivered to a finishing screen, No. 13, that had a screen cloth equivalent to one and one-quarter inch. The oversize from this finishing screen, No. 13, passes to crusher rolls, No. 14, from which the material after crushing is delivered back to the elevator, No. 12, and then over the finishing screen, No 13, again. All of the thrus from the finishing screen, No. 13, pass to a dewatering cup elevator, No. 15. The overflow of the elevator, No. 15, passes to waste, while the dewatered product is elevated and delivered to two coal jigs, No. 16, consisting of a series of cells, eight in number.

The tailings from these coal jigs consisting of finished coal which passed to a dewatering drag, No. 17, by which it is delivered either to storage or directly to railroad cars, No. 18.

The hutch products and bed draws from the coal jigs, No. 16, pass to an elevator, No. 19, by which they are delivered to a screen. No. 20, with a screen cloth of approximately three-eights inch opening. The oversize of screen No. 20, is reground by passing through grinding rolls, No. 21, and the thrus from the grinding rolls are again passed to the elevator, No. 19. The undersize from the screen, No. 20, is passed to a dewatering cone, No. 22, and the overflow from the cone is passed to waste, and the underflow from the cone is fed to the pyrite rougher jigs, No. 23. The rougher jigs, No. 23, consist of two in number, which produce three products:

1. Tailings.
2. Bed draws and hutch products from the first three cells of the jig.
3. The bed draws and hutch from the last cell, which is normally middling product, requiring additional grinding to disassociate any coal that may be adhering to the pyrite.

This middling product is passed to the elevator, No. 24, and delivered to the screen, No. 25; with a screen cloth of approximately 3 mm. opening the oversize of this screen is reground by rolls, No. 26, the thrus of which are returned to the elevator, No. 24.

The undersize from the screen, No. 25, joins the products from the first three cells of jig, No. 23. The tailings from the rougher jig, No. 23, passes to the waste disposal pile by way of the dewatering elevator, No. 27, and belt conveyor, No. 28.

The undersize from the screen, No. 25, joins the products from the first three cells of jig, No. 23, mentioned above, and pass to elevator, No. 20, by which the product is fed to an automatic dewatering cone, No. 30, the overflow from the cone is passed to waste and the cone underflow is fed to a series of pyrite cleaner cells, No. 31.

The cleaner jigs, No. 31, two in number, produce three products:

1. A tailing product.
2. A finished pyrite concentrate from the first three cells.
3. Middling products from the bed draw of the fourth cell. This middling material is somewhat coarse and requires regrinding and is passed to elevator, No. 24, over screen No. 25, and grinding rolls, No. 26, just mentioned.

The finished pyrite from the first three cells of the cleaner jig, No.

31, passes to the dewatering drag, No. 32; here the finished pyrite concentrates are dewatered and discharged into railroad cars, No. 33, the overflow of this dewatering drag going to waste. The hutch products from the fourth cell of the cleaner jigs is circulated back to elevator, No. 29.

The tailings product from the cleaner jig, No. 31, are conveyed to a dewatering cone, No. 34; the overflow from the cone, No. 34, is passed to waste and the cone underflow is fed to elevator, No. 35, then to the vibrating screen, No. 36, with a screen cloth of approximately 2 mm. opening. The thrus from the screen just mentioned are of a size suitable for tabling. The oversize from the screen is conveyed to grinding rolls, No. 37; here they are reground and again passed by way of elevator, No. 35, to screen, No. 36, mentioned above.

The thrus of screen No. 36 pass to the sump of pump No. 38. Here they are pumped to a hydraulic classifying cone, No. 39. The spigot product of this cone, No. 39, just mentioned is split by means of a distributor to three coarse sand concentrating tables, No. 40.

The overflow of the cone, No. 39, is passed to a second hydraulic classifying cone, No. 41, and the spigot product of this cone is split by means of a distributor again to two fine sand concentrating tables, No. 42, and the overflow from the cone, No. 41, is then passed to waste.

The tables 40 and 42 produce two products:

1. A dirty pyrite concentrate which is passed to the sump of pump, No. 43, and pumped to the cleaner table, No. 44.
2. A tailing which is passed to the sump of the tailing disposal pump, No. 45, and here pumped to waste.

The cleaner table, No. 44, produces a fine finished pyrite concentrate which is fed to a dewatering drag which conveys the concentrates to the railway car, No. 33.

The middling from the table, No. 44, is recirculated over the table, No. 44, by means of a pump, No. 43.

* * *

Chairman Morris: This is a rather new subject for most of us. Are there any questions any of you gentlemen would like to ask Mr. Citron? Thank you very much, sir.

Our final paper in this group concerns the "Market Outlook for Sulphur Recoverable from Coal," and this paper will be presented by Dr. Walter H. Voskuil of the Illinois State Geological Survey, Urbana, Illinois. Dr. Voskuil.

MARKET OUTLOOK FOR SULFUR RECOVERABLE FROM COAL

By WALTER H. VOSKUIL
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PART I. THE SULFUR MARKET PROBLEM

Need for New Sources of Sulfur

Sulfur from the salt domes of the Texas and Louisiana Gulf coast has been so abundant and produced at such low cost that it has been almost the sole source of supply. But in 1950 it became evident that rapidly expanding uses for sulfur would soon create a demand larger than this supply could meet, and it would be necessary to make a survey of other possible sources.

There is no world shortage of sulfur: the problem is one of economic production rather than supply. The low cost of sulfur produced from the salt domes by the Frasch process has made it uneconomical to work the higher-cost sources. Now the picture is changing, and the following additional sources of sulfur have been suggested: pyrite, sulfur dioxide smelter gas, sulfur dioxide in stack gases, hydrogen sulfide in coal carbonization plants, oil refineries and "sour" natural gas, coal "brasses" from high-sulfur coals, and gypsum.

Economic Changes in the Supply Pattern

The change from native sulfur to other sources of sulfur means higher production costs. It will cost more to ship the sulfur-bearing ores to points of consumption, and it will cost more to convert the sulfur to the forms needed by industry.

Elemental sulfur is easily transported, which accounts in part for its wide distribution in the United States and abroad. Pyrite is also easily transported, but it contains in its pure form only about 58 percent of sulfur. Commercial pyrite contains only about 41-43 percent. Transportation costs would therefore limit the distribution of this ore from the mine locality. To offset high transportation costs, every effort will be made to develop sulfur ores as near to the market as possible.

Sulfur dioxide, in liquid form, can be shipped in tank cars, and this form of transportation may become very important in the future. Sulfuric acid, the most important form in which sulfur is used, is very difficult to transport and store, and it is therefore advantageous to manufacture sulfuric acid as near as possible to the consuming center.

The sources of sulfur will be somewhat dictated by the sulfur raw materials that are locally available. The sulfur industry will therefore evolve into a large number of widely scattered producing units that use many processes adapted to the raw material available and to the markets to be served.

In order to appraise the trend of the sulfur market, it is necessary to analyze the uses of sulfur in industry and to describe the geographic markets for sulfur.

SULFUR IN INDUSTRY

Preparation

Except for small quantities used in elemental form, sulfur is used in industry mainly as sulfuric acid or sulfite liquor. In preparing these compounds, sulfur is first burned to SO_2. Where S is the raw material used, the preparation of SO_2 is relatively simple and the cost is low. Production of sulfur or sulfur dioxide from natural compounds, such as hydrogen sulfide (H_2S), metallic sulfides (iron, copper, lead, and zinc), or gypsum, entails considerable additional cost, both in the preparation of the product and in the assembly of raw materials.

Industrial Use

Industrial distribution of sulfur by uses is shown statistically in table 1. Increase in sulfur consumption has not been due to new developments

TABLE 1. USES OF SULFUR*
(thousands of long tons)

Use	1935		1940		1945		1949	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Chemicals	555	45.0	800	43.3	1605	54.1	1765	50.4
Fertilizers & Insecticides	239	19.4	410	22.2	600	20.5	740	21.2
Pulp & Paper	204	16.6	320	17.5	297	9.9	330	9.2
Explosives	42	3.4	74	3.8	90	2.9	98	2.9
Dyes & Coal Tar Products	39	3.1	51	2.7	75	2.6	94	2.8
Rubber	33	2.7	47	2.5	58	1.9	53	1.5
Paint & Varnish	48	3.8	54	3.0	94	3.3	210	6.1
Food Products	4	0.1	6	0.1	7	0.1	8	0.1
Misc.	68	5.9	86	4.9	135	4.7	202	5.8
Total	1232		1848		2961		3500	

*Source: Minerals Yearbooks, Bureau of Mines.

but to expansion of existing uses. Four consumer groups — chemical manufacture, fertilizers and insecticides, pulp and paper, and paint and varnish — account for 87 percent of consumption. They accounted for an increase of 2,000,000 tons between 1935 and 1949.

A forecast of future requirements made by projecting the curve of past consumption into the future suggests steady increase in sulfur requirements. In addition we may also assume that chemical, fertilizer, paper, and paint requirements will maintain a growing demand that is going to exceed the maximum output capacity of the Gulf Coast sulfur domes.

Supply and Exports

An important factor in the supply-demand relationships of native sulfur has been the high rate of exports. In the 15-year period 1935-1949, an average of 26 percent of the native sulfur produced has been exported. The record is as follows:

Sulfur Exports, 1935-1949

Annual Average in long tons

Production	3,175,238
Exports	816,900
Percent, exports of production	25.8

Geographic Markets for Sulfur

Production and Shipments

The principal markets for sulfur are the sulfuric acid plants, which are concentrated in the Atlantic seaboard states, in Illinois and Ohio, and in the southern states. The approximate distribution of sulfuric acid manufacture is shown in table 2, given in the Census of Manufactures, for 1947.

The sulfur market has been favored by two low-cost items—production by the Frasch process, and low-cost water transportation for a large portion of Gulf Coast sulfur destined to markets on the Atlantic seaboard and ports on the Mississippi River system.

The distribution of sulfur by coastwise shipments, by inland waterways, and by all-rail haul reflect the wide geographic usage of sulfur. Ninety-seven of the 120 Class I steam railways in the United States report sulfur shipments terminating on their lines. Sulfur shipments to the southeastern states enter the superphosphate manufacturing industry; those to the Middle Atlantic states are primarily for indusrial production. Sulfur destined to New England, the Upper Lake states and the Pacific Northwest figures largely in paper manufacture. In the Upper Mississippi-Ohio Valley shipments, sulfur enters a diversified market in steel, petroleum refining, paint and rubber manufacture.

Illinois and Adjacent Markets

The sulfur markets in states of the Upper Mississippi and Ohio river valleys have one advantage in common—transportation by barge on the

TABLE 2. PRODUCTION AND SHIPMENTS OF SULFURIC ACID[1] (100% H_2SO_4), BY DIVISIONS AND STATES: 1947*

Division and state	Number of producing establishments	Short tons	Value f.o.b. plant (thousands)	Total production (short tons)
United States[2]	177	6,824,756	$89,129	10,780,166
New England[3]	5	102,156	1,808	183,151
Middle Atlantic	26	1,558,181	22,608	2,288,498
Pennsylvania	14	744,565	10,168	855,608
Other[4]	12	813,616	12,440	1,432,890
North Central	40	1,584,241	21,565	2,418,801
Illinois	15	837,008	10,894	1,135,991
Michigan	5	102,928	1,606	133,244
Ohio	14	446,755	6,660	624,377
Other[5]	6	197,550	2,405	525,189
South	92	2,862,891	33,773	5,062,336
Alabama	10	60,996	706	184,333
Georgia	15	36,525	425	241,789
Louisiana	6	343,666	4,432	462,049
South Carolina	9	12,200	164	165,981
Other[6]	52	2,409,504	28,046	4,008,184
West[7]	14	717,287	9,375	827,380

1. Gross quantities including spent sulfuric acid fortified in contact units.
2. Includes data for 85 plants operating chamber units; 82 plants operating contact units; and 10 plants operating both types of units.
3. Includes data for plants located as follows: Connecticut 1; Maine 1; Massachusetts 2; Rhode Island 1.
4. Includes data for plants located as follows: New Jersey 9; New York 3.
5. Includes data for plants located as follows: Indiana 3; Missouri 2; Wisconsin 1.
6. Includes data for plants located as follows: Arkansas 1; Delaware 1; Florida 6; Kentucky 1; Maryland 6; Mississippi 3; North Carolina 9; Oklahoma 2; Tennessee 3; Texas 7; Virginia 12; West Virginia 1.
7. Includes data for plants located as follows: Arizona 2; California 8; Colorado 1; Montana 1; Utah 1; Washington 1.

*Census of Manufactures, Vol. II. Statistics by Industries, p.389.

Mississippi River system and its tributaries, the Ohio and Illinois waterways. This combination of low-cost transportation and production, as long as the supply of Gulf Coast sulfur was ample, precluded the development of alternative sources of sulfur supply.

Consumption of sulfur in Illinois and other states adjacent to the Mississippi-Ohio river system can be approximated from the data on barge shipments on the waterways. This movement for the year 1949 was as follows:

A total of 777,649 tons moved northward on the Mississippi River.

Of this total 232,533 tons was unloaded in the St. Louis and East St. Louis districts, and

339,095 tons was unloaded at points on the Illinois waterway, mainly in the Chicago district.

Consumers on the Ohio River and at Pittsburgh took 199,413 tons and 6,606 tons was shipped beyond St. Louis into the upper Mississippi River area.

Table 3 shows the tonnages of sulfur terminated by railroads in states of the upper Mississipi-Ohio waterway area, for the years 1949 and 1950. The total quantity so reported is somewhat less than the tonnages shipped over the Mississippi, Illinois, and Ohio waterways. These tonnages are presumed to be sulfur originating on river ports and shipped by rail for further destinations in the respective states.

TABLE 3. SULFUR SHIPMENTS TERMINATED ON RAILROADS IN STATES OF THE UPPER MISSISSIPPI-OHIO VALLEY, 1949 AND 1950*.

States	TONS 1949	TONS 1950
Illinois	113,588	100,033
Indiana	37,187	63,932
Iowa	22,893	29,689
Michigan	61,136	63,478
Minnesota	1,004	4,382
Missouri	125,609	36,959
Ohio	118,409	106,705
Wisconsin	70,179	33,207
Total	549,975	438,385

*Source: Interstate Commerce Commission, Bureau of Transport Economics and Statistics.

PART II — SOURCES OF SULFUR

Native Sulfur

Crude native sulfur produced by the Frasch process from salt domes in Texas and Louisiana will continue to be the principal source of sulfur for an indefinite time. The present sulfur problem arises from the fact that demand is exceeding production. The relation of demand to production in recent years is shown in table 4.

TABLE 4. PRODUCTION, MINE SHIPMENTS, AND PRODUCERS' STOCKS, 1947 TO 1950[1]
(in thousands of long tons)

Year	Production	Shipments			Producers'
		domestic	export	total[2]	stocks[3]
1947	4441	3529	1299	4828	3371
1948	4869	3716	1263	4979	3225
1949	4745	3358	1431	4789	3099
1950	5192	....	....	5504	2655
Jan.-Sept. 1951	3964	....	....	3760	2754

[1]Bureau of Mines, Mineral Market Report, Nos. 58, 82, 93, 98, and 102.
[2]Mine Shipments.
[3]Producers' stocks at mines, in transit, and in warehouses at end of period.

Table 4 indicates a consumption of sulfur in excess of production in 1949 and 1950 and a decrease in producers' stocks to less than six months' supply, a situation which is described as "dangerously low."

Sulfur is now being produced in the Gulf Coast area of the states of Louisiana and Texas on the following sulfur-producing domes:

1) Louisiana
   (Lake Washington)
   Grande Ecaille Mine – Plaque Mines Parish

2) Texas
   Orchard Dome – Fort Bend County
   Hoskins Mound – Brazoria County
   Clemens Dome – Brazoria County
   Long Point Dome – Fort Bend County
   Boling Dome – Wharton County
   Moss Bluff Dome – Liberty County (New in 1948)

Efforts to sustain sulfur production in the Gulf Coast are being attempted by exploratory activities on salt domes in Louisiana and Texas as follows:

1) Louisiana – Bay Ste. Elaine
   Exploratory wells being drilled
      Garden Island*
      Nash Dome – Texas
      Venice Dome
      Starks Dome – Calcasieu Parish

2) Texas – Spindletop Dome, Texas – Jefferson County

Supplementary Sources of Sulfur

Potential sources of sulfur of varying degrees of practicality are:

1. Pyrite.
2. Sulfides of non-ferrous metals – lead, zinc and copper obtained in smelter gases.
3. Hydrogen sulfide in natural gas.
4. Hydrogen sulfide from oil refinery operations.
5. Sulfur from coal
   a. Coal "brasses" (iron pyrite) separated from coal at cleaning plants.
   b. Hydrogen sulfide from by-product coke-oven gases.
   c. Sulfur dioxide from stack gases of coal-burning power plants.
   d. Sulfur, as iron pyrite, in washing refuse piles of coal operations.
6. Gypsum and anhydrite.
7. Low-grade sulfur deposits in western states.
8. Reclaimed sulfuric acid.

These alternative sources of sulfur will assume a position of increasing importance. High cost of preparation or conversion of sulfur into marketable forms and high transportation costs of sulfur ores, or sulfur compounds, where transportation to market is necessary, will tend to favor the development of local sources and many production units. This will further result in the development of several types of sources, depending upon the economic situation in a given market area.

Sulfur from Illinois

An examination of local sources of sulfur for Illinois markets pro-

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*On August 30, 1951, the Bureau of Mines announced "the discovery reported by the Freeport Sulfur Co., of a large sulfur deposit at the Garden Island Bay dome in the Mississippi delta, which is expected to produce approximately 500,000 long tons annually before the end of 1953."

ceeds from the assumption that higher production costs of sulfur from these sources may be offset by savings in transportation costs from distant sources.

Coal

Sulfur content in Illinois coal is discussed by Cady[1] and a summary of his findings are reproduced herewith:

"SUMMARY OF OBSERVATIONS ON THE QUANTITATIVE OCCURRENCE OF SULFUR AND ITS FORMS"*

"(1) Total sulfur in Illinois (coals) generally exceeds 3 percent* and in most places and seams ranges from 4 to 6 percent. In a few local areas the sulfur content of a coal is less than 3 percent, not uncommonly in these areas being less than 2 percent. The countries in which these areas are located and coal beds are as follows:

Jackson County	Murphysboro (No. 2) coal
Will County	LaSalle (No. 2) coal
Woodford County	LaSalle (No. 2) coal
Saline County	Harrisburg (No. 5) coal
Vermilion County	Springfield (No. 5) (Grape Creek coal)
Eastern Perry, Jefferson, Franklin, and Williamson counties	Herrin (No. 6) coal

"(2) Within the limits of variation of each group the amount of total sulfur is very erratic, making it difficult to discover any definite relationships.

"(3) Sulfate sulfur is an unimportant constituent of Illinois coals (¼-½ percent).

"(4) (a) Pyritic Sulfur in coals having a low total sulfur content is necessarily low, not exceeding 2 percent in coals containing 3 percent or less of total sulfur, but within these limits it is variable since it may be as little as 0.25 percent.

"(b) Pyritic sulfur in coals having a total sulfur content exceeding 3 percent varies irregularly to such an extent as to account for a 5 percent variation in the total sulfur content, that is, from 3 to 8 percent.

"(c) Free or discardable pyrite, if included in the analytical results, would rarely increase the average sulfur values more than 2 percent and in most cases not more than 1 percent of the weight of the coal. Coals having a total sulfur content of less than 3 percent probably rarely have an additional discardable sulfur content in the form of pyrite of more than 0.5 percent.

[1]Cady, G. H., Distribution of Sulfur in Illinois Coals and Its Geological Implications. Contributions to the Study of Coal, Illinois Geol. Survey Rept. Inv. 35, 1935.

*In this summary, percent values refer to weight of the coal on an ash and moisture free basis."

"(5) (a) Organic sulfur, in contrast to total and pyritic sulfur, displays considerable regional regularity and fairly systematic variation from place to place in certain beds. Local areas of low total sulfur are also areas of low organic sulfur.

"(b) Local variation in organic sulfur is rarely more than 1 percent and generally not more than 0.5 percent irrespective of the locality.

"(c) Low organic sulfur content (less than 1 percent) is usually accompanied by low pyritic and total sulfur content; high organic sulfur content is usually accompanied by high pyritic (more than 2 percent) and total sulfur (more than 3 percent) contents.

"(6) The most significant result of this examination of the occurrence of total sulfur and the chemical forms of sulfur is the conclusion that the organic sulfur is the best index of the sulfur content and that the organic sulfur content is regionally consistent for each coal bed."

Coal "Brasses"

Among the by-product sources of sulfur not now exploited is the pyrite found in coal, referred to as coal "brasses."

Pyrite occurs in bands and nodules in the coal bed, some of which is recoverable from coal in the cleaning process.

Coal cleaned in Illinois and Indiana[2] totaled 38 million tons in 1949 of which 27 million were in Illinois and 11 million in Indiana. The average annual tonnage cleaned in a five-year period 1945-1949, for these two states was 42,807,462 tons.

Assuming one-percent recovery of pyrite from coal processed in cleaning plants, there is on the basis of existing capacity an ultimate possibility of 400,000 tons of pyrite, about 40 percent sulfur.

There are approximately 70 coal-cleaning plants in Illinois and 20 in Indiana, some of which can be equipped to recover pyrite provided there is sufficient incentive to do so. Incentive would include such elements as adequate price, continued demand, and an agreement by the purchaser to take all pyrite produced and offered for sale. The technical problem of using a pyrite contaminated with carbon for the manufacture of sulfuric acid would also need to be solved.

Mine Refuse

In various coal-mining localities in Illinois, there are large tonnages of mine refuse. "The coal in central Illinois, in the Springfield-Taylorville area, is especially high in sulfur . . . the refuse piles contain about 12 percent sulfur."[3] Investigations for the recovery of sulfur from refuse piles have been undertaken by one coal company. Estimates of the quantity of sulfur in these refuse piles are unavailable.

Coke-Oven Gases

The quantity of hydrogen sulfide in gases of by-product ovens in the Chicago industrial district in 1949 is estimated at 30,000 tons. This is

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[2]Indiana production may be considered with Illinois as part of the potential supply of sulfur from coal.

[3]Wall Street Journal, Chicago edition, February 10, 1951, p. 2.

based on data on sulfur compounds in coke and coke-oven gases reported by Wilson and Wells[4] and on reports of the Bureau of Mines of coal consumption and gas production in coke ovens. Wilson and Wells report as follows:

"The sulfur in the coal is distributed among the carbonization products, usually in the following approximate proportions:

	Percent
Coke	50-65
Gas, as hydrogen sulfide	25-30
As carbon disulfide, thiophene, and other organic sulfur compounds	1-1.5
Tar and ammonia liquor	Balance

The following relationships have been given as rough guides for predicting the sulfur contents of coal gas. The hydrogen sulfide content in grains per 100 cu. ft. equals the percent of sulfur in the coal times 365; and the organic sulfur in grains of sulfur per 100 cu. ft. equals the percent of sulfur in the coal times 18.

"Hydrogen sulfide and other sulfur compounds in the volatile products begin to form in quantity around 250°C. (482°F.), but the reactions which produce them are probably largely completed in the temperature range 500 to 800°C. (932 to 1472°F.). Both the sulfur combined in the coal substance itself and that in the mineral matter of the coal contribute to the formation of volatile sulfur compounds. Organic molecules containing sulfur probably decompose under the influence of heat to form hydrogen sulfide and volatile, organic-sulfur compounds. The mineral matter takes part in a number of reactions which produce volatile sulfur compounds. Thus, when iron pyrite, FeS_2, is heated in contact with organic matter, hydrogen sulfide is evolved to leave ferrous sulfide, FeS. The latter, in turn, can react with the carbon of the coal substance to produce carbon disulfide. On heating in contact with organic matter, sulfates in the mineral matter are reduced to sulfides, and these, in turn, can react with more organic matter to form organic-sulfur compounds."

Coal consumed in the manufacture of by-product coke in Illinois and Indiana (principally in the Chicago industrial district) in 1949 was 14,852,295 tons. This coal is obtained mainly from eastern Kentucky, West Virginia, and Virginia and generally is low in sulfur. A sulfur content of 0.8 percent is assumed. This gives a value of 118,818 tons of sulfur in the coal consumed in coke ovens. If 25-30 percent of the sulfur, as stated by Wilson and Wells, appears as hydrogen sulfide in gas, this gives a quantity of 29,700 to 35,600 tons of hydrogen sulfide.

When sulfur content is calculated on the basis of grains per 100 cubic feet, according to the formula of Wilson and Wells, on a basis of 144,268,392,000 cubic feet of gas produced by coke ovens in 1949,[5] using

[4]Wilson, Philip J., and Wells, Joseph H., Coal, Coke, and Coal Chemicals, McGraw-Hill and Co., 1950, pp. 188-189.

[5]Bureau of Mines, Minerals Yearbook, 1949, Chapter on Coke and Coal Chemicals.

coal of an assumed 0.8 percent sulfur content, the potential supply is calculated at 30,026 tons. The equation based upon the formula is as follows:

$$\text{Sulfur (in tons)} = \frac{365 \times 0.8 \times 144{,}268{,}392{,}000}{437.5 \times 16 \times 100 \times 2000} = 30{,}026$$

Several processes have been designed to remove hydrogen sulfide from coke-oven gas with or without the recovery of sulfur. These processes are reviewed in several recent articles in chemical literature:

Organic Sulfur Compounds in Water Gas and Coke Oven Gas: W. A. Kemper and E. W. Guernsey, Amer. Gas Assoc. Proceedings, Vol. 1942, pp. 364-374.

Coking Dividend; Ford Accumulating Pile of Sulphur Extracted from Coke Oven Gas: Business Week, Dec. 18, 1943, p. 74.

Ford Starts Sulphur Extraction Plant to Purify Coke Oven Gas: Iron Age, Vol. 152, Dec. 16, 1943, p. 72.

Hydrogen Sulphide Removal; The Recovery of Sulphur from Commercial Gases: D. D. Howat, The Chemical Age, Vol. 49, July 24-31, 1943, pp. 75-78, 99-105.

Sulphur Removal and Recovery from Coke Oven Gas: Ford River Rouge Plant Uses Thylox System: N. G. Farquhar, Chemical and Metallurgical Engineering, vol. 51, pp. 94-96, July 1944.

Coke Oven Gas (Sulfur Recovery): N. G. Farquhar, Iron and Steel, Vol. 18, No. 3, pp. 84-85, March 1945.

Sulphuric Acid from Coke-Oven Gas: W. A. Leech, Jr., and F. D. Schreiber, Iron and Steel Engineer, Vol. 23, No. 12, pp. 93-101, Dec. 1946.

Sulfur (H_2S) from Industrial Gases: Reed, Robert M., and Hpdegraff, Norman C. Processes in Removal of Hydrogen Sulfide from Industrial Gases. Paper presented before the 117th meeting of the American Chemical Society, Houston, Texas, March 17, 1950.

Johnstone, H. F., Read, H. J., and Blankmeyer, H. C., Industrial and Engineering Chemistry, vol. 30, p. 101, 1938.

Johnstone, H. F., Industrial and Engineering Chemistry, vol. 29, p. 1396, 1937.

Stack Gases of Coal-Burning Power Plants

Sulfur dioxide in spent gases of coal-burning power plants has been considered as a source of sulfur. A comprehensive study of the recovery of sulfur as sulfur dioxide has been made at the University of Illinois.[6] The recoverable sulfur could, if fully recovered, more than meet the sulfur dioxide and sulfuric acid requirements of Illinois and adjacent states.

The quantity of coal used in public utility power plants in Illinois and Indiana in 1950 was as follows:

In Illinois	12,030,578 tons
In Indiana	6,416,858 tons
Total	18,447,436 tons

The sulfur content of coal used by public utilities varies in percentages in a range of about 1 percent to 3 percent. With an increasing tendency to wash coal, the sulfur percentage will also tend to decrease. The quan-

[6]Johnstone, H. Fraser, and Singh, A. D., The Recovery of Sulphur Dioxide from Dilute Waste Gases by Chemical Regeneration of the Absorbent. Bull. Series No. 324, University of Illinois, Engineering Experiment Station, 1940.

tity of sulfur, therefore, entering into the stokers of power plants may vary from 180,000 tons as an approximate minimum to 550,000 tons as a likely maximum. Seventy to 90 percent of the sulfur in the coal enters into the stack gases. The following excerpt is from Johnstone and Singh, *The Recovery of Sulphur Dioxide, etc.*:

"Flue gases from high sulphur coals contain from 0.2 to 0.5 percent SO_2 by volume. At one plant, which burns coal containing 4.45 percent sulphur on stokers, the average SO_2 content of the gas is 0.279 percent for 10.7 percent CO_2. The sulphur trioxide content is 0.0082 percent. At another plant, burning the same coal in the powdered form, the average SO_2 content is 0.413 percent when the CO_2 is 13.6 and the SO_3 is 0.0032 percent. These values indicate that 70 percent of the sulphur enters the gas when the coal is fired on a stoker and this is increased to 90 percent when it is fired as pulverized fuel. The amount of sulphur converted to trioxide, or sulphuric acid vapor, is only about two percent of the total gaseous sulphur . . .

"Gases containing more than two percent sulphur dioxide have long been treated by direct conversion to sulphuric acid either by the chamber process or by the contact process. Dilute gases, however, are costly to treat, but are often sources of nuisance.

"The problem, therefore, requires the development of a process for the treatment of a very large quantity of hot dust-laden gases to remove a dilute constituent, amounting to several hundred tons per day, without undue interference with the operation of the plant, or excessive costs of operation."

The investigations of Johnstone and Singh also showed that the removal efficiency of SO_2 from flue gases varied from 81.8 to 98.2 percent. "Over the twelve-hour test period, during which 650,000 cubic feet of gas were scrubbed, the absorption averaged 90.5 percent, and the residual SO_2 was 64 parts per million.[7]

Johnstone and Singh found that about 90 percent of sulfur in the coal enters the flue gases. Since 90 percent of the above is recoverable as sulfur, it means that, for each 1 percent of sulfur in the coal, 0.8 percent is ultimately recoverable as sulfur dioxide. For the public utility power plants in Illinois and Indiana this would, in 1950 for example, be equal to 0.8 times the average percentage of sulfur in the 18.5 million tons of coal used each year.[8]

In the summary and conclusion of this investigation Johnstone and Singh state, "In this bulletin a new process for recovery of sulfur dioxide from dilute waste gases has been described. A thorough investigation in the laboratory and pilot plant has shown that the process is workable in every respect."

The investigation included a detailed calculation of equipment costs for a sulfur dioxide recovery plant. Although this was made for cost

[7]Johnstone, H. F. and Singh, A. D., *Op. cit.*

[8]It should be pointed out that it is possible that not all public utility power plants could install a recovery process. Also, power plants of manufacturing industries are not included in the above calculations, some of which possibly could make use of the process.

conditions as they existed in 1939, the basis of the calculations, as prepared in the report, can be used to calculate costs under present conditions. The economic position of sulfur from flue gas under existing market conditions in the sulfur industry is determinable from this report.

Refinery Gases

Sulfur is being recovered from hydrogen sulfide present in refinery gases. A plant for the recovery of elemental sulfur has been erected near Long Beach, California, to process hydrogen sulfide extracted from sour gas in adjacent refineries. The primary reason for the erection of this plant was the growing smog nuisance in the Los Angeles basin area to which the refineries were accused of contributing. The plant is reported to be recovering 70 tons of sulfur per day.[9] The process used is similar to the Girbitol process also used in the recovery of hydrogen sulfide from sour natural gas.

The reaction in this process is as follows:

$$2H_2S + SO_2 \longrightarrow 2H_2O + 3S$$

Other projects for the recovery of sulfur from refinery operations, completed or in the projected stage, are the Eagle Point, N. J., refinery of the Texas Company, the Sinclair Refining Co., at its Wood River refinery; the Standard Oil Company (Ind.) is building a 100-ton plant at Whiting, Indiana. Refineries in Wyoming and Montana produce considerable hydrogen sulfide and could process this to sulfur, if a local market developed.[10]

The recovery of sulfur in substantial quantities by oil refineries in the Illinois-Indiana area will depend on the sulfur content of the crude oils processed in this area and the projected price of sulfur after controls are removed.

In general, crude oil shipped to refineries in Illinois and Indiana is low in sulfur content, although some high-sulfur crudes from west Texas and Wyoming are processed in Illinois refineries. In a detailed report of sulfur content of United States oil fields, Smith and Blade [11] classify nine major producing areas in the United States by sulfur content. For Mid-Continent and Illinois fields they give the following data for the year 1946:

Field	Average production B/D
Sulfur content 0 – 0.25 percent	
Mid Continent	210,254
Ill., Ind., W. Ky.	14,855

[9]U. S. Petroleum Industry to Become Net Sulfur Producer, World Petroleum, Annual Refinery Issue, 1951, p. 65.

[10]*Op. sit.*, p. 67.

[11]Smith, H. M., and Blade, O. C., Trends in Supply of High-Sulfur Crude Oils in the United States, Oil and Gas Jour., vol. 46, no. 30, Nov. 29, 1947, pp. 73-78.

Field	Average production B/D
Sulfur content 0.26 – 0.50 percent	
Mid Continent	571,994
Ill., Ind., W. Ky.	21,500
Sulfur content 0.5 – 1.0 percent	
Mid Continent	146,332
Sulfur content 1.0 – 2.0 percent	
Mid Continent	33,909
Sulfur content 2.0 + percent	
Mid Continent	77,915

About 280 million barrels of crude oil is processed annually by refineries in Illinois and Indiana, located mainly in the Chicago area, the Wood River, Illinois, area and southeastern Illinois. If it is assumed that a barrel of oil weighs 300 pounds and the average content of sulfur in crude oil processed in Illinois and Indiana is estimated at 0.25 percent, the total sulfur content of oil processed in Illinois would be approximately 105,000 tons. Only a part of this appears as hydrogen sulfide in the refining process and is recoverable.

Sulfur Supplies Outside the Illinois Market Area

The preceding section covers sources of sulfur from raw materials located in the Illinois market area or shipped into this area for processing. Competition for the Illinois market from sources outside the area must also be taken into account. These potential competitors are hydrogen sulfide in natural gas, sulfur dioxide in smelter gases, pyrite, low-grade sulfur deposits in the Western states, and, remotely, anhydrites.

Natural Gas

The recovery of sulfur from the hydrogen sulfide in natural gas from some fields in Western states has become of interest as a commercial by-product. Hydrogen sulfide is recovered from natural gas as elemental sulfur by the Girbitol process. This process has been described in detail in the technical literature and is briefly described below:[12]

An absorbent solution is passed downward through a bubble tray absorber countercurrent to the gas. The rick absorbent is heated by exchange and stripped with steam in a second column. The lean absorbent is then cooled and recycled. The absorbent may be an aqueous solution of monoethanolamine, diethyanolamine, or a mixture of one or both with diethylene glycol.

The second step in sulfur recovery consists of reacting two moleclues of H_2S with one molecule of oxygen. The process employed was de-

[12] World Petroleum Twenty-first Annual Refinery Issue, 1951. p. 67.

veloped by Claus in Germany about 1880. Improvements were made in the process by I. G. Farben industries during the Second World War. In the modified process, part of the acid gas is burned with controlled air to produce sulfur dioxide and by-product steam. Combustion products are mixed with the remaining H_2S concentrate and passed over a bauxite catalyst. Reaction of the hydrogen sulfide and sulfur dioxide produces sulfur vapor and steam. The sulfur is condensed by direct contact with cooled liquid sulfur.

Sulfur-bearing natural gas is produced mainly in the Western states.[13] Recovery plants and their locations are:

Texas Gulf Sulphur and Pure Oil Co., Worland, Wyoming

Phillips Chemical Company, near Goldsmith, Texas, in Permean Basin fields

Southern Acid and Sulfur Co., McKamie field, Arkansas

Odessa National Gasoline Company and Sid Richardson, Carlson Co., Odessa, Texas

Elk Basin plant, Montana-Wyoming

Sulfur from hydrogen sulfide in natural gas is produced as elemental sulfur and is therefore directly competitive with elemental sulfur shipped in from the Texas and Louisiana Gulf Coast. In elemental form, sulfur can be transported at a low cost and becomes competitive over a wide market area.

Table 5 gives a list of states in which sulfur from natural gas recovery plants will find its principal market. Apparent consumption of elemental sulfur in 1950 in these states was approximately 55,000 tons. An additional 140,000 tons is consumed in Pacific Coast states. Sulfur recovered from natural and refinery gases in these market areas is shown by the data collected by the Bureau of Mines to be more than 150,000 tons. This, together with anticipated development, may be sufficient to satisfy the sulfur demands of the mountain states and Pacific Coast area. An equivalent tonnage of sulfur from Texas and Louisiana will be released to Midwest and Atlantic Seaboard markets.

Smelter gases

Each year, large quantities of sulfur dioxide are evolved in the smelting of non-ferrous sulfide ores. The principal source of by-product sulfuric acid at present is zinc smelters, and secondly, copper and lead smelters. Production of by-product sulfuric acid from zinc and copper smelters in recent years is shown in table 6.

Because the most important source of by-product sulfuric acid is from zinc smelters, their potential contribution must be considered. Zinc is recovered from several ores of which zinc blende is the most important and also the only sulfur-bearing zinc ore. Zinc blende contains 67 percent zinc and 33 percent sulfur. This is the principal ore in the Tri-State district, in the Appalachian zinc belt, in the Couer d'Alene district, and other districts in the mountain states. In complex

[13]There is some production of sour gas in Arkansas.

TABLE 5. APPARENT CONSUMPTION OF ELEMENTAL SULFUR IN THE SOUR GAS AREA, 1949 AND 1950*
(tons)

	1949	1950
North Dakota	174	153
South Dakota	138	20
Nebraska	1,027	1,949
Kansas	1,015	11,664
	2,354	13,786
Montana	308	517
Idaho	726	1,283
Wyoming	1,699	1,728
Colorado	5,479	6,343
New Mexico	381	181
Arizona	24,579	30,240
Utah	1,041	612
Nevada	181	110
	34,394	41,014

*Based upon tonnages of sulfur terminated by railroads in each of the states. Statement No. Q-550 (SCS). 1949 and 1950, Interstate Commerce Commission.

ores, galena, the principal lead ore, with a 14 percent sulfur content, is frequently associated with zinc ores. In addition to the sulfides of non-ferrous metals, pyrite may also be associated in the ore body. Altogether, a considerable quantity of sulfur is present in principal non-ferrous ores. In the annual output of 700,000 tons[14] of zinc from zinc blende, there is a potential supply of 350,000 tons of sulfur, as contrasted with 199,000 tons actually recovered in 1949. Treatment of lead and copper ores and associated pyrite may raise this somewhat. Nevertheless, expansion of output over 241,000 tons from all non-ferrous sources would be not more than double present output.

The possible contribution of smelter-produced sulfur to Midwestern markets, apart from the limited additional quantity producible, is also circumscribed by the demands of the local market. Sulfuric acid made

[14]Out of a processing of 814,000 tons of domestic and imported ore, a conservative figure of 700,000 tons from zinc blende has been assumed.

TABLE 6. BY-PRODUCT SULFURIC ACID (BASIS 100 PERCENT) FROM SMELTING OF NON-FERROUS ORES.*

	from zinc plants	from copper plants	Total
1941	522,000	188,200	710,200
1942	540,000	206,000	746,000
1943	685,000	271,000	956,000
1944	653,000	249,500	902,500
1945	610,938	231,697	842,635
1946	544,529	171,687	716,216
1947	598,703	126,494	725,197
1948	529,478	111,967	641,445
1949	476,932	96,344	573,276
1950	609,571	131,342	740,913

*Sources: Bureau of Mines, Minerals Yearbooks.

from by-product gases appears from the statistics to be insufficient for the local market. In addition to the production of 552,190 tons (1945-49 average) of sulfuric acid obtained from zinc-blende roasting plants, 205,255 tons (1945-49 average) were made from native sulfur.

For the Illinois sulfur market, the contribution from zinc smelters may be limited to output from Illinois zinc plants. In 1949 this was 87,000 tons of slab zinc with a theoretical maximum of 43,500 tons of sulfur.

Pyrite

Pyrite (FeS_2) is frequently considered as the most likely alternative to elemental sulfur as a source of supply for the manufacture of sulfuric acid. Before World War I, 50 percent of sulfuric acid was made from imported Spanish pyrite, 8 percent from imported Canadian pyrite, 16 percent from domestic pyrite incuding coal "brasses." Brimstone supplied only 2.6 percent and the remainder came from smelter gases. Since then brimstone has displaced pyrites from all sources. Pyrites, in order to compete in the acid market, must have local advantages such as low shipping costs of either the raw material or the acid product.

In the event of a shortage of elemental sulfur, pyrites must again be considered as a source of supply. The possible sources of pyrite are:

1. Pyrite deposits in the United States.
2. Pyrite associated with copper, lead, and zinc ores and in the tailings of mining operations and as pillars and walls in mine workings.
3. Imports of pyrite from Spain.
4. Pyrite deposits of Canada.

For the sulfur market in Illinois some of the above sources must be eliminated as impracticable.

Imported pyrite.

Pyrite has been imported into the United States in considerable quantities from Canada and Spain. The Spanish imports supplied the sulfuric acid plants along the Atlantic Seaboard mainly through the ports of Philadelphia and Baltimore. Pyrite was carried as ballast at low rates from the port of Huelva, Spain. Nevertheless, Spanish imports were unable to compete with brimstone from the Gulf Coast salt domes. Imports, which at one time exceeded 300,000 tons annually, declined to less than 13,000 tons in 1949. Spanish imports have ceased to be a factor in the American sulfuric acid industry.

Imports of pyrite from Canada have assumed considerable proportions. Since World War II practically all the Canadian shipments have entered this country through the Buffalo customs district.

Pyrite is produced in Canada as a by-product in the treatment of copper-pyrite ores at Waite-Amulet and Noranda mines in Quebec and at Britannia mine in British Columbia. Both Noranda and Waite-Amulet recover pyrite and ship it to Canadian and American markets (table 7).

It is somewhat difficult to evalute the possible contribution of Canada to the sulfur requirements of the Illinois market area. As shown in the above table, pyrite is available for export, but at the same time, Canada was an importer of sulfur from the United States. A balance sheet of sulfur production and consumption in Canada for a recent year (1949) is as follows:[15]

Production (in tons)	as sulfur
pyrite	117,581
smelter gas	144,290
Total	261,871
Consumption	
pyrite burned	34,600
smelter gas	144,300
imported elemental sulfur	327,800
Total	506,700

[15]Bonham, W. M., Canada's Sulfur Supplies, Canadian Mining Jour. vol. 72, Jan. 1951, pp. 47-50.

TABLE 7. IMPORTS OF PYRITE FROM CANADA, THROUGH THE BUFFALO CUSTOMS DISTRICT, AND TOTAL IMPORTS
(short tons)

Year	Imports through Buffalo customs district	Total imports
1934	49	21,650
1935	105	11,050
1936	157	61,650
1937	655	23,000
1938	5,745	33,580
1939	24,600	157,600
1940	89,650	90,800
1941	254,000	273,500
1942	252,000	317,500
1943	178,000	220,000
1944	151,000	186,000
1945	143,100	153,600
1946	136,100	136,200
1947	41,000	95,200
1948	74,200	84,200
1949	119,500	121,000
1950	....	....

The local demand upon Canadian sources of sulfur is expected to increase in the future because (a) shipments of elemental sulfur from the United States have been curtailed, and (b) Canadian industry has expanded, accompanied by increased sulfur requirements.

Major Canadian expansion of sulfur supply is expected by recovery of sulfur now going to waste in smelter gases of nickel, copper, and zinc smelters. Potential recovery from these sources is estimated at a total of 1,520,000 tons annually of sulfur from the following sources:

	Tons
International Nickel Company	1,000,000
Noranda	355,000
Flin Flon	165,000
Total	1,520,000

Sulfur from these sources would be recovered as elemental sulfur at Noranda and as sulfur dioxide at International Nickel. The latter would be distributed to markets in liquid form in tank cars. Unless these sources of sulfur are developed, increases in Canadian sulfur requirements in the face of decreasing imports from the United States will have to be met by roasting pyrite ores.[16]

Domestic pyrite.

Domestic pyrite does not appear to be promising as a source of sulfur for requirements of the Illinois market area. With the exception of zinc and lead mining operations in Missouri, the Tri-State district, and the Illinois-Wisconsin zinc district, the major non-ferrous metal operations are remote from Midwest markets; and freight rates, either for pyrite or liquefied sulfur dioxide, would be too high to enable these ores to compete with local sources of sulfur supply.

There are four principal deposits of pyrite ores, of 10 million long tons, or mine reserve, in Maine, Virginia, Tennessee, and Arizona. Deposits of less than 10 million tons are located in New York, Georgia, Alabama, California, and Missouri. The last may be worthy of examination as a possible source of sulfur for St. Louis requirements.

As in the case of pyrite associated with non-ferrous metal ores, a high transportation cost is involved in getting this ore into upper Mississippi markets.

Summary

The discovery of a sulfur-bearing salt dome in Garden Bay, Louisiana, does not change the need of establishing a sulfur-producing industry on a broader basis.

There is an abundance of sulfur potentially available although a higher price will be needed to exploit these resources.

The Illinois sulfur market area produces (and consumes) about 24 percent of the nation's sulfuric acid. Sulfur (as brimstone) has been available at low transportation costs over the Mississippi, Illinois, and Ohio waterways.

A decline in the supply of elemental sulfur will necessitate the development of supplemental and alternative sources, such as sour gases,

[16] A large deposit of pyrite is reported at Gondreau, northeast of Lake Superior, about ½ mile from the port of Michipicoten.

smelter gases, stack gas, coke-oven gases, pyrite deposits both primary and associated with non-ferrous ore deposits, and coal "brasses." Within the Illinois sulfur market area or brought into it for processing, there is a ready sulfur supply in the form of coal "brasses," sulfur dioxide in stack gases, hydrogen sulfide in refinery gases and coke-oven gases. There are ample supplies of sulfur among these several sources to supply all the requirements of the Illinois sulfur market if the need should ever arise.

For meeting the supplemental needs arising out of a deficiency of native sulfur supply, a process of sifting will be necessary to find the most economical source of supply from among the several sources potentially available.

Possible producers of coal "brasses" to provide a sulfur supply must evaluate the possible competitive position of sulfur from stack gases, oil-refinery gases, and imported pyrites.

* * *

Chairman Morris: Thank you, Dr. Voskuil. Are there any questions you would care to ask Dr. Voskuil?

Gentlemen, it has been a pleasure to be Chairman of this session and I want to thank you for your interest in this session. I will now turn the meeting over to Mr. Schonthal.

Mr. Schonthal: The only thing I would like to suggest is that anybody who expects to attend the dinner tonight should get his ticket without further delay because we are going to have a big crowd. We have a very good speaker. We have been a little delayed but I think we will still be able to set the dinner for 6:30 sharp. We will call this meeting adjourned. Thank you very much.

(Adjourned at 4:30 P.M.)

FRIDAY EVENING SESSION

November 2, 1951

The Banquet Session was called to order at 8:00 P.M., President Jenkins presiding.

President Jenkins: Your attention, gentlemen, please.

Honored Guests and Members of the Illinois Mining Institute:

Once again we gather here in Springfield at our Annual Meeting. Today's registration shows there are 834 registered, with 149 new members. This brings our total up to about 1,300 members.

I wish at this time to express my appreciation to the membership for their confidence in me in electing me to the Presidency of this Institute. I have enjoyed my term of office very much, which is in no small measure due to the efforts of Mr. Schonthal, our Secretary-Treasurer, who makes the office of President one of no duties. He takes care of all the details and all the things that are supposed to be attended to.

The Institute wishes to extend thanks to all those who participated in today's program. The excellent subjects presented along with the leadership of the meetings is attested to by the large membership which we have present at this Banquet tonight. I believe we have about 600 members present this evening.

Member: Mr. President, I think that calls for a hand. (Applause).

President Jenkins: We have with us a number of students from the University of Illinois. I believe there are 36 students from that University, and among them are a number who are participating in the program of the Institute. There are about 16 here on scholarships and the rest of them are here of their own choice. They are our leadership and management of tomorrow. I would like to have the students from the University of Illinois stand in a body, please. I will not call them by name, but I would like to have them stand so the membership can see who they are. (Applause) I said there were 36 here; I believe I was a little short on that.

We have quite a few honored guests with us tonight. We have more guests than we have ever had on the rostrum at previous meetings, and I would like to introduce those at the Speaker's Table to you now.

Bill Ginder of Coal Age is supposed to be at the far end there.

George W. Sall of Mining Congress Journal, Washington, D. C., and George C. Lindsay of Mechanization, also of Washington, D. C. They are the Press section.

Next is Walter Eadie, Director of the Department of Mines and Minerals of the State of Illinois.

Mr. Maurice D. Cooper of the National Coal Association of Pittsburgh, Pennsylvania.

Mr. Charles W. Connor, Director of the Defense Solid Fuels Administration, Washington, D. C.

Mr. Connor was on our program earlier today.

Mr. Harry A. Treadwell, President of the Illinois Coal Operators Association, Past President of the Illinois Mining Institute, and with the C. W. & F. Coal Company, Chicago.

Mr. W. J. Jenkins, Honorary Member of the Institute and a Past President, from St. Louis, Missouri.

Starting at the far end of the table to my right, Mr. Lawrence Kiss, incoming-member of the Executive Board, Superior Coal Company, Gillespie, Illinois.

Mr. E. E. Green, incoming member of the Executive Board, Old Ben Coal Corporation, West Frankfort, Illinois.

Mr. Moss Patterson, incoming member of the Executive Board, West Kentucky Coal Company, Madisonville, Kentucky.

Mr. J. S. Forman, also an incoming member of the Executive Board, Mt. Olive & Staunton Coal Co., St. Louis, Missouri.

Mr. D. W. Buchanan, Jr., Board Member, Illinois Mining Institute, and President of the Old Ben Coal Corporation.

Mr. William Hahman, Deputy Administrator of the Defense Solid Fuels Administration, Washington, D. C.

Mr. A. G. Gossard, Board Member of the Illinois Mining Institute, Union Colliery Company, Dowell, Illinois.

Our old stand-by, Mr. B. E. Schonthal, Secretary of the Institute, from Chicago.

Next we have Mr. William Bolt, incoming Vice President of the Institute, of the Freeman Coal Mining Corporation, Farmersville, Illinois.

Mr. Clayton G. Ball, incoming President of the Illinois Mining Institute, of the Paul Weir Company, Chicago.

It now gives me great pleasure to introduce our speaker this evening, Dr. William M. McGovern of Northwestern University, Evanston, Illinois. His subject will be "The Road Ahead." Dr. McGovern told me he was born in the United States, he lived a good part of his life in the Orient, his educational background was procured in the English Empire, and now he is back in the United States again, as a professor at Northwestern University in the Political Science Department, and he offers us "The Road Ahead." Dr. McGovern.

"THE ROAD AHEAD"

By DR. WILLIAM M. McGOVERN
Northwestern University
Evanston, Illinois

It is a great privilege and a great pleasure to be with you this evening and to discuss with you rather informally some of the most important problems that face us today as American citizens. I think all of us, whether business or professional men, are concerned with that all-important problem, is it peace or is it war? And if it is war, does it mean victory or does it mean defeat? That certainly comes home to each and every one of us.

Well, quite frankly, I do not know the answer to that $64.00 question, and I do not know anyone who does know the answer. I do not think that Mr. Stalin knows the answer, and I am quite sure that Mr. Truman does not know the answer. But anyway, I do think that there are certain things that we can bear in mind that may throw some light on this question and its possible solution.

It so happens that during World War II I had to leave the academic racket and dress myself up as a Naval officer and go down and serve four and a half years with the Joint Chiefs of Staff, and the job assigned to me during that time was to be a member of the Joint Intelligence Committee, one of the subcommittees of the Joint Chiefs of Staff. I said, "What is the job here that I am to perform?"

They said, "That is simple. You and the other members of your Committee are supposed to make an estimate of enemy capabilities and intentions, upon which the Joint Chiefs will make the war plans." That sounds very simple, doesn't it, sit down in a cubbyhole in Washington and know what the hell the enemy can do and will do!

Well, I was perfectly appalled at first, but later I found out it was not as difficult as I had imagined. It helped us to have the dispatches that the theatre commanders and secret agents abroad sent to us regularly, and our job was putting all of those bits of information together and trying to find out what the enemy could do and then also what the enemy intended to do.

We made some howling mistakes, but we were right more than 90 per cent of the time, and I think that is a pretty good batting average, and what I am trying to do this evening is to call a special meeting of the Joint Intelligence Committee with you as co-members and see if we today cannot make up an estimate of the situation dealing with enemy capabilities and intentions, and let us only hope we will be 90 per cent correct this evening.

Well, first of all we have got to make up our minds as to who are the enemy. In 1941, 1942, and 1943 it was not so difficult to answer that. We had Italy, Germany and Japan as enemies. As of 1951 who is the enemy whose capabilities we have to consider?

To my mind we have got to realize freely and forcibly that the enemy of the Uited States of today is made up of the various Communist dominated countries. Wherever we find a country under the control of the Communist dictatorship there is a secret enemy of the United States and of the American people. That means, of course, Soviet Russia, the various satellite countries of Eastern Europe, Red China and Korea. Those are the enemies of the American people. And what are their capabilities and intentions?

Well, before we can realize what they will do we have got to find out what they can do, and what can they do against us, and what can we do against them. Well, in some ways the enemy is far stronger than we are. Take the question of manpower alone. Russia has 200,000,000 people; the satellites have another 150,000,000. Red China and Red Korea have another 450,000,000. That means the enemy totals almost 800,000,000 people as opposed to our 150,000,000.

If you estimate the number of people actually in uniform, the numbei of rifles and machine guns, the enemy are about 7 or 8 to our 1, — quite a disadvantage to us.

But there are certain things in which we are definitely ahead of the enemy. We are, and they know we are, which is quite important. Among those things are strategic raw materials and the technological know-how to put those raw materials to use. As far as that goes, during the last World War, I went on special missions to each and every one of the theatres of operations and I used to spend weeks at a time in the front line trenches with our American boys. Every time it got too hot for me I would rest up with the admiralty and the generals a few miles back, so I got to know them and I have a lot of respect for the fighting men, and I also had a chance to see a great deal of the enemy and let's not fool ourselves, they were first class fighting men, both the Germans and the Japanese.

Well, why did we win? Equipment? Not especially. We had good equipment, but so did the enemy. We had good tanks, but the German tanks were just as good, if not better. We had good ariplanes, but so did the German Luftwaffe and the Japanese. And we found the Japanese equipment was excellent and their torpedoes were better than ours until the Spring of 1945.

Well, why did we win that war? Primarily because we could out-produce them. The big factor was the American production line. Way back at the time of the Civil War a general said, "He wins the victory who gets there fustest with the mostest men." That is no longer true. In these days you wins or loses who can get there fustest with the mostest men or mostest equipment.

Our airplanes were no better than the Germans', but if we had 3,000 to their 2,000 we won the battle, and in trying to gauge the strength of the Communists with our own strength we have to deal exactly with the production line in general and more especially with two major items. At one time during my service I had to draw up a list of 65 strategic raw materials and their geographic distribution. Of those 65 you can choose two of really primary importance. One of them is steel and the things going to make up that steel, and the other one is oil. Tell me your steel capacity and your oil capacity and I will tell you your ability to wage big scale war at the present time, and it is quite interesting to contrast the Communist figures with our own.

We have good figures about the Russian steel production in 1950. We know that Rusia produced 26 to 27 million tons of steel. We know that the satellite powers of Europe turned out less than 3 million tons. We know that Communist China produced about 2½ million tons of steel. The enemy Axis produced a little more than 30 million tons of steel in 1950.

What about our steel production? Our production was 97 million tons, approximately two times the enemy production put together. Remember, this is American steel production. I am leaving out English and French and German and Japanese steel production, and what is more, that figure is likely to remain constant for some time to come. The Russians are increasing their steel production, but so are we.

Now, to be sure, we have got to face the fact that Russia has enormous coal, iron ore and ferro alloy deposits. On the other hand, the iron ore and coal deposits are very badly placed and the communication between them is bad, making them good for strategic bombing.

What about oil? There the relationship is even more in our favor. Yes, Russia does have oil, quite large quantities of oil, but most of it is in one area, the famous Caspian Sea area, Batum and the Caucasus Mountains, but their reserves are dwindling and already Russia has had to rely on outside sources and the new deposits north of the Caspian Sea have not worked out so well and already Russia has had to rely on Hungary and Roumania.

What about China? They have no oil there. It means that putting the whole thing together the Russian-Chinese Communist Axis put together have about 14 per cent of American production, and again by American oil production I mean just that. I am leaving out the Far East. That is a terrific figure. You have got to have steel and you have got to have oil to wage an all out war, and that is one of the reasons why I think that the Russians are going to be somewhat hesitant in making an all out World War III in the immediate future. They hate us, loathe us, and want to lick us, but they are held back by lack of private resources.

I have said that since 1947 and 1948. Back there many people thought they were going to start a World War 3 then. I said they would not.

Now we are facing 1951 and 1952 and those production figures are still important. I think the Russians will try, if possible, to avoid an all out shooting war for several years if they can possibly prevent it. They are not going to stop fighting, but they are going to have a little fighting here and a little fighting there, hoping others will come in. That is the thing we have got to look at, — not the big war, but the series of little wars, and what we have got to do to prevent it.

So much for their capacities. Now what about the intentions of this Communist Axis? Well, I do not think we need to be very much in doubt about that. We have only got to read the books and articles put out by them to know they have got themselves pretty well organized. All you have got to read is the works of Karl Marx, Lenin, Stalin, and Mao Tse-Tung, the Chinese Communist leader.

The important thing to study is "Das Kapital," by Karl Marx, published back in 1867, but still valuable today. May I suggest you try to read all 3 volumes of Karl Marx some evening if you suffer from insomnia. It is interesting in how bad it is and how good it is. The badness consists of what is going to happen; its goodness is in what the prophesies of what the Communist technique was going to be.

People misunderstand "Das Kapital." They imagine it is an argument that you should be a Communist. Very little of it. Most of it is a series of premises concerning Communism — how it is going to take place, under what conditions it is going to take place, why it should take place.

I counted them some months back and there are 153 prophecies that he makes. I was amazed about three months ago at how many of them have proved right. Of 153 there are 146 that turned out to be wrong, so I would not recommend Mr. Marx as a good prophet.

His basic assumption was that Communism was inevitable, that it must take place in those countries in which you had the greatest development of capitalism and industrialism, and that Communism could not and would not take place in the relatively backward areas with little capitalism. He tells us that the most highly developed countries are where the revolution must take place, — England, Germany, France, footnote, "possibly the United States," and he tells us that the revolution cannot take place in Russia and China, and I think it is extremely interesting that the revolution broke out exactly where he said it could not take place!

It is also interesting that inside of Asia your Communism did not break out in the industrialized areas of Japan, Tokyo and Yokohama, but in the relatively backward areas; not in the cities of Shanghai and Tientsin in China, but in the relatively backward communities of China.

I want to point out also how right he was in indicating the tactics that the Communist governments were going to institute against the Democratic nations, and there prophecies have been developed by Lenin, Stalin, and Mao Tse-Tung. I remember a book by Lenin, "State and Revolution," and a book by Stalin,"Problems of Revolution," and last, a book called "China's New Democracy," by Mao Tse-Tung. The first two are in English, — good translations. The last one has an English translation, but it is a bad one, so I would suggest you read it in the original Chinese.

What are they saying to these people? They are saying over and over again that peace is impossible with the Democratic powers, that it is and must be war to the death between the Communist powers and the Democratic powers. That is not what I say; that is what they say. We have got to realize those are the philosophies — sometimes a hot war, sometimes a cold war, sometimes a lukewarm war, and sometimes a truce between wars in which to lick their wounds and prepare for another one, but they have no intention of coming to a long time, lasting agreement. We may have an armistice in Korea, but that is not a peace. We had better be prepared for the aspect of a temporary interlude between major struggles for power.

Now most people have realized that is true of the European Communists, but what appalls me is the fact that for so many years we were blind to the intentions of the Chinese Communists. We knew about the Russians, but the Chinese Communists were just a bad bunch of apples. Since 1945 I have read dozens of books by various people, most of which assure us that the Chinese Communists are not really Communists, they are agrarian reformers, anti-Fascist progressives, anything but not really Communists! This is and that was stuff and nonsense and I am perfectly appalled at how many people in America, including people in our State Department, were hoodwinked by those remarks.

I spent my boyhood years in China and in the Philippines. I grew up speaking Japanese and Chinese, and since 1935 and 1936 I have been convinced they were Communists, and in 1945 I was sent out to make an estimate of their intentions, the Nationalists and the Communists and the smaller groups. I had long talks with the leaders of the Chinese Communists in North China. I had a talk of over two hours with Mao Tse-Tung, the Number One boy.

I remember before I talked with him I pulled out of my pocket a memorandum from the State Department in which they said, "In your conversation with him, do not forget that Mao Tse-Tung is not a Communist!" And several times I suggested to him that he was not a Communist and each time I made that suggestion he got madder and madder, and he assured me five times that he was a Communist. I then had to make up my mind whether I was going to believe what the State Department said about Mao Tse-Tung or what Mao said about Mao, and I was foolish enough to believe what Mao said about Mao, and I was right!

He said he was not a Socialist but a Communist, and a Kremlin Communist. I was not too surprised when he said that because on the wall behind him were painted pictures of Lenin, Marx, and Stalin.

I remember when I was again back in the Far East in 1946. This time I was not allowed behind the Communist lines, and so I went to Nanking and spent several weeks there with nothing to do and lots of time to do it in, and in case you find you have some time on your hands, what do you do? You talk to the newspaper people and listen to their wild rumors, and I used to play a little penny ante with them. I said to them, "I think you are wrong. Mao is going to say so-and-so within the next few weeks" whenever the discussion got around to him.

They woud say, "Oh, I'll bet you ten dollars on that." Well, I never bet if I can help it, and then only on a sure thing, and never more than a dollar. I made five bets altogether and I won all five of them, and they wanted to know how in the world I knew what Mao was going to do. Did I have secret agents? No, I did not. I didn't tell them that, though. I will tell you how I did it.

Through Mr. Lawton Stewart at the Embassy I used to go down there and through the State Department I used to get telegraphic excerpts of what Pravda and the New York Daily Worker were saying. I got them the next day because we had good connections. I knew that Mao would get them too, but he did not have such good connections and it would take him a week to ten days to get them. I was betting he was going to follow the Party line, and he did. Therefore, I was not surprised when he followed the Party line at all, and I think I can tell you what the long term intentions of Mao Tse-Tung are.

What are they? In many cases he told me, and in other cases you can find them written in his books and various newspaper and magazine articles. He has a definite long term program. What is it? First, in time, is the conquest of the whole of Korea. He is not primarily interested in Korea because Korea has so few raw materials. He wants a victory in there to make us lose prestige, to make us "lose face," the most terrible thing in the world to their way of thinking. He thinks if he can make us lose prestige or "lose face" we will lose all our power in the Far East. Always it is not merely to achieve a victory but to make it seem as if it is an American defeat.

And second he wants to have a strategic hold over Japan. He does not, I am convinced, want to invade and conquer Japan. Japan has too few raw materials. But as he has said, "Korea is a dagger pointing to the heart of Japan," and if he can get control of Korea, and especially the port of Pusan, then the Japanese will be intimidated into surrender. But far more important to him than Korea is the Island of Formosa, or Taiwan. He who controls Formosa really controls militarily the Far East, because of the superb use of it as an aviation and submarine base, but also because it is the most industrially developed of all the Chinese provinces. He wants the factories and mines there.

But far more important than Formosa are Indo-China, Thailand or Siam, Malaya, including Singapore, Indonesia, and the islands of Borneo and Sumatra, and last, he is desperate to secure the Philippine Islands. That is his program and I know that and I know why.

Why? Industries like sugar. As I have told you, China is very backward and Mao Tse-Tung has the idea that the only solution for China's problems is industrialization, and the only way to do it is through raw materials. He thinks you can solve the population problem by taking half of the people off the farms. China has a great plenty of coal but she is very much lacking in iron ore and in the basic ferro alloys of manganese and chrome. He thinks if he can get the iron ore of Malaya and the iron ore of the Philippines and more especially the ferro alloys of manganese and chrome of the Philippines he can build a huge steel industry with his native gold.

Why Indo-China and Thailand? Simple — a rice basket. If China has the rice of Indo-China and Siam she can exist.

Why Borneo and Sumatra? Again simple. Oil. You cannot have a highly civilized civilization without oil and the only way you can get that is with oil.

Now that is his long-term objective. We were fools not to believe him. Of course he calls it a "program of liberation." The Communists have a funny set of words. They never conquer, they liberate; they do not have slavery, they have freedom, but if you will turn the words around you will know his program. And next will be Indo-China and then Thailand and then Malaya and then Formosa and Borneo and Sumatra, and then the Philippines. I may be a little wrong with the timing, but not much.

He feels if he attacked the Philippines he would have a war, but he feels if he attacks Indo-China well, what is that to us? So he wants to get the outlying areas first and then the Philippines, but the Philippines are the final stroke, and we had better bear that in mind. And there is no appeasing him; the more he gets the more he wants.

Well, there is an additional factor. What about the other nations in Asia? Where are they going to stand, with us or against us? What about India, Pakistan, Iran and Arabia and Indonesia? Let us get those countries into our considerations in trying to make as accurate as possible an estimate of our long term capabilities. What do they want?

Now that is harder to judge. It is very simple to know what the Communists want. They want what the Kremlin tells them they want. That is obviously not true of these other powers. India does not want what Pakistan wants. Pakistan does not want what Egypt wants, and so on. But there are certain points which, if we study them, will give us some notion of their intentions and which way they will jump.

And what is their ideology? Nationalism, and a special type of Asiatic Nationalism. What is the ideology and intentions of Asiatic Nationalism? Well, they have many points of dissimilarity, but they have many points in common. The first thing you have to notice is that Asiatic Nationalism is very new and hence is very fanatical. That sounds strange, but I mean it. Asiatic Nationalism is very new, very modern, and hence, very fanatical.

Nationalism is something like a childhood disease; the older you are when you get it, the harder attack of it you get. If you are a child and you get chicken pox or mumps or measles, that is not so bad. If Mom or Dad gets it, that is pretty serious. And if Grandpa gets it there is hell to pay! And so it is with nationalism. It is very strange to note how nationalism as a political force is really very popular. If you will read your ancient history you will find how little nationalism there was in ancient Rome and Greece, for example. The wars were between city states and not between nation states. You had fights between the city states of Athens or Sparta or Corinth, for example. The same way with Rome. Rome jumped overnight from being a city state to being an empire, and there never was any nation state.

In the Middle Ages we get plenty of nationalism. Boys will be boys and the girls will egg them on. You will fight over religion but not nationalism. You get a little touch of nationalism around 1500 and even in the 16th and 17th Centuries nationalism played a significant role. Who is going to run it? The Bourbons, the Hapsburgs.

But in the 18th Century you have fights for the Rights of Man against kings, but not the rights of man in the abstract, and nationalism as a really important force in Europe starts about 1800. The first really important nationalism movement was the Greek War of Independence in 1815, and then we get the Irish nationalist movement, the Polish nationalist movement, the Hungarian nationalist movement, and the Italian nationalist movement.

And you will find that those nations that achieved their nationhood early got a good, sound, healthy dose of nationalism, but those nations that got it later got a hard dose. Italy and Germany got it much later and they had a harder time of it, and countries like Ireland and Poland got it still later and got a triple dose, and then you go to Asia and they got it harder still. As a result of when they got it, it is three to five times as strong there as any place in Europe.

Let us look at the difference between Irish nationalism and Hindu nationalism. If you go to Ireland – and I have some cousins there, they are fiercely nationalistic, so they say. Now, the average Irishman is interested in three things: women first, booze second, and nationalism third. The Hindu is interested in nationalism first, women come in a bad second, and booze does not come into the picture at all. That is a big difference.

Well, the second thing is that you have got a very strange thing in these nationalist movements. In Europe and Asia these movements have usually started out as literary movements and then been transformed into political movements and then into military movements. The nationalist bunch usually starts with a group of long-haired men and short-haired women discussing folk dancing and books and banshees, and then pretty soon it becomes a political movement, and pretty soon the young men begin shooting with machine guns. So the nationalist movement starts with ballets and moves to ballots and then to bullets.

There is another curious thing about nationalist movements in that so many of them have been started either by foreigners, by semi-foreigners, or by expatriates. Why, I do not know, but it follows. I am amazed at the number of nationalist movements started by people not a member of that nationality. Take a case like Greece, for example. The founder of the first great nationalist movement in Greece was an Englishman, George Lord Byron. He was a grand man, but he didn't know any Greek except what he learned at Cambridge University, which was not much!

I had an ancestor who was a leader of the Greek nationalist movement. His name was Dr. John Scott. He got all fired up about Greek independence and he joined Lord Byron's army, and he must have been a better doctor than he was a soldier because he was captured by the Turks and he was about to be shot when he said, "Don't shoot. I am a doctor," so he saved his life, and he worked his way up in captivity until he became a court physician to the Sultan of Turkey. He never was allowed to see his patients, the ladies and various concubines. They would shove their arm through an opening in the cell and he was allowed to feel their pulse. On the basis of the pulse he had to diagnose the case and administer the medicine. In the end he was freed, sent back to England where he married and left descendants and they have been descending ever since and here I am.

One of them was the great leader of the Irish movement in the 19th

Century, Charles Stewart Parnell. He was an Irishman. His father was English; his mother was an American – not a drop of Irish in him. We think of the Irish as having a great gift of gab, being nearly always staunch Catholics, and being fond of hootch. Charles Parnell was a poor speaker, he was not a Catholic but a strong Protestant, and he was a teetotaler, and yet he was the leader of the Irish nationalist movement!

Who was the outstanding leader of the German nationalist movement? His name was Houston Stewart Chamberlain, an Englishman. There were two brothers, Basil Hall Chamberlain and Houston Stewart Chamberlain. Basil went to Japan and married a Japanese girl and ended up as a Professor of Japanese Language at the University in Tokyo. His brother Stewart went to Germany, became a German subject, married the daughter of Richard Wagner, and proceeded to write a bunch of books in German – "Life of Wagner," two volumes; "Life of Goethe," two volumes; a book on God, only one volume; "The Foundation of the 19th Century," two volumes, and that was the basis of the whole Nazi ideology. You can say that the whole of Hitler's "Mein Kampf" was only a footnote to the ideology laid down by Houston Stewart Chamberlain.

Who was the founder of the Indian nationalist movement? Allan O. Hume. He retired as a civil servant and thought the Hindus should take an interest in politics. He thought they sat on their fannies too much. He organized the Indian Nationalist Congress and he even had to pay the dues, and they eventually got excited. Then came Annie Besant, an Irishwoman, and Tilak, and Gandhi, and Nehru.

Then there are the semi-foreigners. Adolph Hitler was not really a German; he was an Austrian, and that is not quite the same, and he had the greatest difficulty in being nationalized as a German.

You can see another example of that in Rudyard Kipling, the great poet and short story writer. Kipling was one of the great leaders of Indian nationalism. He was born in India. His father and mother were English, but he was born in India and sent back to England for an education and he was more pro-British than anything else, and he wrote a poem, "What do they know about England who only England know?" The idea was that "I, who was born in India, know more about the glory of the British Empire."

Well, I can understand that. I am not a great nationalist or a leader. I am an American. I have an American father and mother. I was born in New York City, but at least I had sense enough to leave New York City at the end of 6 weeks and take my mother along with me. I spent a lot of my boyhood in China and the Philippines, and I was exposed to education in England, France and Germany. I spent nearly half my life abroad, and the net result is that I am more violently in favor of Americanism than people born in Kankakee, Kokomo and points West.

Last, the expatriates. They are really interesting. I do not know a good word for it, really. A high grade word would be a deracinated person. What does that mean? A deracinated person is one whose roots have been dug up in boyhood and transplanted in alien soil. Gandhi is one; Nehru is another, and Sun Yat-Sen of China is another, Ali

Pasha in Egypt is another, and Mossadegh of Persia is another. They differ widely, but they are all deracinated people.

Let us take Gandhi as an example. He was a very fine man and I have great admiration for him. Gandhi was born in India, but in his early teens he was shipped to England, not to be educated there, but to become an English gentleman. He wanted to feel like an Englishman, look like an Englishman and think like an Englishman. In those days he was not dressed like the pictures you are accustomed to seeing of him in a diaper. In those days he was dressed fit to kill in English clothes – tall silk hat, Prince Albert coat, striped pants and spats. He wanted to know, in those days, how to learn to play the fiddle and dance.

The English failed to receive him. They said, "Oh, a native. Go back to your place." And he got mad and the Hindus got madder and madder. You take the whole of Gandhi's philosophy. There is almost nothing there from the old Hindu philosophy. You do not get a single word of Gandhiism there. The words are not found in the Hindu books. He got the names out of Western books. The ideology he got from the west. If you ever want to make the Gandhi Cocktail, here is the recipe: Add one third of John Ruskin, English Socialist; one third of Henry David Thoreau, North American philosopher; and one third of Tolstoy, Russian Socialist. Mix well. Add a Hershey bar for coloring and you have the Gandhi Cocktail.

That same thing is true, with variations, of Mr. Nehru. He was a Hindu who went to England to become an English gentleman. He went to one of the best schools, Harrow. He went to one of the best colleges, and after becoming an English gentleman he was still a "native" to the English and he did not belong and he got mad as hell and he went back and has been one of the great leaders of Hinduism, but you have got to realize he is a Hindu who is fundamentally an English gentleman and he hates the English like hell.

I do not mind whether he hates England like hell, that is none of my business, but he also dislikes America. I have talked to him and I have told him America is different from England. I showed him a copy of the Chicago Tribune to prove to him we are not like the English! He said, "You smell too much alike." He dislikes us not directly but indirectly. Nehru is not a Communist or a Russian, but he dislikes England so much he would like to see her licked and he would like to see us licked too, and you cannot buy him. Well, I could go on indefinitely.

Here is Sun Yat-Sen, the great Chinese leader. That is what we call him. The Chinese call him "Sun Won." He was born in Canton and grew up in Hawaii. He never knew Chinese any too well – written, classical Chinese. He never studied Confucius. When he was an old man and I was a young man I met him several times and I was amazed that I knew more about Confucius than he did.

Well, I grew up in China and he grew up in the West, and you can see in his letters that he got these western ideas. He got the ideas from Thoreau, Thomas Jefferson, Abraham Lincoln and George Bernard Shaw. That became his book, "The Three Principles of Government" when you put them all together.

Those three principles are Nationalism, Democracy, and Welfare Stateism, and I asked him, "Where did you get those notions?"

He said, "Boy, don't be silly. I got those from Lincoln's Gettysburg Address. 'Government of the people,' Nationalism; 'by the people,' Democracy, Freedom; and 'for the people,' Welfare Stateism."

So much of this Asiatic nationalism is founded by Europeans who hate Europe. I can give you a Gallup Poll on that. Let's go down to Calcutta and walk along the main streets together and we will see a young man there dressed fit to kill in Brooks Brothers Clothes, short hair parted in the middle, slicked down with Kreml, horn-rimmed spectacles and patent leather shoes talking English with an Oxford accent and he hates England like poison.

Walk into one of the shops along the street and you will see an old Hindu. He is pro-British. He doesn't know anything about England.

That same thing is true in China. Walk down Bubbling Well Road or Nanking Road or Avenue Joffre in Shanghai. You will find people dressed in American clothes – Sears Roebuck, Montgomery Ward class. You know he is anti-American. If he is a Ph.D from the University of Chicago or Columbia University he is violently anti-American. Northwestern is not so bad.

Go another ten feet and you find an old fashioned Chinese, dressed in a kimono and soft slippers, with a little goatee. He is pro-American. That is important. We have never realized the ideology of the East. We have been very stupid both in our handling of Asiatic Communism and Asiatic Nationalism. We have never understood them.

There is nothing we can do about Asiatic Communism. If they are Communists now, they are forever. But there is something we can do with Asiatic Nationalism. If we will throw John Ruskin and Henry David Thoreau at them you can get them to understand.

Yes, we have got to fight it this way. We have got to realize that it take fire to fight fire. You have got a violent and fanatical Communism and we have got to match that with violent and fanatical Nationalism. Get the Asiatic Nationalism on our side and then we can sic them on the Communists. It is ridiculous to think we can police the world, but if you get Asiatic Nationalism on our side and get Asiatic Nationalists fighting Asiatic Communists then with our additional technical know-how we can turn the trick, but we have got to know their ideology.

You know, we are very silly. Every nation has got its own slogan. The words that sound good to you and me sound horrible to people in China and Japan. For instance, go down to Mexico. They like the word "revolutionary." "The Revolutionary Party." That sounds good. That is fine. Go down to Cuba. They like the word "revolutionary" too. "The Authentic, Real Honest-to-God Revolutionary Party."

But not in America. In America you can be the daughter of a Revolutionary, but not a Revolutionary.

In France you have the Radical Socialist Party, which is the good, sound right wing Republican Party, but in order to get the votes they call it the Radical Socialist Party. But in America, for God's sake don't call it that and expect it to appeal to the housewife.

Our Voice of America prepares a number of scripts that would go over well in Evanston or Springfield, but they do not mean a thing to the people they are beamed at. "Democracy" means "good" to us, but in China it means "messy." What is going to appeal to them and us? Freedom and liberty. We have got to make them see, and they can be shown, that freedom for India, Persia, Asia, Indonesia means freedom not from the weakened decadence of England, France and the lot, but freedom from the Russian imperialism posing as Communism. If they can see we will share in that love of freedom, that we do not want to dominate them; that we will aid them to be free, not to fight their battles for them, it will help us greatly.

We have been stupid in Korea. We have to fight the battles for the Koreans. We did not train the Chinese armies soon enough. It makes it look like American imperialism, which it is not, but it looks that way. Get the free Koreans to fight the Red Koreans. If we can have a crusade for mutual freedom then we are safe. We can arm this terrific force of Nationalism and then with our technical know-how we can be the leaders of a free, moral world in which we can look forward to "peace in our time" and in the time of our children. Thank you very much. (Applause).

* * *

President Jenkins: Thank you very much, Dr. McGovern, on behalf of all the members of the Institute. I am sure we will all be able to understand the newspapers more thoroughly when we read through those several definitions which you have given.

It is my last privilege this evening to introduce to you the incoming President, Mr. Clayton G. Ball of the Paul Weir Company, Chicago.

President Ball: Gentlemen, I have been forcefully told that the best thing for the new President of the Illinois Mining Institute to do is to be seen and not heard, and I intend to comply with my instructions. I do wish to express my deep appreciation for your expression of confidence in selecting me as your President and to assure you that with the help of the newly elected members of the Board and especially with the unfailing guidance of Mr. Schonthal I will do the best I can. Under those conditions I feel we will have a successful year as has been the case in the past.

I hope I will see all of you here next year and a lot more members of our mining fraternity in addition. Thank you all.

I declare the meeting adjourned.

(Final adjournment at 9:15 P.M.)

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THE JOY CONTINUOUS MINER

By A. LEE BARRETT
Research Engineer, Joy Manufacturing Company
Franklin, Pennsylvania

The continuous mining program that our industry has embarked on is indeed a farflung undertaking. Steady progress has been made but it takes a lot of experience to evolve a completely integrated continuous mining system. I fully agree that continuous mining is not a machine; it is a system, and mine concentration will be one of its important factors.

During the development of our machine, we have encountered many problems in the field. Element design has changed two or three times basically and at the present time there are some improvements that have not been embodied in any machine of that type which were developed as a result of our experience underground.

The general character of these improvements lies in four categories. First, there is the problem of preventing trouble. A continuous machine is not very continuous when it is broken down and not operating, so unusual attention must be directed to designing in such a way that trouble will not happen. We feel strongly that in the long run we must be much better than we have been in conventional loading machines. Loss in tonnage shows up immediately when continuous mining stops. Another important consideration is the necessity to provide accessibility for adjustment and inspection. Hydraulic hoses and machine parts do wear and fatigue, and it is necessary that we be able to inspect and replace those items. So a great deal of attention has been given to the gradual modification and perfection of parts and elements to make possible this quick inspection and easy adjustment.

One thing that cannot be lost sight of is the question of replacement. It must be possible to replace units of the machine with maximum ease. This must be taken into consideration in design. These are the kinds of attacks our engineers have been making on the problem.

Some New Developments

We have come out with some relatively new developments in continuous mining. One of the things obvious from the beginning was that few operators are perfect with a machine of our type, where the control of the boom upwards and downwards is governed by the operator. It is like playing the piano. Skill is required to make a smooth top and a smooth bottom at the right place and since some operators have that skill and others do not, our attention has been given to designing an automatic stop and bottom control device. This design came out rather simple. It is essentially a hydraulic brake, such as is on your automobile, with a lost-motion device added. A dial chooses the amount of lost motion desired when the brake is applied, and controls the machine boom, within perhaps one-sixteenth of an inch of the given chosen spot. That no doubt will improve the clean-up and coal quality.

Another important development from our point of view is the rotary ripping head. That is something we have been working on for two or three years. The first test model is over two years old. We have learned a lot and no doubt there are still some things to learn. However, the rotary has conclusively proven a number of advantages. One is longer bit life; we have nine bits in the rotary drum, which replace some 80 bits previously used in the chains. Interesting and somewhat surprising to us, these bits will last eight to ten times longer than the individual bits. Apparently, the reason is that the bit is more deeply submerged and has more bursting effect than cutting effect. Another advantage of the rotor is lower maintenance cost resulting from the fact that four out of six of the original chains are not used. Finally there is the lower power consumption—a drop averaging 30 percent. Perhaps the most interesting point of all is that the coal size has greatly improved. The minus 1/4 range of coal is approximately cut in half with a rotary head with the possibility of an even greater improvement in the future. At least, it does bring continuously mined coal up into a class with coal mining by other methods as far as the smaller sizes are concerned.

One of the other things we have men doing in th past two-year period is studying the matter of dust control. All through the coal mining operation we have the dust problem and a great deal of work has been done with high-pressure water, which has met with considerable success. However, there are some applications where water is not too favorable from the point of view of the screening or cleaning.

Making the sump cut

Continuous miner loading into Shuttle

We are at the present time experiencing some rather successful tests on the use of foam. This, to my knowledge, first started at Penn State. We have been following the program they originated, making a number of variations. There seems an excellent opportunity of providing even better dust control than we can have with high-pressure spray water as foam spreads the water out over a much wider area and removes the dust more effectively. No doubt we will hear more about foam in the future.

This year we have a new form of miner—the 24-in. walking machine. This we feel is an interesting development in that it greatly simplifies the structure. Essentially, as far as transportation and operation at the working face is concerned, the moving parts are reduced to one main element, whereas before we had sumping slides, turntable bearings, turntable and caterpillars. Now one element or shoe bears on the floor and is completely universal in its conduct, and can move the machine in any direction.

This machine sumps to a depth of 24 in. As one cut is finished, the approach to the next cut is measured by the walking machine itself, so that the operator does not have to feel his way to the face. The same thing is true with respect to turning as here, too, the element width is measured. This will save operating time and will improve operating efficiency in that the exact cut, the exact column of coal, will be attacked, whereas before the column width attacked was in the hands of the operator.

The traveling rate of the walking machine is somewhat slower than the caterpillar machine. The caterpillar is 35 ft a minute, which is, in our opinion, about the most economical moving speed. The walking machine moves 25 ft per min, walks automatically and can go straight ahead or in a curve.

Looking In The Future

In considering continuous mining in general, it is certainly true that the over-all system will be the most important consideration—cost and production wise. If today we had an absolutely perfect continuous miner in itself that we could mine coal at an amazing rate per minute, we still would not be able to realize high over-all production. Operations behind the continuous miner must first be improved.

First, we must consider the mining system, but in order for a mining system to be adapted to this philsophy, we need some new tools. One attack on the new tool problem, with respect to transportation, is the extensible mobile belt conveyor. One model is a 24-in. belt, which will advance 60 ft. The tail pulley is on caterpillars. The rollers are carried on flexible cables. They line the belt in transit so that the machine and its belt is quite clearly insensitive to exact location. After 60 ft have been traversed, an additional 120 ft of belt is provided and a 60-ft extension is installed in approximately ten minutes. The total possible extension of the 24-in model is estimated at the present time at 600 ft. There will be produced later a wider belt which will probably extend at least 3000 ft. The extensible belt, in our opinion, is a good solution to this general transportation problem, in that it is a simple device which can be depended upon to operate with regularity.

Starting a cross cut

It is believed that at least half of cost reduction in the future will be realized from such general changes. We will wind up with our mine in a small package. It won't be scattered over wide areas as most mines are today. It seems entirely feasible that we should get 5,000 tons a day out of a working area having a total length of 600 to 800 ft. That is undoubtedly a bit in the future, but not too far in the future. We certainly will find continuous mining machines working in a multiple-unit section, perhaps six or eight, very close together, and problems of supervision, drainage and ventilation and the other problems connected with mining can be reduced greatly since the mine has become a small package.

It is very important in continuous mining to have equipment which will stay on the line. If it is down, it won't be mining coal, and that shows up in dollars and cents in a hurry. In an extensive belt of this kind, we have one caterpillar drive unit in the tail roller, one in the storage unit, which works each time the room is worked out, one hydraulic motor. The machine is fairly simple, and we are quite sure it will be reliable.

Another approach to the transportation problem is the stainless steel shaker. Our people have been working with this device for five to seven years. Mr. Joy has a lot ideas, and this is one of them. At the present time it is not produced in the form that appears to me to provide the greatest hope for transportation behind the continuous miner, but it certainly can be used for that purpose. It is a cheaper type of device certainly than the extensible belt. The difficulty in connection with using shakers of this kind behind a continuous machine would be the question of extension. While the extension is relatively simple, it is not as simple as pushing a button and advancing the unit forward. Two jacks in this particular unit must be moved each time the tail section is advanced, and the belt must be retensioned. That is a simple matter, compared to adding a shaker pan. It perhaps represents a third of extension time, but we cannot waste that time now, and in order to use the conveyor behind continuous mining, it must have a mobile tail unit. However, it is a cheap means of transporting coal and no doubt will find many applications, particularly in pitching seams.

I am sure we all agree that there have been great strides made in continuous mining. What has happened in the past two years is to me more or less amazing. I have been living quite close to it. We have new ideas cropping up and no doubt in the next ten years the engineers are going to live a very vigorous life. We will have new developments coming along, at as great a pace as they have in the past, and without doubt it will be very much to the good of the industry.

Reprinted from 1951 "Coal Mine Modernization" Yearbook through courtesy of The American Mining Congress, papers presented at the American Mining Congress, Cleveland, Ohio, May 14-17, 1951.

THE GOODMAN MINING AND LOADING MACHINE

By M. F. CUNNINGHAM
Vice-President, Goodman Manufacturing Company
Chicago, Illinois

The Goodman Manufacturing Company has designed and built one model of a Mining and Loading Machine. This first was placed in a mine in southern Illinois on November 1, 1950, and remained there until April 10, 1951, when it was brought back to our factory in Chicago, cleaned up, and is now on display here at the Exposition.

Before commenting on the results we obtained in our first field tests, a general description of the machine should be given. It consists essentially of three parts; a main chassis mounted on caterpillar treads, a rear conveyor which swings through an arc of 90°, and a cutting and loading element which also swings through a 90° arc.

Description of the Machine and Operation

The mining head has an overall mining width of 3½ feet. This head consists of a cylinder held between two parallel arms and driven by two cutter chains. The digging cylinder has five cutting discs spaced on 6 inch centers. Each disc contains 8 bits. Also rigidly mounted to the cutting cylinder are ten conical shaped roller wedges. There are 19 cutting bits in each of the two driving chains, thus making a total of 78 cutter bits in the entire mining head.

Each of the five discs on the cutting cylinder is set to cut kerfs 2½ inches wide. The two driving cutter chains cut 4¼ inch wide kerfs. This leaves a 3½ inch core between each cut. These cores are wedged off by the conical roller wedges mentioned above. Thus 50% of the mining is accomplished by cutting and 50% by wedging.

The cutting head can cut from 6 inches below the mine floor to 64 inches above the floor, giving a total range of 70 inches. Immediately below the cutting head is a gathering or loading head similar in design to those used on our conventional track and caterpillar mounted loading machines. This head normally floats along the mine bottom but can be raised or lowered by hydraulic power for tramming purposes.

The mining head is designed to cut downward from top to bottom. The coal taken from the face, therefore, falls directly in front of the loading head and is picked up by it and placed on a through running chain conveyor. The mining and loading element can be sumped to a depth of 18 inches with the main chassis of the machine remaining stationary. A complete cycle consists of sumping the head to a depth of 18 inches at the top of the seam, then cutting downward to the mine floor, withdrawing 18 inches and swinging over 42 inches and upward to complete the cycle.

The cutting and loading mechanism is driven by two 75 hp. continuous rated, water cooled motors. One 8 hp. continuous rated motor is used to drive the main conveyor. One 7½ hp. one hour rated motor is used to drive the two tandem hyrdaulic pumps. Two 7½ hp. one hour rating motors are used to drive the caterpillars for tramming. There are, therefore, a total of six motors on the machine, totaling 180½ hp.

The overall dimensions of the machine are as follows: 27 feet long, 90 inches wide, overall tramming height 34 inches. The minimum width of working place is 10 feet, the maximum width is 18 feet. The coal line height is 28 inches. The conveyor is 20 inches wide. The machine will turn a 12 foot cross cut 90° from a 12 foot room or entry. The operator is 15½ feet from the coal face.

Results of the Test Operation

In building our first machine we attempted to design into it the following six important functions: and below is a statement of our opinon as to how well we have succeeded.

1—Flexibility

2—High capacity

3—Ability to produce coarse coal

4—Ability to load all coal mined

5—Production of a minimum amount of dust

6—Low maintenance

1. We have definitely proved that the machine has full flexibility. It can follow uneven or rolling bottom and it can drive right angle cross cuts 12 feet wide from a 12 foot entry.

2. We were attempting to get a capacity of 2 tons per minute or better, which, we felt, would enable us to produce about 420 tons of coal in a 7-hour shift, based on 50% operating time. We have almost reached this rate but not quite. With the digging cylinder illustrated here, we have attained better than 1¾ tons per minute and we have every reason to believe that we can push the mining rate to over 2 tons per minute by making certain changes in the operation of the machine.

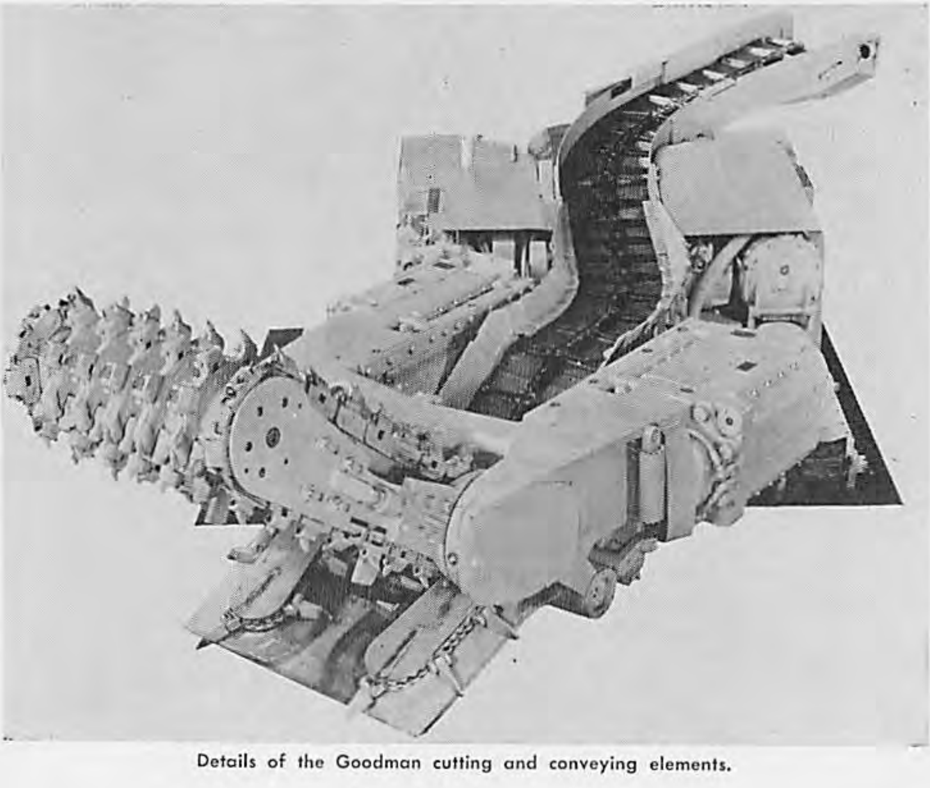
3. We have been somewhat disappointed in the results we have obtained to date with the digging cylinder described above. This has produced 70% plus ¼ inch and 30% ¼ inch by zero. The percentage of the extremely small sizes in this ¼ inch by zero group is somewhat larger than we had hoped for. We have reason to believe, however, that the results we have obtained with this first head in coal sizing will be

A general view of the Goodman machine

greatly improved by other types of digging cylinders which we have designed and built for test.

4. Our loading mechanism has proved very satisfactory in that it loads practically all of the coal taken from the face. There is some small spillage which we believe will be overcome completely with some slight changes on the loading head.

5. It is difficult to make a statement regarding the amount of dust made by our machine. Our mining head attacks the face at the roof and mines downward. The coal is thrown to the bottom directly in front



Details of the Goodman cutting and conveying elements.

of the loading head. We have found that the operator has excellent visibility of the front of the machine when it is running. We use watei under pressure in order to further reduce the dust.

6. Basically we feel confident that we have a low maintenance machine. We make this statement in spite of the fact that we were not able to operate for a full shift at any time during the test because of breakdowns on the machine.

Improvements to Be Made

We found several "bugs" in the design. One of the most serious, and the one which resulted in our not being able to get a full shift's operating time, was the take-up device for the main conveyor chain. We use a through running conveyor which eliminates the need of a hopper. Since both the mining and loading heads advance and retract 18 inches in their operating cycle, it is obvious that a take-up device must be provided for the conveyor chain which serves the gathering head. The design and location of this device gave us a tremendous amount of trouble.

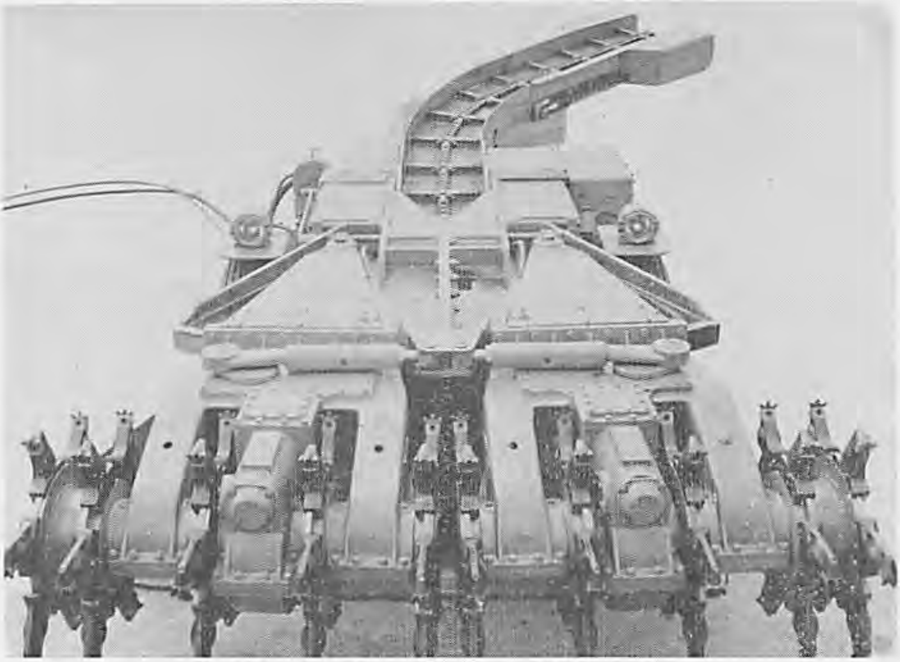
When the machine was running free, the take-up device performed perfectly. When mining, however, fine, damp coal was carried back into the take-up device by the chain flights and deposited in and around the device. This dust gradually built up to a point where it prevented the take-up from operating. When this happened, the machine had to be stopped. This trouble often caused breakage. The difficulty with this take-up could not be overcome without its complete redesign and relocation. Fortunately, we know how and what to do and a new design will be incorporated in the machine before it is again sent into the field for further test.

We encountered further mechanical difficulties with the machine which resulted in lost time. These, however, have been largely overcome and we have no fear of them in the future. As a result of the above difficulties, we are not in a position to quote any large tonnages per shift. We have had no electrical trouble whatsoever on the machine and are well pleased with its low power consumption.

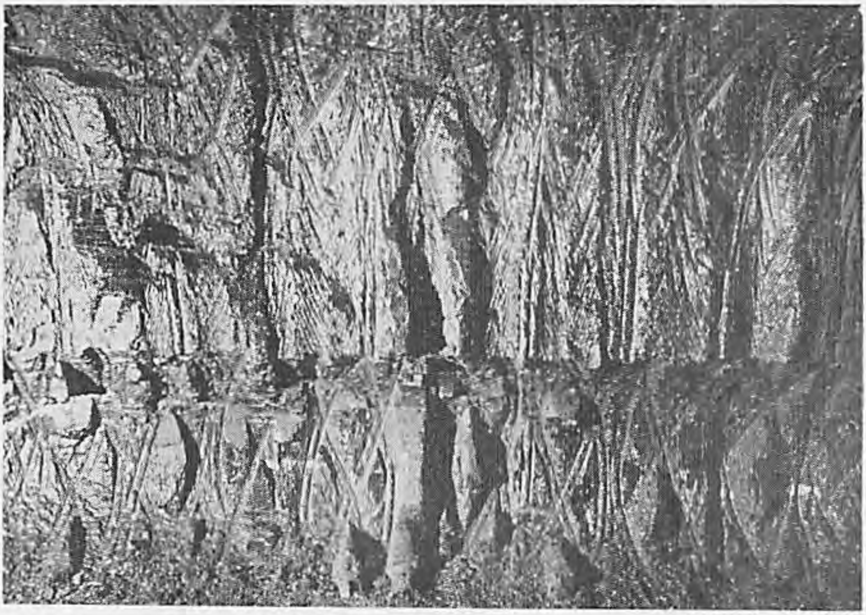
Conclusions

In conclusion, the Goodman Company is very confident that the principles incorporated in the design of this first machine are well founded and will result in our having a good commercial machine in the foreseeable future. We are commited to the policy of a thorough working out of all mechanical difficulties in the mechine before offering it for sale. This calls for continued field tests and such tests will continue after this machine has been rebuilt to incorporate all of the changes found necessary in the first field test.

The Goodman Company feels that so-called continuous mining machines will have a definite place in coal mining, but we are equally convinced that conventional mining equipment will continue to hold a dominant position in the mining of coal for a long time to come.



Front view of the Koal-Master



Intersecting diagonal kerfs make diamond projections

Cut head makes sumping cut

All cutting bits are identical and travel at the same speed. They are mounted on a solid tool holder with heavy shafts and antifriction bearings. The entire cutting device may be compared to a heavy duty milling machine. This rugged construction and solid mounting of the tools permits deep penetration of each bit and results in coarse cuttings instead of the conventional bug dust cuttings. It must be emphasized that this method of cutting coal with a milling cutter produces the diamond pattern only in the direction in which the cutter is fed. Therefore, the roof and floor, as well as the ribs, are smooth.

The sumping force is produced by a combination of traction by the rubber tired wheels and special rib jacks. This arrangement works very satisfactorily but further improvement in the arrangement of the cutters might permit us to sump without the aid of the rib jacks. The machine is equipped with two roof drills, one on each side. These are hydraulically driven and have a low gear for setting the roof bolts.

The normal repetitive cycle of the machine is as follows:

1. Elevate cutter head to the roof.
2. Sump cutter to a depth of approximately 24 to 30 in.
3. Cut down with the machine stationary and the boom moving down to the floor.
4. Pull back with cutter on the floor to smooth out floor cut.

The present test indicates a very favorable KWH per ton ratio plus a steady power demand during the cutting cycle. The 60 HP motors have not become hand warm at any time. Indications are that improved bits will even improve the present power demand.

Summary

Summarizing, we can say that this principle of cutting intersecting diagonal kerfs has shown possibilities for cutting coal with very little horsepower. We further feel that this principle is adaptable to any coal structure or coal seam. Features of the machine that should be emphasized are as follows:

1. Deep cutter bit penetrations producing coarse cuttings and a minimum of fines.
2. Complete gathering of cut coal with no spillage.
3. A flexible machine that will operate in variable seam heights and all mining systems.
4. Cutting cycle easy and attractive to machine operator.
5. Machine simplicity insuring long life and easy maintenance.
6. Identical cutter bits assuring uniform wear and long life.

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SLOPE DRIVING WITH A CONTINUOUS MACHINE

By H. A. TREADWELL
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Orient Mine No. 3, of the Chicago, Wilmington & Franklin Coal Co., is a new development located one and one-half miles southwest of Waltonville in Jefferson County, Ill.

Here the No. 6 coal seam lies approximately 800 ft. below the surface and is practically level with only small local grades. The overlying strata are flat, and consist of various colored shales, siltstone and a few layers of sandstone that--with the exception of the bed rock sandstone which lies about 15 ft. below the surface—vary in thickness from a few inches up to 8-10 ft. The bed rock is 45-50 ft. thick. There was very little underground water in the strata above No. 6 seam in the area where it was planned to sink this mine.

The coal company's previous experience with high-speed single-car hoisting cages as well as with 15-ton capacity skip hoisting for lifts of 550-600 ft. has proved to be satisfactory over the years. However, it was known that slope hoisting with a belt had many advantages over conventional car or skip hoisting. Therefore, a study was made of the various problems involved in slope construction before opening up mine No. 3.

It was felt that a 16 deg. slope was the maximum that should be used. Such a pitch with 800 ft. of cover would require approximately 2850 ft. of slope to reach the coal seam.

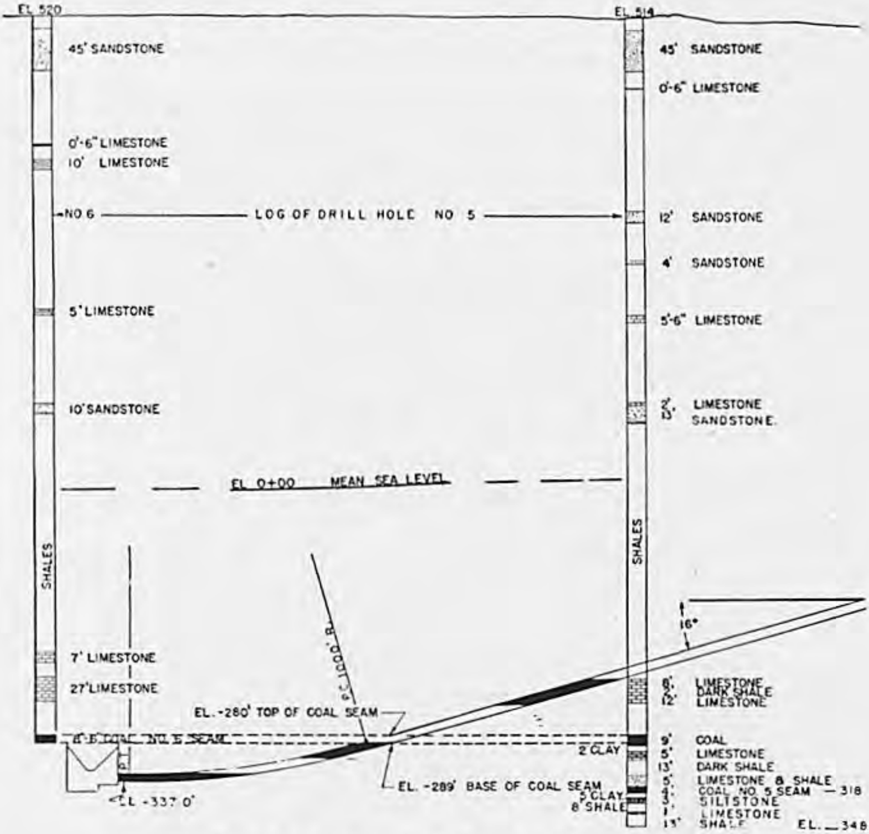
One of the major problems was to find a satisfactory belt for the job. The average high grade belt being used successfully in shorter slopes at shallow mines would require at least two or three transfer points in the slope. It was desirable to avoid transfer points if possible, and it was found that a steel cable cord belt would handle the job in a single flight. The belt manufacturer's engineers were very helpful.

The next questions were what size slope to use, and whether two small slopes would be simpler to construct and more satisfactory to operate. A careful study of the actual cores from drill holes indicated that a large percentage of the slope could be cut with a McKinlay entry driving machine. In the area where the McKinlay machines could be used no blasting would be needed, leaving the strata undisturbed and timbering would be reduced to a minimum, thus making it possible to use reinforced gunite for lining. The use of the McKinlay machine would simplify the two-slope sinking job since one slope could be used for material and one for the belt to give better operating conditions. It was decided to use two slopes 7 by 12 ft. on 40-ft. centers.

Old Machines Revamped

Two old machines, designed and built for cutting and handling coal, which would operate sucessfully on grades of 10 percent were tried and found sufficiently satisfactory. It was necessary to change the position of the conveyor from the upper part of the machine to the bottom in order to reduce its slope while operating on a down grade of 16 deg. To accomplish this the frames of the machine were turned over.

Driving of the slopes was started December 11, 1947, with an open cut 103 ft. long and a maximum depth of 25 ft. where it faced up against hard sandstone. The material in the cut above the bed rock consisted of about 15 ft. of surface soil, clay, hard pan and soft sand-



Slopes on 16 deg pitch intersect coal seam 800 ft. below surface

stone. A dragline and bulldozer were used to excavate the soft material. The hard rock was drilled, blasted and loaded in a truck with a clam shell. Excavation was completed January 15, 1948.

A rectangular section 7½ by 14 ft. of reinforced concrete was placed in the open cut extending seven ft. into the hard sandstone to make a water-tight seal. In this concrete section the top is eight in. thick, the sides and bottom 12 in. and the length 110 ft. Chimneys, stacks or openings, 6½ by 14 ft., were built into the rectangular concrete section above each slope at a point 80 ft. inby the portal. These chimneys provide an opening to the outside to assure continuous ventilation should the mouth of the portals be obstructed. The concrete section was completed March 3, 1948, during weather conditions that were bad, with rain, snow, sub-zero temperature, and plenty of wind. All concrete work had to be protected against freezing.

The operating schedule used in the sinking of the slopes was as follows: day shift, 7 a. m. to 3 p. m.; second shift, 7 p. m. to 3 a. m. The time between shifts was used principally for maintenance work, machine repair work and shooting when necessary.

Install First Entry Driver

On February 15 slope sinking was started using conventional drilling, blasting and hand loading on a No. 61A conveyor that brought the material to the surface where it was hauled away by trucks. On March 15, an 8-BU was placed in each slope eliminating the hand loading. By April 16 the face of the north slope was 247 ft. from the portal, driven through approximately 77 ft. of sandstone, 51 ft. of dark siltstone and 9 ft. of slate. Drill hole logs near the projected slope indicated that there were 500-525 ft. of various kinds of shale immediately ahead. It was thought this was a good place to install the first McKinlay machine in order to test its use in this type of work.

The machine was moved to the portal of the north slope and lowered to the face by a cable controlled by a bulldozer. It took two days to reach the face and about eight days to reassemble, install necessary power lines and reset the chain conveyor for handling rock up the slope. The machine was started April 27, 1948, with a "green crew" and only one experienced repairman on the job.

It must be remembered this machine was built to work in coal. Here it was used to work in rock.

Naturally it took time to break in the machine crew, train additional repairmen and educate the supervisory force. From April 27 to June 27, with the second shift operation starting May 16, the machine, in 30 operating days, advanced the face 136 ft., an average of 4½ ft. per day, not at all an exceptional advance, but by this time the men were reasonably well trained, the repairmen were keeping the market in shape, and the supervision had improved.

During this trial period from April 27 to the end of June the rpm of the rotor arms was reduced from 14 to 7 to cut down the dust, to improve cutter bit operation and reduce the overload on the two 70 hp. motors that drove the rotor arms.

A most serious obstacle was the fact that the bottom of the face was approximately 4½ ft. in advance of, and slightly more than 2 ft. lower than the loading point of the machine. Broken material accumulated at the face in a pile 3½ ft. high before spilling onto the conveyor. This trouble was overcome by the re-design of the propelling blades on the ends of the cutter arms and by installation of a paddle wheel to move the material from the discharge point of the propelling blades to the conveyor. This device was nicknamed "the lawn mower" by the men because of its appearance.

From July 6 to 31 the machine worked 21 days and drove 187 ft., or slightly more than 9 ft. per day.

Machine in South Slope

July performance proved conclusively that the McKinlay could do the job. All improvements that had been made on the machine in the north slope were incorporated on the entry driver to be used in the south slope. The conventional method of sinking there was discontinued the first of June with the face at 405 ft. from the portal and the improved machine was moved to the face. This machine was started August 10 and had driven 175 ft. by August 30. In the 18 days of operation it advanced about 10 ft. per day.

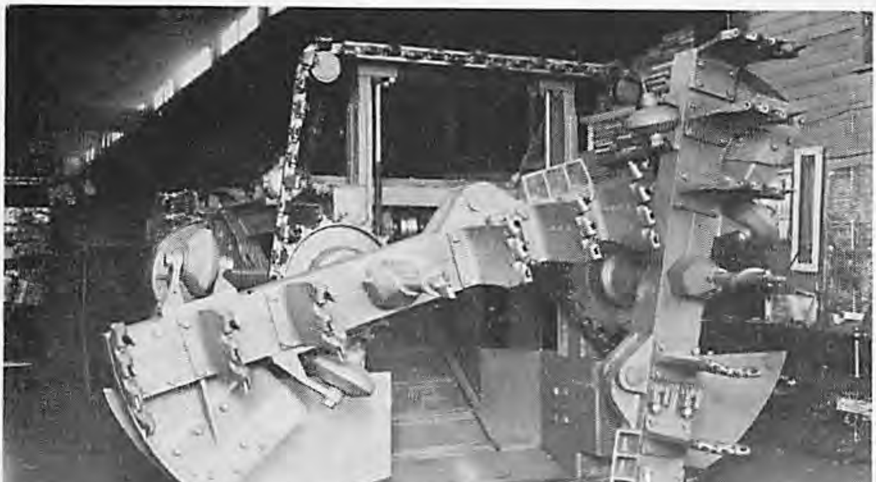
Slope haulage was the next problem. Yardage was being lost through failure of the system to handle the material. The original haulage plan was laid out with a 45 deg. crosscut every 250 ft. and track in the south slope to the last open crosscut. A surge hopper with 10-ton capacity was placed at the end of the track and a chain conveyor was used to convey the rock from the face machine to the surge hopper. A 6-ton drop-bottom car was used to haul the rock to a bin on top where it was disposed of by truck.

Roof arches intersect where North machine crossed South slope

The chain conveyor part of the haulage worked satisfactorily while the equipment was new and the pans were maintained in proper alignment. When the pans and chain became worn it was almost impossible to keep them in alignment and stop the chain from climbing in the pans, thereby allowing the pans to fill up and spill material along the sides of the conveyor. To correct this conveyor lengths were reduced by shortening the distance between crosscuts. The change improved operation, but did not fully correct it. As the original conveyors were practically worn out they were replaced with a wider and heavier unit. The new 16-in. conveyor with deeper flights was installed about the middle of September and improved the haulage. Between September 15, 1948, and January 22, 1949, the machine advanced approximately 11½ ft. per day.

During the fall and early winter the tool holders on the McKinlays were shortened from 18 in. to 12 in. and an extra cutter bit was added to the outside toolholder. These changes strengthened the toolholder and improved the cutting operation. Because the rock cores from the face, bottom and top, frequently broke into large chunks that could not be handled satisfactorily a rotary core breaker was developed that spalled off the core in pieces smaller than a man's head. The angles on the wedges on the bottom and top cutter bars were increased. These changes materially reduced the large-rock problem.

Reduced size of the material coming from the face, along with the new conveyor, improved the operation but not for long. By the middle of December the 16-in. conveyor showed considerable wear and began to give trouble. By the end of the month it was decided to abandon the conveyor part of the system. It was replaced with a 10-ton track-mounted surge hopper, with a shuttle conveyor bottom, behind each McKinlay.



McKinlay machine before conveyor pitch was changed for slope sinking

Section of slope driven by McKinlay entry driver with ribs and roof gunited

A switch was laid through the last open crosscut and the track extended in both slopes to the surge hopper behind the machines. This revised haulage was put in operation January 22, 1949, and materially improved the performance in each slope. From January 23 to June 14 the machine advanced 15½ ft. per day.

Move Machine Back

Although the shale varied in hardness all this material as well as sand or limestone strata 18 in. or less in thickness was cut sucessfully. When cutting became so difficult that it was necessary to change the tungsten carbide cutter bits in less than 6-in. advance, the machine was moved back from the face about 12-15 ft. to allow sufficient space to drill, blast and load the broken rock. The method used to load out the material from the shot face varied with the distance expected in hard material. If the distance was short, four rounds or less of 5-ft. holes, a sufficient distance was mucked back from the face to drill and then shoot the next round. This system worked well up to a maximum distance of less than 22 ft. providing the machine had been moved back a full 15 ft. The machine was used to load the muck pile and required about two shifts to trim the shot section and move into the face ready to cut. Another method used was to place a small conveyor next to the rib alongside the machine and move the shot material to the regular

First Period: Experimental
April 27-September 15, 1918. Average advance per day with the machine 6.7 ft.

Second Period: Operation with 16-in. conveyor in haulage system
September 15-January 22, 1919. Average advance per day with the machine 11.4 ft.

Third Period: Operating with full track haulage
January 22-June 14, 1919. Average advance per day with the machine 15.1 ft.

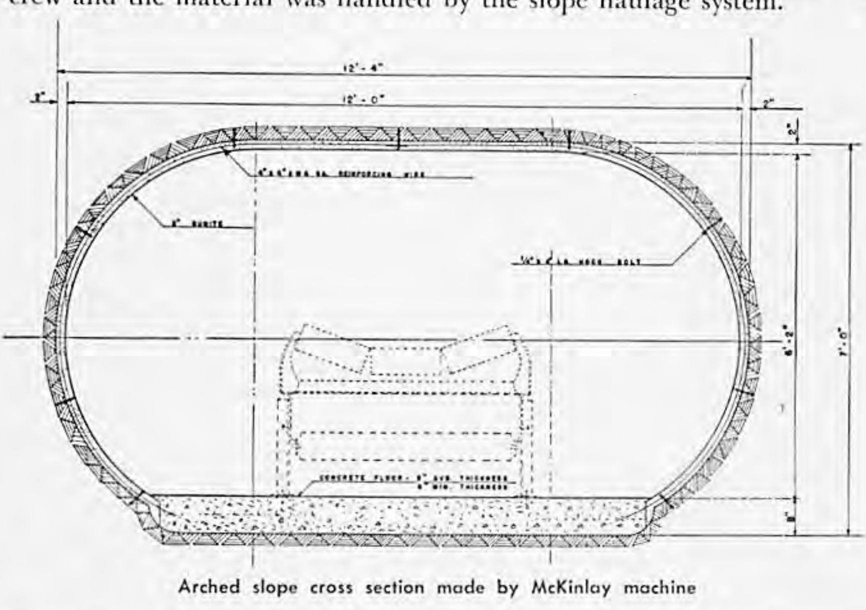
Percentage of slopes driven by the various methods employed:

Open cut.	3.6 percent of total slope distance
Conventional method.	7.8 percent sinking before McKinlays were installed
Hard rock bands.	16.0 percent bands not cut by McKinlays
Material cut by machine.	72.6 percent slope driven by McKinlay
	100.0 percent

disposal system. A variation of this method was to discharge the small conveyor onto the machine conveyor from which it was discharged into the disposal system. Any of the systems used was slow and hard work. Mucking up a 16-deg. slope by hand is a man's job.

There were a total of 21 locations in the two slopes where the rock was so hard that it was impractical to try to cut the material with the machines. Eleven of these areas consisted of siltstone, six of limestone, two of limestone and sandstone, and two of limestone and siltstone. The total distance through these areas was 911 lin. ft. with an average advance of 5.3 ft. per day.

The 11 crosscuts driven between the slopes amounted to 324 lin. ft. While this work is not taken into account in the percentage of rock that could not be cut by the machine, the work was performed by the sinking crew and the material was handled by the slope haulage system.



Arched slope cross section made by McKinlay machine

The sinking of the slopes has been divided into three general periods. The first or experimental period in which so many changes were made in the machine so as to improve the operation in rock; the second period during which a few changes were made in the machine and the haulage was improved by the installation of a larger conveyor; the third and final period began when the conveyors were taken out and full track haulage was used.

Ventilation Air Conditioned

A 5-ft. centrifugal fan rated at 75,000 cfm. was installed above the chimney in the north portal to ventilate the slopes. This fan was operated blowing. The actual quantity of air used varied between 30,000 and 40,000 cfm. In the winter the air to the slopes was passed through fin type steam coils located in the intake chimney of the north slope. The heating unit had capacity to raise the temperature of the outside air from 10 deg. below zero to a minimum of 40 deg. above. This tempering of the air gave good working conditions in the slope and prevented the freezing of the fresh gunite. Without the heating system it was necessary to wear overcoats, ear-muffs and mittens.

Just outby the last open crosscut two 5,000 cfm. blowers were installed equipped with 18-in. vent-tubing. The tubing was carried on the upper right hand rib of the slope to within 15 ft. of the face giving good ventilation at the machines. As the distance between crosscuts increased two 18-in. tubes in place of one were used to conduct the air to the face. Later, tight line brattices were installed along the right rib of the entries and coated with gunite to eliminate leaks. This line brattice was installed to clear the muck cars, the full ventilating pressure was carried behind the brattice with only a short section of tubing at the inby end to conduct the air to the face. At all times there was good ventilation at the face as well as through the entire slope system.

The slopes were exceptionally dry and no difficulty was encountered with water accumulating at the face. Down slope from the portal 311 ft. a small sump was installed in No. 1 crosscut to collect any surface water that might accumulate. The sump had a capacity of about 1500 gal. and was seldom pumped more than once or twice a week.

In order to hold the timbering to a minimum and to protect the shale from the action of the air a preliminary flash coating of gunite was used. This preliminary coating was maintained to within 50 ft. of the face at all times and closer whenever possible. The usual method of application was to place a 1/8-3/16 in. coating on the fresh surface, and a second coat was applied during the next gunite period. The two coat preliminary job was from 1/4-3/8 in. thick and proved effective in protecting the exposed ribs and roof from weathering action of the air.

Gunite equipment was carried on a three car trip with the machine on the inby end, the sand on a car next to the machine, and tools and cement on a truck outby the sand.

At the beginning of the job, guniting was done once or twice a week, but as the daily advance of the slopes increased it was necessary to gunite every other night and sometimes every night. The five-man crew con-

South slope, concrete portal area

sisted of: one foreman, one nozzle man, one gun operator, and two laborers. Compressed air was piped down the south slope in a three-inch line with 125 psi pressure at the compressor. Water was carried down the slope in a two-inch line and a small pump was mounted on the machine truck to furnish the correct water pressure. A pressure reduction valve was substituted for the pump after slope depth supplied more than 125 psi gravity pressure. The crew's working shift was from 11:00 p. m. to 7:00 a. m. and when they were not guniting they did general maintenance work, laying track, cleaning roads, timbering, or working on ventilation.

Efficient Manpower Use

The average McKinlay crew consisted of the following: ½ foreman, one operator, one operator helper, two men to look after track, conveyors, ventilation, cut jack-hitches, and any other general work, one-half repairman, and one-half man who started at 3:00 a. m. on repair shift and stopped at 11:00 a.m., also one-half repairman who started at 11:00 a.m. and worked until 7:00 p.m., making a total crew of six men per machine. Two sinking shifts with two machines, or four machine shifts of six men each made a total of 24 men.

The repair crews of four men per shift. 3:00 p.m. to 7:00 p. m., and 3:00 a.m. to 7:00 a. m. actually amounted to only four man-shifts as these repairmen completed their shifts on the machines and are counted in the six man crew.

A bull gang of four men was used on the day shift in the slopes to take care of back work.

The hoisting crew consisted of one engineer and one roperider on each of the regular three shifts per day, and required a total of six men.

Total Sinking Crew For The 24-Hour Day	
Machine Operation	24
Repairmen between sinking shifts	4
Flash Gunite Crew	5
Bull Gang, Day Shift	4
Hoisting Crew	6
Top Crew	8
Total Men	51

The top crew included one truck driver, three top-laborers on each sinking shift, or a total of eight men.

Crosscuts were driven by men included in the 51-man sinking crew. The right angle crosscuts were generally worked from both ends, the angle crosscuts from the south end with a short conveyor or 8-BU loading machine.

Slopes Lined With Gunite

As stated earlier, the first 110 ft. of each slope consisted of reinforced concrete rectangular in shape and poured in the open cut section. The next 137 ft. in the north and 295 ft. in the south slope were driven by drilling and blasting with the usual irregular rib and roof line. The ribs and roof were scaled, and "I" beams placed where necessary. A good quality cement-block wall was built and the open spaces in the blocks filled with cement mortar. The space between the solid rock and the back of the wall was filled with rock from the trimming operation.

The driving of these slopes with McKinlay machines afforded secondary advantages of considerable value beyond those of rapid advance and reduced sinking cost previously described. The arched roof and rib contour provided greater strata stability than slopes driven by drilling and shooting and the surrounding strata were not disturbed by blasting.

Use of the McKinlay machine made unnecessary the steel or concrete tunnel lining often required in slopes driven by conventional methods. In order to take advantage of the improved conditions it was planned to use reinforced gunite for permanent low cost slope protection the full length of the slopes below the upper concrete portal sections.

It was only natural that the company should give serious study to the use of gunite for this slope protection since it had been used extensively and to good advantage at its other mines for more than 25 years. Through study of the more recent mine applications, and as a result of consultation with contractors specializing in the use of gunite on other than mine construction, a plan was developed and adopted for use in these slopes.

Specifications called for a two-inch thickness of cement gunite reinforced with a 4 by 4 mesh welded steel wire netting made of No. 6

wire. A preliminary flash coating of gunite had been applied as slope driving progressed. This prevented the weathering of the shales so no further strata conditioning was necessary.

Reinforcing mesh was secured to the roof and rib by means of ¼ in. by 4 in. cinch pins or hook bolts. These pins were equipped with a lead expansion sleeve which held them tightly in the hole drilled by a small air chipping hammer. A four-man crew using two hammers were able to install 1200-1500 sq. ft. of reinforcing mesh per shift through a McKinlay driven area and less than half of this on the ribs of a drilled and shot section.

The reinforcing mesh wire was purchased in rolls six ft. wide, containing 200 lin. ft. Two pieces of mesh thirteen ft. long by six ft. wide were used to cover the 25 ft. of rib and roof from floor to floor. The reinforcing wire was lapped one mesh at all connecting joints and the cinch pins secured the connection. In order to prevent sagging of the mesh and to afford a uniform surface for the finished gunite it was found necessary to space the cinch pins on three-ft. centers laterally and about 24-in. centers down the slope. Alternate lateral rows were staggered to form a diamond support pattern. The reinforcing mesh was spaced one in. from the flash coat of gunite.

Application of the gunite was carried out in two stages. The roughing-in coat was applied to fill the space between the wire mesh and the flash coat. This coat was applied to an area approximately 15 ft. in length by 25 ft. of perimeter, or 375 sq. ft. Then this same area was given the finishing coat which covered the reinforcing mesh to a depth of about ⅜ in., making a total two-in. thickness. A 1¼ in. nozzle gave best results when using 80-90 psi air at the nozzle, and approximately five psi higher water pressure. Good results were obtained when the material hose did not exceed a maximum length of 300 ft. A 5-psi increase in air pressure was used for each 50-ft. length of hose beyond 100 ft. This set-up gave about 10 percent loss from rebound and very little sloughing of the green gunite.

Mixture used in this work was one part cement to three parts sand. The screen analysis of the sand has an important bearing on the results both as to application and ultimate strength of the finished gunite. At least 50 percent of the sand should be plus ⅛ in. and approximately ¼ in. top size. Sand with about 10 percent moisture gave better results than dry sand.

Through the machine driven area the two-inch thickness of gunite used five cu. ft. of material per lin. ft. of slope lining, allowing for rebound and enlarged area at crosscuts.

To apply gunite the roof and ribs of the slopes by methods described above, the following crew was used: two nozzle men, who alternated in handling the nozzle and shifting the material hose, one gunite machine operator, one man feeding the dry gunite mixture into the machine and two men mixing the cement and sand.

This six-man crew plus a foreman were able to mix and apply 225-280 cu. ft. in an eight-hour shift. A typical shift's work amounted to the application of 1250 sq. ft. of finished gunite, or 50 lin. ft. of slope lining.

Delivery of materials to the guniting location from the top required the equivalent of one additional manshift for each guniting shift.

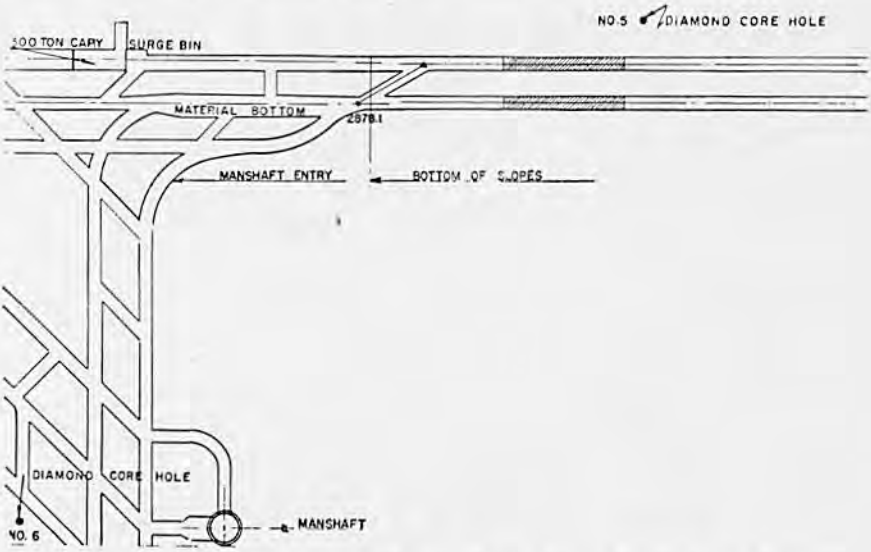
Including the four-man crew used to apply the reinforcing mesh preparatory to gunite application, a total of 11 workmen and one foreman was chargeable to each shift of slope lining.

Following completion of slope lining a reinforced concrete floor was placed in the slope from the portal to the back end of the underground surge bin machinery gallery. This floor was poured to a minimum thickness of six in. and used an average of about eight in. of concrete. The floor in the McKinlay driven areas was never more than six in. high or low, but varied considerably more through shot areas. The same type wire mesh reinforcement in the slope lining was used for the floor. A 12-man crew placing ready mixed concrete averaged 100 lin. ft. of slope floor per shift. The floor was finished to a continuous and accurate grade so that the belt-conveyor chairs were set on the floor without need for further leveling.

Benefits Summarized

Underground conditions encountered during the progress of this work were good. Just what the effect of machine driving had to do with promoting these conditions is an intangible quantity. There is much reason to believe that the elimination of blasting through all except the hard rock areas can be given credit for the little timbering required.

The fact that the machines were operating on continuous survey lines for both lateral alignment and vertical grades resulted in a uniform section devoid of the usual wide and narrow clearances.



Slope bottom layout provides surge bin for belt loading with manshaft and materials-handling facilities

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MECHANICAL LOADING WITH BRIDGE CONVEYORS

By A. B. CRICHTON, JR.
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Johnstown, Pennsylvania

Today, many operators of progressive mining companies are thinking and planning for continuous mining. We will all agree that the theory of continuous mining is sound but its practical application is another story. For many operators, the results accomplished to date do not compensate for the additional problems created. The idea of mining continuously is not new; it has been the dream of mining engineers and machinery inventors for some 75 years. Until recently, it appeared fantastic to many practical mining men, and as far removed from present day equipment and methods as our "off track" equipment did to the miner's pick and shovel some 15 years ago.

It is difficult, during those periods called "normal times" in the coal industry – when a portion of the industry is operating at some profit – to interest but a few in supporting new developments or assisting in financing research programs for coal production and coal utilization equipment. As a result, individual coal companies have either had to "go it alone," or fall in line with the rest and become guinea pigs for the manufacturers of mining equipment, hoping somebody, someday, would come along with something that would save our scalps.

Fortunately, this attitude on the part of coal producing companies has changed considerably for the better during the past several years. Since the advent of agencies such as Bituminous Coal Research, there has been a greater concerted action on the part of many large and small producers, to mutually help ourselves. This program has been generously assisted by the equipment manufacturers. However, great enthusiasm and even greater impatience is evidenced when cost reductions are urgently needed because of diminishing markets, lower prices, and increasing wage scales.

Research, and the subsequent development of revolutionary equipment, often seems slow and is always very expensive. Without a doubt, the industry expects too much in too short a time. The efforts of the equipment manufacturers and the various agencies to develop cost-reducing equipment have been admirable and not in the least insignificant.

The coal industry, like a sleeping giant, has been awakened. It is recovering from its lethargy and, not unlike the resurgent Phoenix, it has risen in youthful freshness from its own ashes.

Difficult Problems Posed by Continuous Mining

Many of us are already familiar with the problems encountered in an attempt to mine coal continuously. Many of these problems will be solved, but some, perhaps never. Initial capital investment will be large, not only for face equipment, but for the cleaning and drying plant. Increased power and ventilation requirements are imposed. Often, gas is suddenly liberated in large quantities. Dust is always a problem and the only way it can be minimized is by piping water to the face for spraying at high pressures. This, in turn, increases the moisture content of the run-of-face product and often complicates screening on the tipple. The roof is always a problem in any coal mine, I don't care how good it is. It must be handled properly – supported, pinned, taken down, broken off behind timbers or cribs, but it's always there and it falls only one way. Every one has a peculiar roof and in only a few places is it peculiarly good. Very few so-called continuous miners can operate continuously because of the transportation system and most of us would have to spend enormous amounts of money to provide continuous haulage.

The continuous miner has no face preparation. This is a seriously limiting and inflexible feature, especially since the machine mines its coal from one or two places. Perhaps the analysis of the coal in the property varies considerably; today the seam may be excellent – better than it ever was – and tomorrow, it may be terrible. But the operation can't jump from one good spot to another and many companies producing a limited tonnage from a property cannot cope with such a problem. Perhaps limited recoverable acreage does not warrant a large capital expenditure for increased tonnage and a cleaning plant. There may be other limiting factors, too, such as markets, taxes, and the labor supply. Think back to the days of pick mining when we got a cleaner, blended, uniform face product. Mining then was certainly less complicated, but most of us couldn't live with pick mining today because of our high wage scale.

A continuous miner in our intense desire to get well quickly, is suggested as a panacea for many ills, but we belatedly discover that we've bought more trouble than ever existed originally. My view is that we are not proving anything by having a machine grind out, drill out, rip out, burst out or vibrate out coal without stopping, for six or seven hours, unless such a mehod is really improving our situation – from all angles. in the final analysis, we are all seeking the same fundamental result – a merchantable coal at a cost which will provide us a profit. To many of us, reduced costs will permit lower prices, which, in turn, will enable us to retain business that is about to convert to oil or gas. Then, too, there is always the desire to regain lost markets.

The foregoing is related to the theme of this paper since it is the result of considerable investigation and evaluation in our effort to solve a problem peculiar to us. This presentation is not to be construed as an indictment of continuous miners or the principle behind continuous mining; it is straight reporting on development of equipment and a system which best serves our own company's needs, and which may serve yours. Following is an account of the conditions which guided and controlled our planning.

A Continuous System With Loading Machines

We operate a relatively new mine (opened 1944) producing very excellent quality coal from the erratic Sewell Seam in Nicholas County, West Virginia. The seam varies in thickness between 30 and 55 inches. The roof is good and the bottom is hard. Maximum grades rarely exceed 1½ percent. The coal, which is of firm structure compared to most coals is southern or central West Virginia, is shot with compressed air and our product is 75 percent coarse over ⅜ inch. There are no banded impurities in the seam, but frequently when coal higher than average is encountered, a bone coal appears at the top and occasionally from 2 to 8 inches of draw slate come with the coal. We have three calcium chloride washers to remove free impurities in the ⅜x8-in. size. The ⅜x0 coal is loaded raw and rarely exceeds 4% ash or 0.60% sulphur. For nine or more months out of the year, we enjoy a good market for coals of domestic size and the differential in price between screenings and prepared sizes is as much as \$2.50 to \$3.00 per ton.

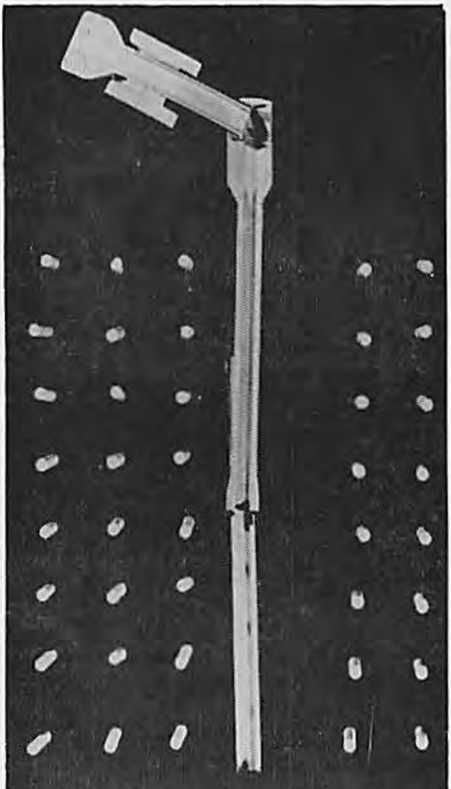
This is a 440 volt A. C. all-belt conveyor mine with some 4 miles of 30 and 36 inch conveyors in operation as of this date. We are using conventional equipment which consists of shortwall cutting machines transported on crawler trucks, flexible shaft drills connected to and operated by the mechanical power of the cutting machines, loading machines, shuttle cars, shaker feeders which receive coal from the shuttle cars to regulate its flow to the panel belts, chain flight conveyors, and, as mentioned before, a compressed air system for the shooting of the coal at about 10,000 p.s.i.

In spite of this equipment, good natural conditions, and a very efficient, low labor cost haulage system, it was urgently necessary to greatly increase tonnage per man shift to reduce costs. After careful consideration, we did not believe that any so-called continuous miner on the market today could be satisfactorily adapted to our conditions and give us a decided improvement, from every standpoint, over our present methods.

The Piggyback Bridge Conveyor

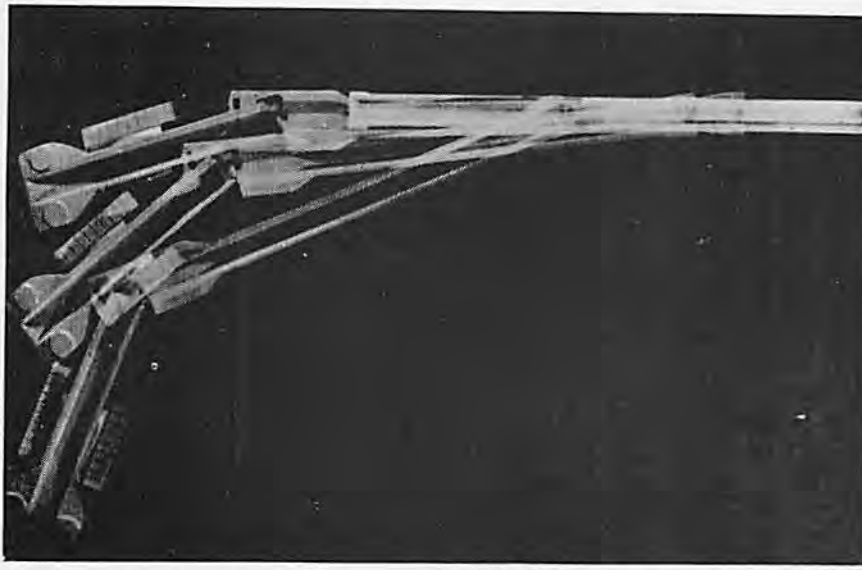
Our search for a more continuous loading arrangement has resulted in the development of a unit employing conventional equipment with one significant but simple and inexpensive addition. This innovation is the bridge of "piggyback" conveyor which links the loading machine to a chain flight conveyor and permits the loading of coal at a face, almost without interruption. It so successfully bridges the gap between loading machine and conveyor that the two combine to form one entire system which operates as one continuous loading machine. In this all-conveyor mine, no one else so much as pushes a button between the loading machine operator and the tipple and coal moves continuously from the face to the surface.

The piggyback conveyor combines in one superimposed, individually powered machine, advantages such as, double jointed flexibility, tele-



Pivot action at loader boom permits operation in close timbering

scopic effect of extension and retraction following the loading machine since they are connected, automatic load-centering eliminating spillage, quick attachment to and detachment from the loading machine. These are the keys which have unlocked the solution to the problem of continuous loading with conventional mobile loading machines. This system is adaptable to all seam heights and the chain flight conveyors operate at capacities far beyond those previously experienced. A converted loading machine with bridge conveyor attached is no higher than the original, standard machine. Operation is possible under any conditions of low seam height where present, conventional loading equipment is used.



Diagrammatic view emphasizes the flexibility of the unit

Maneuverability is greater than with any mechanical arrangement in service today, because of the two "wishbone" pivots which together give a complete 360° pivot action and keep the load centered regardless of position. The 180° action of the loader at the point where it is connected to the conveyor, gives it twice the pivot action of a loader with a swinging tail conveyor. The discharge end is carried on a four-wheeled "dolly" which travels back and forth on the flanged conveyor line pans, permits the unit to load the room or entry conveyor, positioned at an angle of 90° either side. The unit can reach either side of the conveyor line about 35 feet for the purpose of driving cross-cuts. This is the almost-in-line combined length of the 14-foot converted loader and the 26-foot piggyback, when connected. This permits rooms or entries on 70-foot centers and the breakthroughs can be driven half distance from either side.

One of the major difficulties with mobile machines loading directly on chain conveyors is the trouble encountered when operation is attempted in more than two rooms or entries. Insufficient maneuvering space is provided between end of the pan line and the face in the center places. In West Virginia, for example, three entries must be driven, to comply with the mining law, in panel sections where belts are used, since belt conveyors are not permitted on either intake or return airways. They must be placed on "neutral" ventilation by bratticing both sides of a center airway. As a consequence, at least three entries must be driven.

A feature of the piggyback is retraction of the unit completely out of the way of the ramming loader and other face preparation equipment. This is possible since the tail pulley of the main conveyor need not be

View of unit showing the dolly support of the discharge end

carried close to the face as is necessary for hand loading or with conventional loading machines. The shorter, more maneuverable converted loading machine makes the operation of three or more places no problem at all.

Operating Crew and Results

The loading crew consists of the loading machine operator and his helper. The helper's duties with the machine require but a small portion of the available face time; he connects and disconnects the loader from the piggyback which remains in the place; he handles the cable when the machine is tramming; he may occasionally knock down some hanging coal, but this is unusual in low seams where the head of the loading machine can be raised to loosen it. His duties, for the most part, are timbering, resetting safety posts, positioning pans and chain to be added when the face is loaded out, and, if a cutting machine is stationed at each face, he may have it sumped in for the cutting crew when they arrive.

The loading machine operator devotes his complete attention to loading coal – loading almost continuously. He never has to look away from the face to locate his transportation medium – never has to reposition his tail conveyor – never has to tram coal using his loading machine as a shuttle car – never has to worry about spillage – and never has to stop for pan-ups during the loading cycle.

A standard unit crew consists of five men – two with the loading machine, two with the cutting machine, and a utility man who supplies the faces with timber, rock dust, pans and chain. He also extends compressed air line and sets timber. If coal from panel belts is loaded into mine cars, we try and arrange the set-up so one boom man will handle the coal from at least two piggyback units.

A happy combination of equipment is the primary reason for the high tonnage per man shift on these units. We are cutting with Goodman shortwall machines with a 40-inch per minute feed, equipped with bug-dusters. Attached to the gear end of the cutting machine through a permanently attached speed increaser is the 900 r.p.m. auger speed, Crichton flexible shaft drill. This is an all-mechanical unit which enables us to drill during the cutting cycle. Drilling time per 3-inch diameter, 8-foot deep hole to accommodate Airdox cartridges, is 20 to 25 seconds each, so that an entire face some 30 to 40 feet wide, requiring 8 to 10 holes, can be drilled in less than 5 minutes. This high speed, light weight, mechanical drill was developed by our company. The cutting machine and drill unit is transported between faces on a Joy caterpillar truck. Our loading machines are 12-BU Joys. With this balanced arrangement of face equipment, our crew members perform all necessary face duties; for example, the cutting crew also drills, shoots and sets timbers.

All standard caterpillar-mounted loading machines are adaptable to the piggyback system, provided the capacity of the machine is not greater than the capacity of the transportation equipment. The conversion is simple and inexpensive, requiring the removal of the conventional long, swinging boom and the swing jacks with necessary hydraulic attachments. A short, straight tail conveyor with the necessary hitching device for connection to the piggyback is substituted. Conversion can be accomplished at less cost with more immediate advantages at cost-saving results than any other mine modernization plan. Another very important feature is the fact that this arrangement of loader-conveyor combination will operate near peak capacity in closer timbering than will any other mobile loading unit.

Shortened boom of the mechanical loader discharging at 90° into the piggyback

In our search for an arrangement to give us more continuous loading time, we learned that J. B. Long of Fayetteville, West Virginia, had developed a conveyor and had successfully experimented with it by hand loading methods. This seemed to supply the missing link. With the cooperation of the Long Super Mine Car Company, who supplied the experimental units, my company, in our own shop, converted a 12-BU Joy loader for use with the piggyback. We substituted a short, straight conveyor for the standard, long swinging type, thus eliminating swing jacks, 8½ feet of conveyor and 17 feet of conveyor chain. We developed the hitching device for use with a "wishbone" pivot at the front or receiving end of the conveyor.

The motor and speed reducer, which is the independent drive for the 26-foot long bridge conveyor, are housed in a compartment behind the small hopper at the receiving or loader tail end. Power to operate this motor is taken from the loader through a short length of cable which can be disconnected at a permissible plug when the loader disengages from the bridge conveyor to move to another face. The piggyback, itself, stays in the place. The loading machine carries it through the loading cycle.

We have based the development of this arrangement on the theory that the first criteria for any unit of companion machines is maximum loading time. The system is an outgrowth of independent mobile loaders attempting to load onto a conveyor system. If it has been generally understood why maximum loading time or even as high as 25 percent loading time was never accomplished with this arrangement, apparently nothing was done about it, the equipment manufacturers offered no solution and the operators suffered with it for years.

Objectives to Be Reached

To summarize our objectives, we were striving for:

1. As nearly continuous loading as possible.

2. An arrangement of equipment which could be handled by the loading machine operator alone and still permit him to direct his attention to the fall of coal and the uninterrupted loading of it.

3. A unit which could maneuver at all desired angles away from the pan line at maximum distance (60-foot face) so that the loader could operate in wide face and drive cross-cuts.

4. An arrangement which would eliminate spillage as completely as possible.

5. A face product with minimum contamination, particularly of ⅜ inch minus size.

6. As high a percentage of ⅜ inch plus coal as possible to bring maximum realization, to facilitate cleaning and for better loadability. A course face product requires less power for loading and is much easier on equipment.

7. The lowest possible maintenance and repair cost.

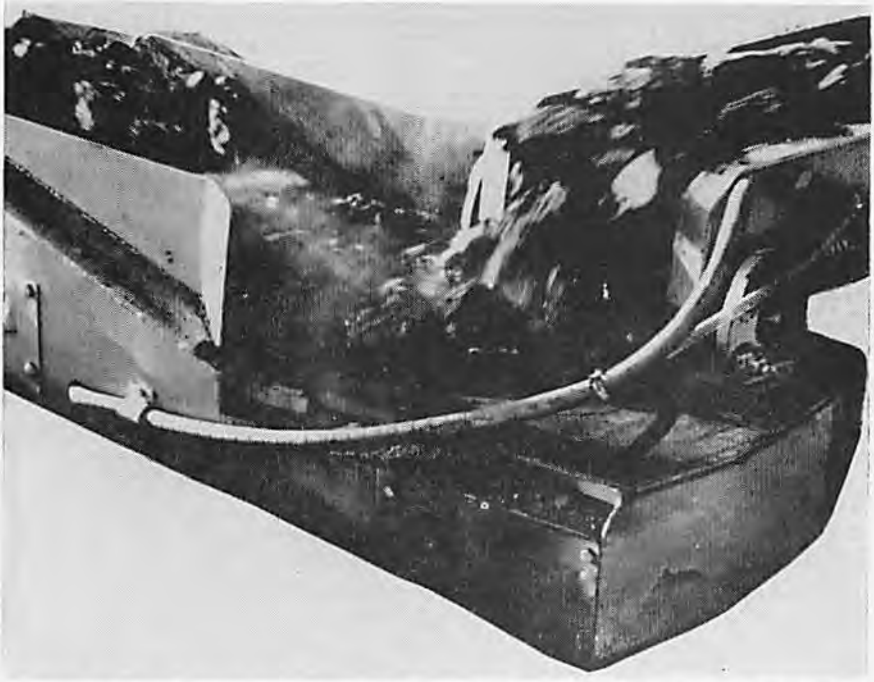
8. A minimum amount of dust.

9. A face system which would surrender none of the advantage of the previous system.

10. A system producing the highest possible tonnage per man shift.

As to results with our piggyback units, over a period of the past eleven months we have produced approximately 130,000 tons at a face cost of not quite $110,000.00, or about 84½¢ per ton placed on the haulage system. This figure includes all down time and equipment moving time. The coal produced since February 1st of this year is under the present contract which provided for the increase of $1.60 more per man employed. Our highest tonnage for any one shift was a fraction over 53 tons per man shift with a face cost of 32¢. Our best unit results for a one month period was 4,313 tons, 174 man shifts, 24.7 tons per man shift, and a face cost of 68¢. This coal was produced from an area where the seam height averaged between 41 and 42 inches.

Perhaps the following could be called "thoughts at random" as it is difficult to follow any particular sequence, but they all add up to what I call a "basic mining philosophy." While the following reasoning seems perfectly logical to us, perhaps these opinions are based on conditions peculiar to us and to our particular situation. We are commercial operators and do not contend that our theories and our aims apply to everyone in the industry. Over a period of a few years, we have developed some pretty definite ideas about mechanical mining in general, with



Hitching pivot and electrical connection between the loading machine boom and piggyback which I expect many of you to differ. However, they explain the basic thinking behind the evolution of the piggyback conveyor.

Very few of us have ever approached the capacity of "conventional" mining equipment — meaning all present-day loading, hauling, cutting, drilling and shooting equipment or methods excluding so-called "continuous" miners. The coal industry has been screaming at equipment manufacturers for fifteen or so years for higher and higher capacity loading machines. They have been built, we have bought them and then operated them only a proportion of the available face time. For example, we will all agree that a 14-BU Joy will load properly shot coal at the rate of 5 tons per minute or 300 tons per hour. This machine then, when producing 300 tons per shift is being operated at about 15 percent of its capacity. Either preparation or haulage is bottlenecking its production. But nevertheless, we now turn our thoughts and attention to a continuous miner before learning how to properly apply present equipment.

Since our company placed piggybacks in operation, we actually average better than 50 percent loading time, many units operate 66 percent of the available face time and occasionally a machine will load coal 5½ out of 6½ hours, or 85 percent of the face shift. This is coming closer to getting the capacity of the loading machine.

Regulated Belt Loading

Another problem which unavoidably confronts us in the operation of an all-belt mine is regulation of flow. At our mine we operate fifteen belts; nine are for main line and six are for panel haulage. We have one main and two secondary confluence points with six right angle panel belt transfer locations. We have learned in the operation of these belts at 400 feet per minute that to avoid spillage, we dare not load a 36-inch belt at a rate greater than 8 tons per minute or a 30-inch belt more than 6 tons per minute. Belt cleaners don't pay dividends and are a nonproductive, constant payroll load. Proper flow regulation will eliminate almost all spillage.

On all shuttle car sections, regulation is accomplished with shaker feeders which receive the shuttle car load at a discharge rate of 6 tons per minute and smooth it down to one ton per minute when fed to the belt. We use shuttle cars for seven entry heading developments. Elsewhere, in panels and rooms, we use piggybacks attached to 12-BU loaders at one ton per minute, discharging on chain flight conveyors which, in turn, carry the coal to 30-inch belts. The 12-BU loader is its own regulator. Our average loading rate with this machine is .7 tons per minute, or about 40 tons per hour.

Our aim is to arrange that this machine loads 150 tons per unit shift, or a total loading time of 3¾ hours, which is 57 percent of the face time. This is 25 to 30 tons per face man, depending on whether the crew consists of five or six men. When we occasionally hit 200 tons per shift, we get 40 tons per face man, 45¢ per ton face cost, and our machine has loaded coal continuously for five hours and has operated 77 percent of the available face time. I submit that this is done without groaning, straining or shirt tearing. It is smooth, easy operation. No belts are being flooded, no equipment is being smashed about and the section foreman is a happy man, moving from face to face in his battery-powered jeep, contentedly chewing his tobacco.

Low vs. High Tonnage Per Unit

This brings me to the highly controversial portion of this paper. It is our theory, perhaps because of our particular set of conditions, that we do better with low tonnage per section, few men per section but high tonnage per man shift. Some claim this makes for higher capital investment per ton and per man employed. With this we disagree and feel we can defend our position. To begin with, if a high capacity loader such as a 14-BU is connected to our piggyback, regulation at the face is impossible. Belts are flooded if loading is performed simultaneously on various sections and coal converges at confluence points. This necessitates cleaning spillage. Further, conveyor pans 20 inches wide and 15 inches deep are required to carry the slug load and men can't juggle pans of that size around in 40 inches of height. True enough, with a 14-BU, the face is loaded out more quickly and the loading machine has a longer time to sit idle.

Many operators favor the big tonnage section, say, 400 tons and 20 men. When this section suffers a breakdown, 20 men are sitting there with their hands in your pocket while a mechanic repairs, perhaps, a broken conveyor chain. If the section is down for a shift or two, you're really hurt, I don't care how big the mine, and this hits you right down the line on your necessary non-producing men.

Our mine is geared to 2,500 tons per day and we rarely fluctuate more than 150 tons from this, barring a major interruption which shuts us down completely. Our maintenance on the small loading machine is very low. Since we have cut 8½ feet off the tail, shortening 17 feet of conveyor chain, and also eliminated the swing jacks formerly needed for shuttle car loading, we have materially reduced the load on the motors. Shuttle cars are not smashing into the loader's tail conveyor. The "bob-tailed" machine is easily trammed and timbers are rarely knocked out. The machine is perfectly balanced, carrying the hopper end of the piggyback a few inches off the bottom.

This, then, is the story of the final development of a mining system using the piggyback conveyor in conjunction with conventional equipment, which enables us to approach the full potential of our loading equipment and our transportation system. It is, perhaps, a small contribution, but we feel it is progress. It has helped us reduce costs and we hope it will help others. In so doing, we hope it will help coal find its rightful place – the dominant fuel in the energy markets of the world.

DISCUSSION

Carel Robinson (Robinson & Robinson): It is my opinion that Mr. Crichton has given an excellent paper. The figures he presented are very stimulating but I don't agree with him in reference to the capital cost. The studies we have made of the "Piggy-back" — and we have been following it since it was first conceived about three years ago — is that if it is installed in the right places in the right mines, and under right conditions, the capital cost per ton of annual productions is not greater than with any of the several other methods of loading and handling coal. It impresses my firm as being the forerunner of a new method of mining. We think it will be almost as revolutionary as trackless mining was when first introduced. It must, however, be recognized that it can be applied successfully only to a limited number of places.

This development fills a need that has been felt for a number of years. A good many mines have tried loading from conventional machines, directly into chain conveyors; some were successful, others were not. I know of one mine where, in coal 33 inches thick, a force of five men, averaged, over a long period, 140 tons to 160 tons per shift. Then, they got into bad roof conditions, and the tonnage dropped to 40 or 50 tons per shift. Other mines have tried loading directly into conveyors, and have had trouble.

With the bridge conveyor as described, it is possible to cut off about eight or ten feet of the loading machine boom, so that it is much more maneuverable in weaving through timbers, under bad roof, and into a number of working places. Thus, in a more extended territory the preparation can be kept ahead of the loading machine much easier than when the operation is confined to one or two places. This has been found a very great help.

Another point Mr. Crichton brought out and which might be stressed, is the difficulty of driving break-throughs with the conventional machine loading into a conveyor. When driving a break-through, frequently the machine boom will not reach the room conveyor. Then, the procedure is for the loading machine to leave the conveyor, tram to the face, load the boom and tram back. This tramming back and forth causes loss of loading time and increases maintenance cost. With the Piggy-back, these difficulties are eliminated, because the breakthrough can be driven just as easily and efficiently as a regular working place. Furthermore, places can be worked 45 or 50 feet wide whereas when loading directly into the room conveyor, the room width is limited to about 25 feet.

Mr. Crichton brought out a rather negative attitude towards the continuous mining machine. Our firm has, until now, been unable to find a satisfactory arrangement, except at a very heavy capital cost, for providing continuous transportation. However, the Piggy-back study that has been made indicates that it can be of great help to the continuous miner and at a lower capital cost for transportation than with several other systems that are being developed.

One plan which has not been tried, but which is entirely feasible, would be to have in back of the continuous miner, two chain conveyors set parallel and two Piggy-backs. The continuous miner would hook to the number one Piggy-back and advance 20 to 25 feet. While this is being done, the second chain panline could be extended, and when advanced, say 25 feet, the machine could be switched over to the other Piggy-back. Time required for this would be about 20 to 30 seconds. Then, while loading into the No. 2 chain conveyor, the No. 1 conveyor could be advanced 25 feet and the cycle continued. Thus, in driving 400 feet and break-throughs, there would be a loss of time of less than two minutes in making the change over from one conveyor to the other.

Another plan would advance a room or entry continuously for a distance of 50 feet. At the start of such a cycle, the chain conveyor would be laid up to the face of the working place, with the Piggy-back discharging at a point 30 feet back. The continuous machine would then drive ahead a distance of 50 ft. without any interruption in the transportation system. At that point, the break-through would be driven. Then it would be necessary to stop loading until the chain conveyor was extended 50 feet to the face. This would complete the cycle, which would then be repeated. This method has been tried on a limited scale and found to be entirely practicable.

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OTHER RECENT DRILLING DEVELOPMENTS

By GENE H. UTTERBACK
Chief Engineer, United Electric Coal Companies
Chicago, Illinois

The subject of this paper, "Other Recent Drilling Developments," would intimate that the entire field of drilling other than that discussed in the two previous papers will be covered. Such is not the case. A similar paper presented in 1949 by Mr. Howard Frisbie probably gave better coverage of the subject than I have been able to prepare for this meeting, and, as a matter of fact, a description of one of the drills discussed by Mr. Frisbie is also included here.

Due to the impracticability of covering the entire field this paper has been limited to the discussion of three different drilling machines.

Tractor Mounted Compressed Air Drill

The machine illustrated in Figure 1 was built by Hart & Hart of Providence, Kentucky, and the following information was furnished by Mr. George Hart of that company.

This machine uses a Jaeger Model 600 air compressor direct connected to a Caterpillar D-8 tractor. The compressor actually delivers about 550 cubic feet of air per minute at 100 pounds pressure and this is sufficient air to supply two conventional 4 inch drifter drills. The compressor, mounting frame and air receiver and all other parts of compressor are mounted on a Standard D-8 tractor, as one unit, and secured to the tractor with six 1¼ in. studs and thirteen ⅝ in. cap screws. There are no bolt holes to drill, or any cutting of tractor frame. All bolting is done to standard Caterpillar drill holes.

The frames for supporting air drills on front of tractor are secured to tractor with six 1 in. bolts and eight ⅝ in. bolts, all utilizing standard Caterpillar drilling. The drill support frame is so designed to permit immediate spacing of holes to be drilled, as each drill support arm swings around a vertical axis on each side of tractor radiator. The drill support frames can be kept vertical to the tractor by adjustable braces on each side of tractor frame. The frame is also designed to support long boom drifter drills, thus permitting the use of a long starter steel.

In Mr. Utterback's absence, his paper was presented by Mr. T. H. Latimer, Engineer, United Electric Coal Companies.

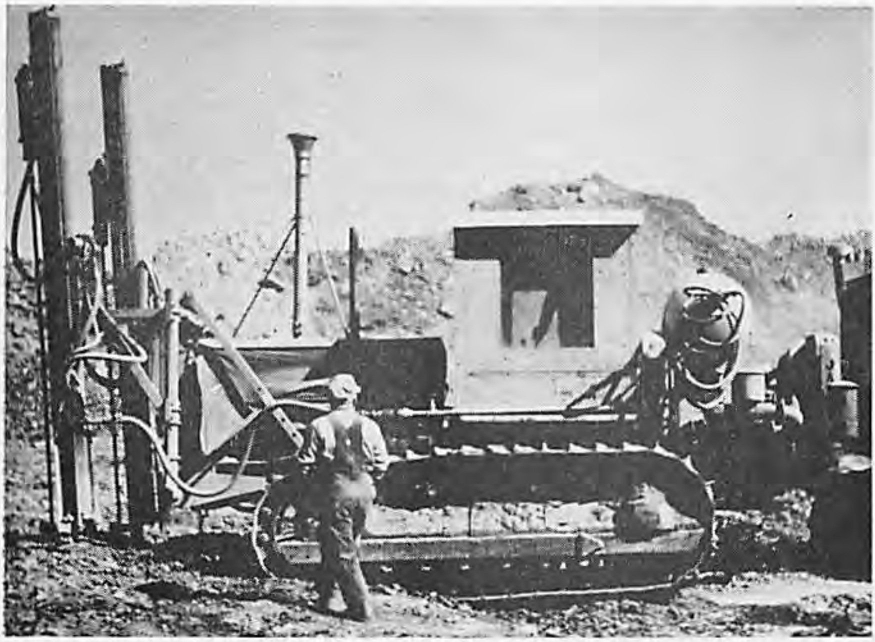

Fig. 1. Hart and Hart air drill

The steels may be from 14 to 16 feet in length, or even longer, making the changing of drill steel less frequent in deep drilling and in many instances eliminating the changing of steel at all.

This mobile compressor and drilling unit will move well over rough terrain, mud, ditches, boulders and steep slopes. The compressor may be disengaged from the tractor drive shaft by means of in and out internal and external gears; thus permitting tractor to be operated without the compressor running. Moving from one set of drill holes to the next is done in 12 to 15 seconds. Three men are required to run the machine, two drillers and one tractor operator. When drilling two inch holes 8 to 12 feet deep in hard limestone, an average production of 250 feet per hour can be expected.

As most of you probably know, Hart & Hart built this machine to drill the limestone ledge between the No. 11 and No. 12 coals in West Kentucky, but wherever compressed air drilling of small diameter holes is necessary, it could well be the proper tool.

Rotary Drill Designed for Hard Sandstone

At the Homestead Mine of Sinclair Coal Company in West Kentucky the problem of drilling sandstone over the No. 12 seam was solved by building a machine specially designed to fit predetermined specifications. This drill was described in Mr. Howard Frisbie's paper in 1949, but it seemed to me remarkable enough to repeat the description, and Mr. Frank Gilbert, Superintendent at Homestead, has given permission to do so.

As can be seen in Figure 2, the raising and lowering mechanism, controlled by hydraulic cylinder, is a sort of pantagraph arrangement, whereby the boom point, carrying the drill motor and tools, when lowered or raised, travels in a nearly vertical straight line. While this is remarkable enough, the real value of the Homestead machine lies in the Ward-Leonard type of control used on the electrical equipment.

"The main D.C. generator is a 34 KW, 1800 R.P.M. unit, direct connected to a 75 H.P., 3 phase, 60 cycle, 440 volt induction motor. The direct current excitation is provided by a separate motor generator set which consists of a 1½ KW, 125 volt generator direct connected to a 3 H.P., 3 phase, 60 cycle, 440 volt induction motor. The drill motor is a 29 H.P. shunt wound direct current motor which is connected direct to a gear reduction of 9 to 1. Eight points of speed are provided by magnetic contactors actuated through two master switches, one for reversing direction and the other for acceleration."

This type of electrical equipment solves the problem of variable speed on the drilling head where is needed high speeds at light loads and slow speeds with high torque at heavy loads. Mr. Gilbert advises the machine is drilling an 8 inch dry hole in an overburden consisting of 90% white sandrock, using a three-wing mole-foot head with diamond point bits. The average overburden is 46.7 feet and the drill averages 34.3 feet per hour. Anyone familiar with the sandstone over No. 12 coal must admit this is good production for rotary drilling without air or water.

Difficult Drilling Solved by New Type Machine

The third drilling machine to discuss is one built for The United Electric Coal Companies for use at their Fidelity Mine near Du Quoin,

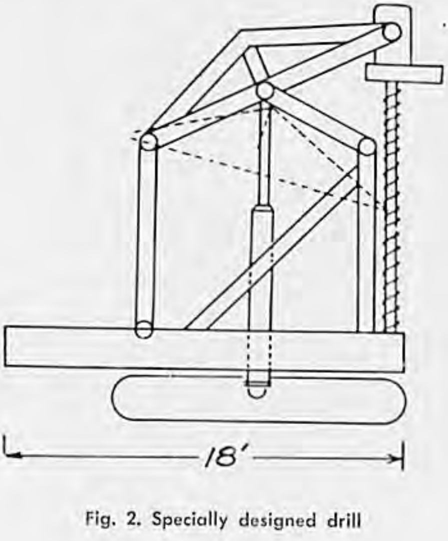

Fig. 2. Specially designed drill

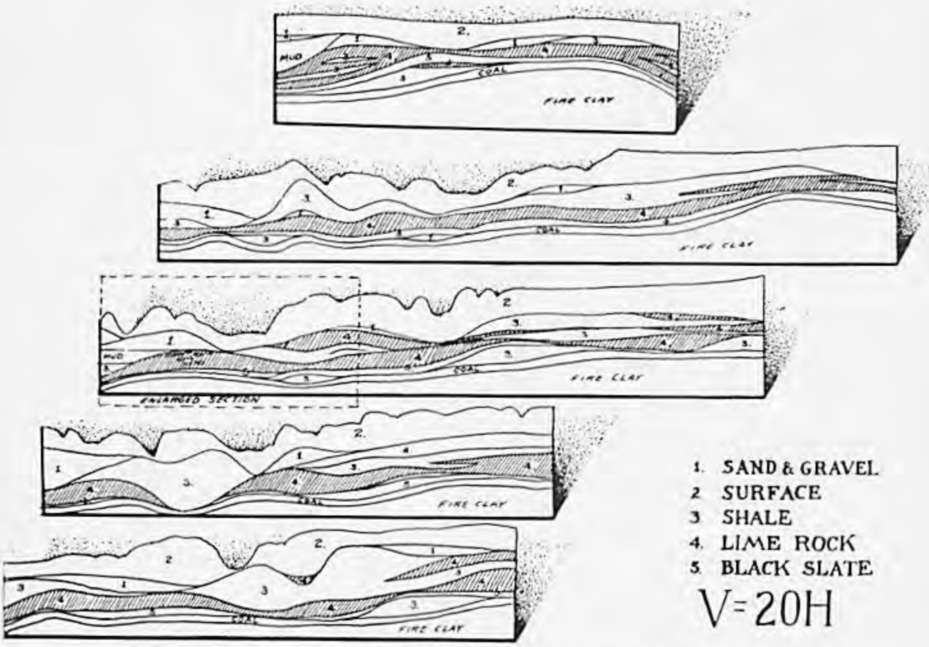

Fig. 3. Cross sections showing blasting problems

Illinois where an unusual overburden structure has made blast hole drilling an aggravating and expensive operation. As can be seen in Figures 3 and 4 the drilling and blasting problem is complicated not only by the top stratum of limestone, but also by the inervening layers of mud and sand.

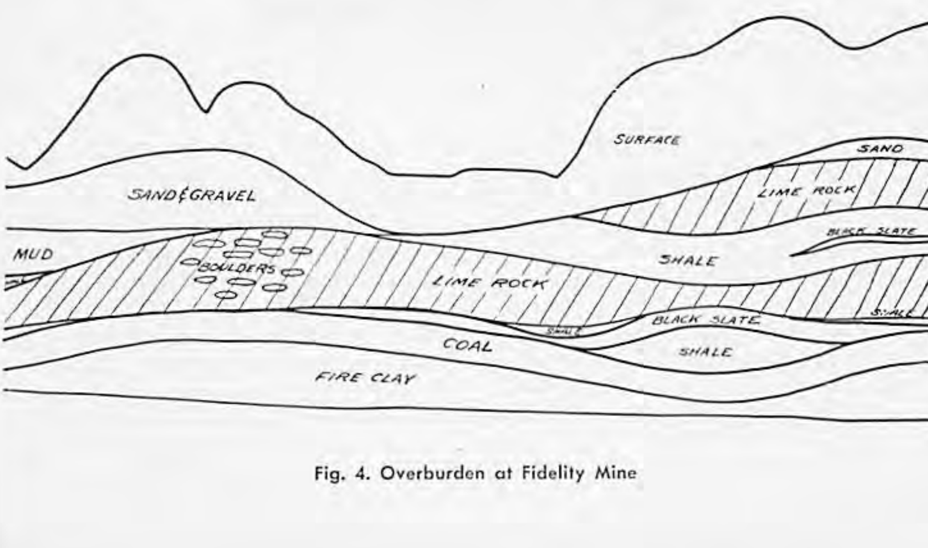

Fig. 4. Overburden at Fidelity Mine

For the last several years the 9 in. blast holes have been drilled by 42-T churn drills and the blasting done with LOX except where the holes were cased through the sand, in which case the holes are loaded with fixed explosives. While churn drilling is dependable it is also slow, hence expensive, and where possible is invariably replaced with a faster,

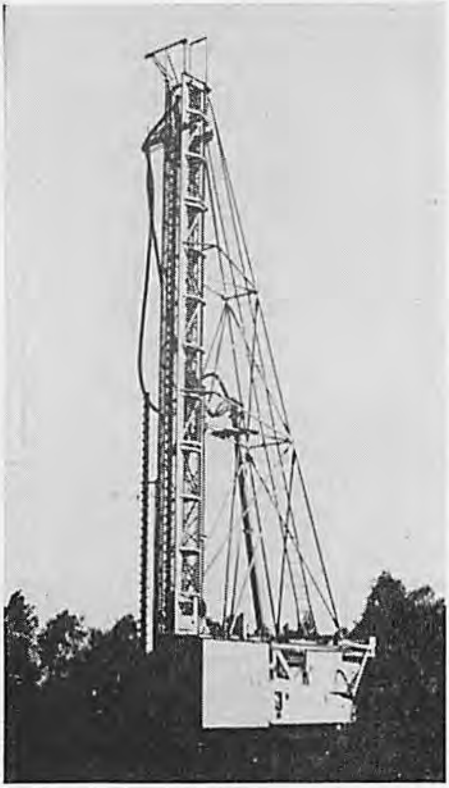

Fig. 5. View of first Reich Bros. drill

cheaper method. At Fidelity the churn drills were, and are, averaging 125 to 150 feet per shift per machine and for a mine geared to produce 10 to 12 thousand tons per day the overburden drilling becomes a task of considerable magnitude.

Consequently, the Company decided to try a new approach to the drilling problem and Reich Brothers Manufacturing Company at Terre Haute, Indiana was employed to design and build a drill that would combine the speed of auger drilling and the versatility of churn drilling. To obtain minimum time per hole it was decided to utilize a 48-foot stroke, with an extra 20-foot section of drill stem to be added for deeper holes. Fig. 5 gives an overall view of the machine as first built, and while some changes have been made since then, it is still the same in general principle.

With a 48-foot continuous stroke available, the fast removal of top soil and clay was deemed necessary to utilize fully the advantage of the long stroke; therefore, an auger spiral was welded on the outside of a

Fig. 6. A close-up of the high pressure oil lines

5½ in. flush O.D. drill stem. This spiral proved its worth, when on the second day of testing, a 9-inch hole was drilled 44 feet deep through clay and soft shale in one minute and 37 seconds. This high speed augering was possible only with the addition of water through the drill stem in the amount of 120 gallons per minute at 300 pounds pressure. When augering a similar hole dry, 8 minutes were required.

Description of Drill Details

The problem of driving a 48-foot drill stem with auger flights was solved through the use of a gear reduction mounted on top of the stem, powered with light-weight hydraulic motors. The gear-box is so constructed that the main spindle, when screwed onto the drill stem, takes the entire downward thrust of approximately 15 tons. The water swivel is permanently connected to the top of the gear-box spindle, and sends water through the spindle into the drill stem.

The oil is conducted to the hydraulic motors through high pressure flexible hose which is connected to permanent piping through high pressure swivels about halfway up the rear side of the mast. The flexible hydraulic hose and high-pressure water hose travels with the gear-box from the top of the 60-foot mast down to the deck of the drive. See Fig. 6.

All drilling operations in rotation and up and down feed are done through high-pressure hydraulic pumps, motors and cylinders. Two 35-gallon per minute 3000 p.s.i. pumps are used for the rotation fluid motors, and one 20 gallon per minute 3000 p.s.i. pump is used for the feed cylinder, making a total of 90 gallons per minute. The oil is run in a sealed system with only an air filter on the reservoir open to atmospheric pressure. In order to prevent dirt from contaminating the oil system, the oil is filtered continuously through large full-flow 50 micron filters.

The full 48-foot stroke was achieved through an arrangement of wire rope sheaves, using two sets of 6 turns around the cylinders for down feed; and another set of 6 turns of wire rope from the cylinder cross heads to sheaves mounted on a frame beyond the cylinder for up-feed. This arrangement with a 10 inch I.D. cylinder and 8-foot stroke results in a 48-foot travel of the gear-box which is connected to the free ends of the wire rope. With 100 tons pressure in the cylinder a 15 ton pressure results on the drill stem.

Drilling Records

Logs were kept for every hole drilled over a three month period, which included depth of hole, thickness of each stratum, length of time to drill each stratum, hydraulic pressure on rotation and down feed while drilling each stratum, and all pertinent data connected with the drilling. See Fig. 7.

Horsepower required for turning the auger drill stem was easily computed from the rotation hydraulic pressure, and varied from 25 when drilling hard limestone to over 100 horsepower in wet, sticky clay. The chart showing typical pressure does not show rotation pressure this high, but in many instances it did go higher.

Down feed pressure varies inversely to the rotation pressure, with practically no pressure in clay up to 15 tons in hard rock. Water pressure is supplied by two Moyno rotary positive displacement pumps of 60 gallons per minute each, and a maximum pressure of 300 p.s.i. Experiments were tried using one pump for water which was all right in clay, but did not give sufficient flow for removing limestone cuttings. The cuttings would stay in the hole until ground up like sand, but when the second pump was cut in, limestone cuttings up to 3/8 in. were floated out.

Average drilling time, as shown in the chart, for a 9 inch hole 45 feet deep, composed of 12 feet of surface, 8 feet of top rock, 10 feet soft shale,

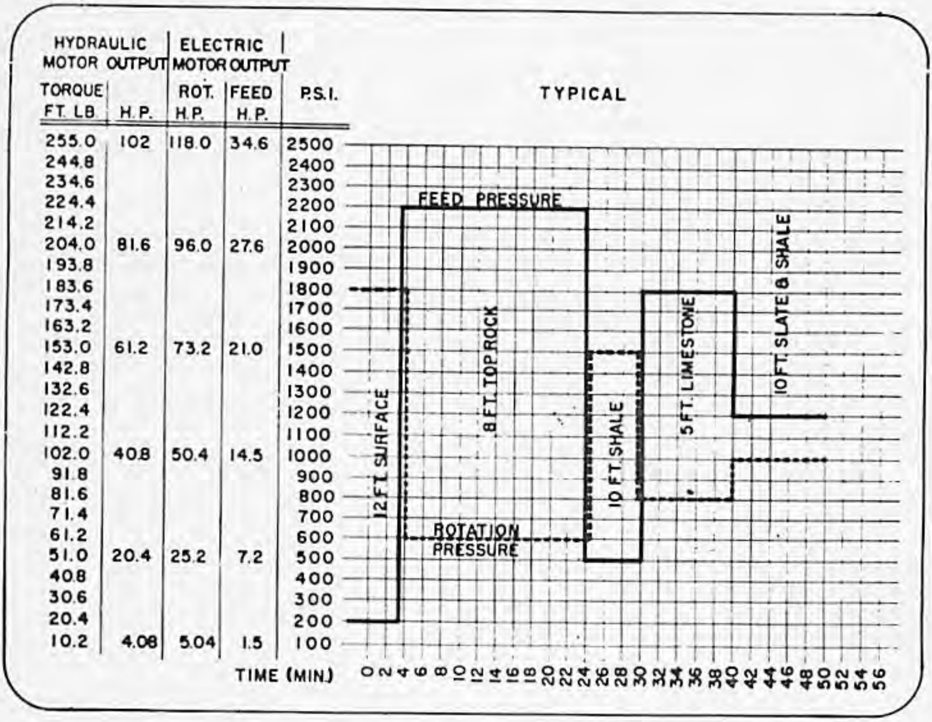

Fig. 7. Drilling log

5 feet hard blue limestone, and 10 feet slate and hard shale, was 48 minutes. Further experiments are being carried on which will enable us to drill a 70 foot deep hole without adding drill stems, which should further reduce drilling time.

The writer wishes to acknowledge the valuable assistance of Mr. Wendell Reich in the preparation of this paper, and for information furnished by Mr. George Hart of Hart & Hart, and Mr. Frank Gilbert of The Homestead Coal Company.

DISCUSSION

Wendell Reich (Reich Bros. Mfg. Co.): About two months ago we substituted a 900 cubic foot air compressor for the water pumps as a means for removing cuttings from the hole. This has proven very satisfactory in that we are getting limestone cuttings as large as three-quarters of an inch from the hole. We are using a nine inch Hughes air jet bit and believe that this is the first time a bit of this diameter has been successfully used with compressed air.

While the initial cost of compressed air equipment is $15,000 using 200 H.P. and only $1500 for water pumps using 40 H.P. I believe the advantages of air over water are apparent. We were using seven thousand gallons of water to drill a forty-eight foot hole. The water was pumped from the pit into a ditch, then to a pond and returned to the drill a mile and one half away. The use of water in the winter causes no end of trouble.

Two months ago we installed a new rotary gear box with two large hydraulic motors replacing six small motors that had given us considerable trouble. Since the addition of the new gear box and large motors we have had very little trouble.

Recently we drilled eight 9 in. dia. holes 40 feet deep, containing from fifteen to eighteen feet of limestone per hole 40 feet deep, in 5½ hours which included all moving and set up time. We feel that the recent addition of compressed air will be a great advantage to our drilling.

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SUPERVISORY TRAINING

By G. M. THURSBY
Vice President, H. C. Frick Coke Company
Pittsburgh, Pa.

It is perhaps presumptuous of me to appear before a group of experts in mine management such as is represented here this morning, in the hope that I may increase your store of knowledge about one of the problems that faces management today. You may not agree with my approach to it, but I trust I can leave you with some viewpoints that will be helpful to you.

To exist in this world, man is totally dependent upon the things which nature provides. Food, clothing, and shelter can only be obtained by changing the form and location of the stores of nature. Man must work to bring about the changes that are necessary to convert the products of nature to his own use. How hard he must work and how much of nature's bounty he may enjoy depends upon his ability to master and improve the processes by which he changes the form and location of the raw materials of nature. In creating our modern civilization, he has reduced the time and human energy required to satisfy his needs by developing tools that do his work faster, and by developing sources of energy to replace muscular energy in driving his tools.

Through his association with other men, he has created markets for the exchange of his products with those produced by other men. Out of this process has grown the art of specialization, where all men are totally dependent upon each other. So we have all become specialists in one form or another, in the process of adapting the products of nature to satisfy human need. Our ability to carry on in our particular specialty would be extremely limited if we did not have at our disposal the knowledge that has been heretofore accumulated and preserved for our use. Our job is to add to that store of knowledge so that those with whom we live and those who will live after us will have the benefit of our ideas and experiences. Knowledge cannot be self-contained. It can only be created by an interchange of information growing out of thought, research, and experience.

We are here this morning as a part of a great industry that is engaged in the difficult task of wrestling from nature, its greatest store of energy material — bituminous coal. We are here in pursuit of the work we have been trained to do, by both education and experience, and we came to exchange information with each other on the various problems that confront us. Your program committee has delegated to me the task of discussing Supervisory Training.

Now I do not like the term "Supervisory Training," because it implies the mastery of a routine by repetitious performance. That is not the purpose of supervisory training programs. What we try to do is interchange ideas within the management group for the purpose of creating a mutual benefit that is advantageous to management as a whole. After all, supervisory training is a reflection of executive management's desire to build a more unified, understanding, and cooperative management group. It is a natural advance in the art of good management which results not alone from the normal progress in this art, but as well, from necessity induced by the substantial increase of the area in which management must be qualified and informed.

Many operations of the bituminous coal industry have gone through a transition from small, compact productive units, where management worked and lived in constant association with its supervisory force, to large units of production where the supervisory force is much larger and is drawn from a wide geographical area. The lack of opportunity for constant contact that has developed makes it difficult to impart company policy in the easy manner of the days when units were small and self-contained.

Our industry has been fortunate in one respect. Legal requirements for certificates of competency plus the admirable ambition of those who toil in the mines to qualify for promotional opportunities has supplied us with a nucleus of men who are skilled in the basic essentials for supervisory responsibility in our industry. For too long a period, however, we have reposed in the belief that management's job is done when it appoints a legally qualified man to a supervisory job. To secure efficient supervision under the complexity of modern management, we must go beyond that point and make certain that our supervisors are mentally and psychologically equipped for their job, and that in addition to their technical knowledge they are adequately schooled in human relations, and that every tool and device which will help them dispose of their responsibility is made available to them.

In considering the problem, it is well to fix an overall objective. It is my thinking that this objective should be toward giving the supervisor an understanding of his area of responsibility, and the authority he has to meet that responsibility. If we can do that successfully, our supervisors will increase in stature through improvement in self-confidence with the result that management responsibility will be more efficiently administered.

After determination of the need and the fixing of an objective, we must approach the task of planning a detailed program to accomplish the objective. While it is not possible to outline a detailed plan that will fit the requirements of all employers, I will endeavor, with your indulgence, to broadly chart a course of training for mine supervisors that works toward the objective I have described.

At the outset we must make some basic decisions on:

1. What supervisors are to be included in the program?
2. Are we going to do the job alone, or are we going to invite the participation of other agencies?
3. What subject matter will be dealt with in the program?
4. Where and at what time will conferences be held?
5. What personnel will direct the program and lead conference discussions?

In considering the personnel that is to be included in the program, decisions will be influenced by the size of the company for which the program is being considered In the bituminous coal industry, mine supervisors below the grade of Mine Foreman make up most of the supervisory force. In small company organizations, it seems advisable to limit participation to those below the Mine Foremen grade, on the supposition that the Superintendents and Mine Foremen will be entirely familiar wih all aspects of the program and will perhaps have much to do with planning and operating it. In larger organizations, however, where the planning and operation of the program is carried out without the participation of these higher level officials, it is important that they be included in the first group that is exposed to the program. Should the size of the organization justify it, a pilot course that includes only Superintendents and Mine Foremen may be undertaken. This approach is desirable in that it acquaints higher level officials with the nature of the program in which the officials who work under them will participate.

If possible, it is an advantage to do the job of establishing and operating the program within your own organization. While advice and counsel from outside agencies is desirable, the responsibility for planning and operating it cannot be avoided by management if successful results are to be obtained.

The selection of subject matter for conference discussion is most important. It must be chosen with the idea of creating interest in the participants and accomplishing the objective of improving the competence of the supervisor. I favor a course that we may divide into three major sections, i.e., Industrial Relations, Safety and Operating Practices, and Accounting.

The broad purpose of the Industrial Relations Section would be designed to aid all supervisors toward a better understanding of the company and its policies, and the authority and responsibility of foremanship, as well as to improve leadership and create a better understanding of human relations. It should be opened by a study of the various types of organizations that exist, what motivates their formation, how they operate under law, and who owns and manages them. Finally, it is well to analyze your own company as to its formation, ownership, and management.

We should then move on to an analysis of the labor force, pointing out the functional differences between labor and management, and then study the first line of management, which is the foreman, and analyze the problems of his responsibility and authority.

We should then undertake a discussion of human relations and attempt to provide a basis for the opinions of employees regarding the company and how they are formed; what employees respond to; what their basic motives are; and what part ambition, criticism, fair play, pride, self-respect, etc., have in creating employee attitudes. We should study leadership, pointing up the basic characteristics of a leader and draw a comparison between a driver and a leader. We should stress the importance of placing the right man on the right job and go into the problems of selection, discipline, promotions, transfers, layoffs, and discharges. It is necessary that grievances be studied with emphasis on their origin, why they exist, the type of persons most likely to have grievances, and how to handle and settle them.

Labor laws that govern management and labor should be reviewed in rather complete form, and a comprehensive study of the wage agreement between the company and the union should be undertaken. Experience has shown that this Section of a program can be covered in about twelve sessions of two hours each.

The Safety and Operating Practices Section of the program should be designed to thoroughly familiarize all supervisors with company safety rules and operating standards, state mining laws, and the Federal Mine Safety Code. For the most part, this part of the program will be highly technical in character, since it must deal with ventilation, mining methods, transportation, use of explosives, electrical installations, mine rescue and first aid training, and the many other technical phases of modern mining. While it may seem to some of us that a review of such basic subject matter is superfluous, since all supervisors are presumed to be familiar with it, I am sure you will be surprised at the amount of benefit that can be derived from a free discussion of the practical application of the mining law, the Code, and company policy as they relate to your company. Even though such a discussion represents only a review of matters we are already familiar with, all of management will benefit by accumulating a more intimate knowledge of the day-to-day problems that face the supervisory force. The details which are to be dealt with in this Section of the program, are most important, so discussions under it can hardly be completed within less than twelve sessions of two hours each.

The Accounting Section of the program should not be designed to study broad accounting principles. Rather, it should be limited to those phases of accounting that concern the records originated by the Foreman and the summary records that are produced to measure the results of his responsibility. Consideration should be given to such matters as timekeeping, calculation of wages, material requisition records, cost accounts, and cost controls. I have found that, once a Supervisor has been told the purpose of the records he originates, and under proper guidance has studied the summary reports that are available to him, his recordings improve in legibility and accuracy, and basic cost reports become of increased value to him in the management of his responsibility. This Section of the program can be reasonably covered in six sessions of two hours each.

The entire program would require thirty sessions of two hours each, or a total discussion period of about sixty hours.

To insure success for the program, the conferences should be held at a convenient location where adequate and comfortable facilities are available, and at a time that is most convenient to the participants. I think that no more than two sessions per week should be scheduled, which of course, would complete a cycle of discussion over a fifteen-week period.

Choice of the personnel who will direct the conference and lead conference discussion is most important. I favor the idea of choosing persons from within the internal organization of the company for that responsibility, since they know more about their own affairs and the policies of their company than any outsider could know. In my opinion, each of the three main Sections of the program should be led by a different person, but one of the three should be charged with directing the overall program.

Should you undertake such a program, you will find that its evaluation is difficult, for in large measure you will be dealing with intangibles. I can assure you, however, that experience under similar programs has improved self-confidence within the management group, resulted in a better inter-relationship within management, and stimulated the efficiency of management within the company as a whole.

When we talk about management, keep in mind that the individual Supervisor who is initially responsible and influential at the point of production is one of the most important persons in management. How well he does his job and what efficiency he attains depends upon how well we equip him to do the job.

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OPPORTUNITY UNLIMITED

By HENRY C. WOODS
Chairman of the Board, Sahara Coal Company
Chairman of the Vocational Training and Education Committee
National Coal Association

America needs more engineers and that means our colleges need more engineering student enrollments. Last year's record number of 50,000 engineering graduates have all found employment. But there remain many openings in all branches of the profession, so many that the situation has been listed as critical by the Secretary of Labor.

This year's classes show 26,500 freshmen registered for engineering courses, which is 27 per cent below that of last year and 20 per cent below the figure at the beginning of World War II. Of these 26,500 freshmen, 13,000 may be expected to graduate in 1954 – which is less than half the peace-time requirements of the nation. Civilian peace-time needs alone require 25,000 graduate engineers every year, and this number easily increases to a minimum of 30,000 during periods of emergency.

Why the Shortage of Engineers

Many factors contribute to bring about this situation.

First, our colleges now are enrolling students who were born in 1930 and 1931. These years, you will recall, were the worst of the depression years, when the birth rate was far below normal. Naturally, that means that today there are fewer students for all college courses, including engineering.

Second, right after World War II, the government paid expenses under the GI Bill of Rights for students who were just embarking on their college courses or were continuing those already started. Many of these were outstanding students and got better grades than the general run of students; some entered the engineering field. However, many of the G. I. students are no longer in school and their places have *not* been taken in the classrooms by anywhere near an equal number of new students. In November 1950, for example, the enrollment of veterans receiving higher educational benefits under the G. I. Bill of Rights was placed at 575,000 as compared with 856,000 the preceding year, a drop of 33 per cent.

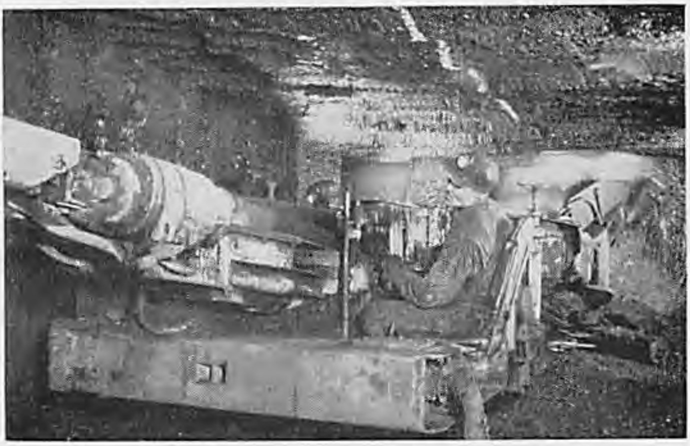
Third, during the war the government drafted graduate engineers, removing them from the field of research, and also took students who

Modern Loading Machine clears out dirt and shale from old haulage way which will be improved into a modern installation with heavy track for new haulage equipment. This clearing of old haulage ways is part of the program for consolidation of the Jones & Laughlin Steel Corporation's Vesta No. 4 and No. 5 Mines in Washington County, Pa. Some of the old haulage ways were used back in the days when mining was done with a pick and shovel and then carried out of the mine in old fashioned mule carts. Shown at the forward conveyor controls is George Malizak of Vestaburg, Pa. while Andrew Phillips of Fredericktown, Pa. is handling the controls of the rear conveyor.

hadn't completed their engineering courses. These conditions helped to create further shortages in the engineering ranks.

Finally, and a more recent cause for less student interest in engineering, the Bureau of Labor Statistics released a statement before last fall's college enrollment to the effect that there was an over-supply of engineers. Obviously, this had its effect in the attitude of college engineering students and in the high schools with students who were considering college engineering courses. The Bureau has recently reversed itself and announces that employers are now seeking additional engineers, after absorbing the engineering schools' record 1950 graduating class of 50,000. Defense work, the Bureau states, will continue to add to the normal peacetime demand.

(*Editor's Note*: The Bureau of Labor Statistics' bulletin "Employment Outlook for Engineers" was published before the outbreak of the Korean conflict and it predicted the future demand for engineers on the basis of normal peace-time needs. The subsequent spurt in demand for engineers – arising from the requirements of the defense production program – naturally could not be foreseen.)



Continuous Mining Machine at work exemplifies the progressive methods and the ingenuity of the coal industry. This underground mechanical marvel wraps up the cycle of coal mining in one operation. It cuts and loads at the same time and eliminates the necessity for drilling and blasting. The continuous miner is served only by a shuttle car.

It is part of the job of the coal mining engineer to decide on the type of machinery and equipment best suited to a particular job. He also may be engaged in developing new machinery and technological applications which contribute to productivity, efficiency and safety. Jamison Coal & Coke Company, Farmington, W. Va.

All in all, there is an urgent and increasing demand for engineers, which means that educators at both high schools and university levels may well be serving the nation's, industry's and students' best interests by encouraging young men to enter the undermanned engineering field. At the high school level, it is important to note that a course in coal mining need not interfere with other subjects, but may be substituted for those of less value in preparing for employment in any industry. Coal mining requires a knowledge of English, mathematics and science. Those subjects are basic in almost all modern industry, so that studying their application to coal mining is useful to a student even though he never enters that business.

Outlook in Coal Mining

Educators and students contemplating careers in mining are urged to acquaint themselves with the facts of today concerning coal mining.

Many schools still use text books that convey an entirely erroneous description of coal mining, because the books have not been revised for years. Statements in these books often refer to conditions that have been obsolete for a generation or longer.

Coal is entering its brightest era and for that reason offers a bright future for the engineers who will be responsible for producing and preparing it for the hundreds of thousands of uses to which coal is put today.

Here is what the coal mining industry offers young men today:

An Ascending Industry.

While the known reserves of gas and oil are expected to be exhausted in 35 years, we have enough coal to last far more than 2,000 years. New uses for coal are constantly being discovered (nylon for example, is just a few years old) and from many laboratories are coming miracles of research. New advances are being made in the application of power and heat too, as exemplified by the new type of locomotive, the improved coal burning stoves and furnaces, and many other inventions employing coal as basic fuel.

The industry is in the midst of a transfer from wholly hand-operated methods to complete mechanization. Today in 90 per cent of the mines, all coal is loaded by large electrical machines. Coal is drilled by electrical drills rather than by hand. Coal is shot down by compressed air (to avoid the danger of explosions or catastrophies).

In most mines where electrical locomotives were used to haul the coal to the bottom in small pitcars, today the modern mines are using belt or chain conveyors. Slopes instead of vertical shafts are used in all new up-to-date properties. Electric lights are used below ground instead of open flame lights. Safety hat and steel-capped shoes are worn by the miners for safety reasons. Mines have spent millions in measures which have reduced accident rates to the level of other comparable industries such as steel and automotive. Mines are so much more modern than they were 10 or 12 years ago that one hesitates to predict what to expect in new methods in the future.

Main Haulageway of modern mine is coated with "Rockdust," or finely powdered limestone, blown with great pressure. Coating protects against the spread of a coal dust explosion. Rockdusting — standard now in bituminous mining — has helped give the industry an increasing better safety record. Consolidation Coal Company, Monogah, W. Va.

Huge Bucket lifts a 40-cubic-yard load after biting into rock and dirt to uncover the rich supply of coal lying near the earth's surface. Not all coal is mined deep underground. In one year in the United States as much as 135 million tons of quality coal have come from surface mines. A giant shovel like this today costs $850,000 – and this is only a single item in modern-day mechanized mining. Sahara Coal Company, Harrisburg, Ill.

Bituminous Coal Research, founded about ten years ago, is financed by wide-awake coal producers and it has spent millions of dollars in the development of modern appliances to use coal. It has studied air pollution and the possible derivatives from coal such as oil, gas, drugs, plastics, nylons and many others.

One of the greatest strides that has been made in the past 15 years is the development of equipment and "know-how" in getting the last ounce out of the burning of coal for steam or electrical use. Witness the fact that in 1920 it took 3.2 pounds of coal to produce one kilowatt of power; now it requires only 1.24 pounds for each kilowatt – almost a 60 percent savings!

In coal mining, it is truly the heyday of the engineer.

Immediate Employment.

With the current shortage of mining engineers for peace-time pursuits, and the added needs for defense work, the young man should find no difficulty in obtaining employment upon graduation.

Good Compensation.

The young coal mining engineer just out of school receives a starting salary of from $250 to $300, which is better than the average of all industry; advancement is limited only by his own ambition and ability.

Employment During Vacation Periods.

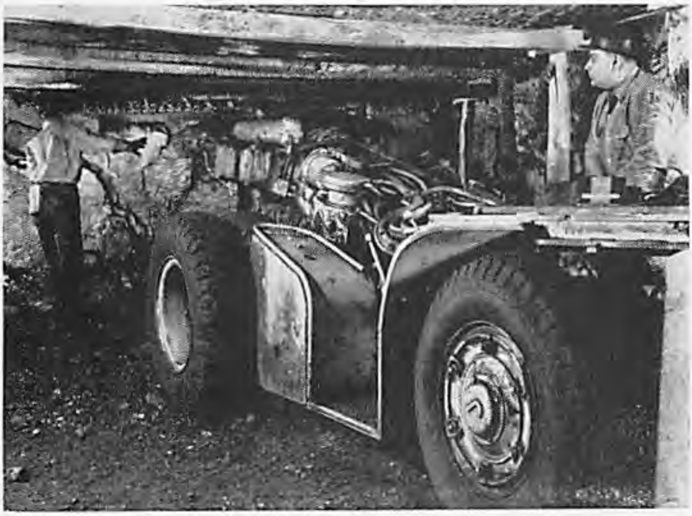
In many cases, the serious-minded college student may make arrangements to work in a modern coal mine during his summer vacations, thus gaining first-hand knowledge before graduation of the work to which he is devoting his career.

What Industry Expects of Young Engineer

So much for the opportunities and inducements offered the graduate mining engineer by the coal industry.

Now what, in return, does the industry expect of the young engineer? And in what manner may high schools and colleges cooperate in the best interests of all?

Graduates in mining engineering may be prepared for work by giving them sound instruction in the courses generally considered essential to the profession. The industry is not deeply concerned with the details of those courses. In fact, the average man in the coal industry does not wish to insist upon a rigid program. Therefore, he differs not much from his brothers in the teaching profession, who evidently are not unanimous in their opinions, or all colleges would be alike. That would be a calamity. For the good of the profession it is just as well that there should be differences in regard to details. In the long run it appears that a student who graduates in mining engineering, at the end of four years in an accredited college, gets about the same kind and amount of instruction that he would have gotten in any similar institution.



Electrically-Operated Coal Cutter mounts a nine-foot cutting blade with whirring steel bits. This Mastodon coal cutter can cut a full 360 degree arc in the coal face. This and similar machines give America's bituminous coal mines almost unlimited capacity for production. Consolidation Coal Co., Owings, W. Va.

It is taken for granted that the graduate will have a good understanding of English, mathematics, mechanics, electricity, chemistry, physics, geology and surveying, in addition to his major courses in mining. Somewhat belatedly, industry hopes he will have had at least an introduction to the subject of labor relations, the importance of which is only too clear at present.

The coal industry expects, of course, that the students in mining engineering will be taught the strictly mining subjects by men who have had practical experience in the mines and who keep themselves well informed in regard to current methods by summer work or by well-planned inspection trips.

In Addition to Educational Qualifications

While the undergraduate is subject to the control of members of the teaching profession, industry expects him to be trained in certain ways that are not a part of his text-book subjects, but can be made an inseparable part of his development by the skillful supervision of his teachers.

Dependability may well be considered first because there is nothing more important. It seems so simple that one may almost think it could be ommitted. Probably most employers would overlook certain shortcomings if the young graduate demonstrated that he was thoroughly dependable. If he always appeared at the right place at the right time with the proper equipment, he would soon be well established as a welcome member of his organization. The graduate who gets a reputation for being undependable is beaten in his industry before he starts.

With or without an introduction to labor relations in college, the graduate is expected to develop ability in this most important field. Beginning with himself, he will find it essential to deal aggreeably with his immediate associates. Getting along in friendly fashion with his own small group will be a great help as his responsibilities increase and he is required to deal with large numbers of persons. On a still larger scale, his interest in his community may grow at the same time by volunteer work in any one of a great number of useful activities.

Industry expects the graduate engineer to be a mature man at the time he gets his first job. It is believed that he has reached the stage where he has put away childish things. Supposing that he has better than average intelligence, industry expects him to continue to grow intellectually and that he is moved by a desire to fit himself for responsible jobs when they are offered to him. For this reason, employers are apt to look over his college record to see what he did that would indicate his fitness for leadership. There is interest in knowing what he did beyond what he was required to do.

As evidence of his mental growth, it is expected that the graduate will do independent thinking; that he will not take too much for granted. When he reads a report, he should develop the ability to see whether the subject is new or whether it is just a description of an old method that has been superseded by something better.

For the same reason, the graduate should be able to accept conditions that have been arrived at by sound experience rather than cling to something else that seems better in theory. In this connection, it may be remarked that the ability to successfully operate a personal budget will be noteworthy, as it may be assumed that a man who knows how to conduct his own affairs will be prepared to assume the larger responsibilities of industry.

Membership in A.I.M.E. will indicate to the employer that the graduate is interested in the mining industry as a whole and is, therefore, good evidence of something more than a local outlook. Such young men will generally find encouragement in their inclination to take part in the affairs of their local section.

Quite apart from college training and mental ability, the newly employed graduate will be expected to be willing to do hard manual labor for a time. This will give him an understanding of the actual conditions of work done by those he will later supervise. He will gain their confidence and be better able to see that the work is carried on in a safe and efficient manner. Part of this experience may be acquired by the well-advised student in his summer vacations during his undergraduate career. Such work would make a favorable impression on a prospective employer, especially if the graduate showed a willingness to continue it until he was prepared for something better.

The man in authority in the coal industry will not quarrel with the professor of mining engineering over details of curriculum. He will be tremendously pleased if the school sends him graduates who possess a good foundation in the courses studied and who may be depended upon to do their work faithfully and intelligently. Such men will be ready when the time comes to assume their places as leaders of an essential industry.

This feature article which appeared in the March-April 1951, issue of the magazine "OCCUPATIONAL TRENDS" is reproduced here in its entirety for the use by educators and interested students, by permission of Bellman Publishing Company, 83 Newbury Street, Boston 16. Information concerning additional copies may be obtained by writing Vocational Training and Education Committee, National Coal Association, Southern Building, Washington 5, D. C.

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FORTY-TON COAL HAULERS AT HARMATTAN MINE

By L. E. BRISCOE
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and
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Manager of Sales Development
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In the broad belt of bituminous coal fields in the United States, stretching from the Ohio border to the midlands of Kansas, open pit strip mining on a large scale continues to expand. In 1946, 21.1 percent of bituminous coal and lignite was mined by open pit methods, and this was increased to 24.2 percent in 1949. In the period between January 1948, and December 1950, 97 strip mines with a capacity of 1000 tons per day or more were opened or placed in development. One of these new, modern strip mines is the Harmattan mine of Fairview Collieries Corp., near Danville, Ill., which produced its first coal in January 1949, after a seven-year period of planning, construction and development. Fairview Collieries Corp. is one of the operating subsidiaries of Ayrshire Collieries Corp., of Indianapolis, which operates seven mines in Indiana and Illinois, and ranked sixth in annual production in 1949 among the large strip mine operators. Ayrshire Collieries Corp. operates a fleet of 60 coal haulage trucks, ranging in size from 20-ton to 40-ton capacity. The Harmattan mine is the first Ayrshire operation using 40-ton capacity coal haulers. These units have been carefully watched and compared with 32-ton and 20-ton coal haulers at the other mines to determine whether a large capacity hauler gives a lower cost per ton, or if there is a point of diminishing economic returns.

Harmattan mine has an estimated life of at least 20 years. It is a dragline operation, stripping an average of 72 ft. of overburden to recover a 6 – 6½-ft. seam of Illinois No. 7 coal. This seam is underlain by heavy, dense fireclay. Since the overburden is porous and contains two seams of water-bearing sand, and the coal lies below the water level of several small streams nearby, adequate pit drainage is most important. A 25 cu. yd. Bucyrus-Erie dragline with 180-ft. boom, working 24 hrs. a day, seven days a week, removes the overburden, which contains no rock or shale. A second dragline, a Model 1250B Bucyrus-Erie is now being assembled, and will be ready for operation in the spring of 1951. This new dragline will have a 30-cu. yd. bucket on a 200-ft. boom.

Harmattan's modern preparation plant

The preparation plant at Harmattan was designed for 600 tph of washed, prepared coal, but in actual operation has produced as high as 900 tph. Four Euclid 40-ton coal haulers transport raw coal from an electric powered 7½-cu. yd. Marion coal loader over a haul distance of 1½ miles, dumping into a drive-over hopper of 200 tons capacity at the preparation plant.

New Combination Developed

Ayrshire officials had certain guides which led to the installation of 40-ton capacity trucks, in fact, requirements dictated that a new combination be developed by the truck manufacturer; for this is the first use in coal hauling service of the large single flotation type, 27.00 by 33 30-ply tire. Since 40 percent of the coal loading takes place on fireclay, the question of traction and flotation is immediately raised. Ayrshire engineers originally proposed seven 20-ton capacity Euclid coal haulers, equipped with 21.00 by 24 single tires. Experience showed a single low-pressure tire of large cross section had greater flotation and tractive ability than two high-pressure tires of smaller cross-section with equivalent carrying capacity. From an operating viewpoint, the 20-ton unit promised satisfactory haulage on the type of fireclay at this mine, but past history showed definite savings and lower cost per ton-mile when the company used 32-ton trucks. But these larger trucks all were equipped with dual tires and no single tire available supplied adequate tire capacity for a 32-ton payload.

There had been widespread application of a 27.00 by 33 single tire on 25-cu. yd. bottom-dump earthmovers in earth fill dam construction, where flotation on soft fill is essential, and 40-ton coal haulers, equipped with 18.00 by 24 dual tires had been used by several mining companies. At Harmattan these elements were combined, resulting in the use of

Coal hauler dumps into 200-ton hopper

four Model 9LDT-104W Euclid 40-ton single-tire coal haulers, rather than the seven 20-ton machines originally proposed.

Specifications of 40-Ton Coal Haulers

Model – Euclid 9LDT-104W
Engine – Cummins Model NHS, 275 HP
Transmission – Fuller 5-Speed
Front Tires – 14.00x24 – 20-Ply
Tractor Drive Tires and Trailer Tires – 27.00x33 – 30-Ply Single
Trailer Capacity – 47 cu. yd., Struck Measure
Net Weight, No Load – 61,900 lbs.
Over-all Length – 50′ 7½″
Over-all Width – 10′ 8″
Top Speed – 25 MPH

Try Fluid Drive

One-way haul distance at Harmattan will eventually reach four miles and additional trucks will be installed as the length of haul increases. A fifth haulage unit has just recently been placed in service and is equipped with a new development which is creating much interest and comment in all fields of off-highway haulage: the Torque Converter.

This latest unit is equipped with a 300-hp Cummins Model NHRS engine, Allison torque converter and hydraulically-actuated Allison torqmatic transmission, rather than the 275-hp Cummins engine and conventional five-speed transmission. Engine horsepower was increased better to match the design characteristics of the torque converter. The Allison converter and 3-speed planetary type transmission are well liked by the drivers, since shifting can be accomplished easily by merely moving a shift lever from one position to another without let up on the throttle.

Driver fatigue is greatly reduced as there is no clutch pedal or conventional gear shift lever to operate. Engine speed remains practically constant, and the diesel engine is not subject to harmful "lugging" at low rpm as is the case with the standard transmission if the operator fails to shift properly. There is a continuous power flow to the rear axle, with no loss of power due to declutching, such as occurs with a clutch and transmission. Since the torque converter exactly matches the horsepower requirements to go up grades, or haul over a soft roadway in the pits, the driver is always efficiently using all of the net horsepower available at the drive wheels to get higher road speeds. The torque converter unit may be expected to have better performance and lower cycle time in pits having variable grades or road rolling resistance.

Initial and Operating Costs Higher

However, these benefits are not without cost. The increase in engine horsepower from 275 to 300 hp adds about $750 and the Allison con-

Single 27 by 33 tires give adequate flotation and traction verter and transmission add about \$2880, so that initial investment per truck is an additional \$3630, or about 10 per cent.

Early records show that fuel consumption per hour is higher with the 300-hp engine and the torque converter, averaging 8.75 gal. per hr. compared to 5.83 gal. per hr. for the original trucks. However, the torque converter unit is being loaded with an extra pass from the 7½-yd. loading shovel, so that it is hauling more tons of raw coal per load and per hour. Cycle time comparisons on a 1½-mile haul to the tipple, including 0.4 mile in the pit and on the fireclay, 0.8 mile on a well-maintained haul road with grades from 0 – 4 percent and 0.3 mile on a permanent ramp having an adverse grade of 3 – 4½ percent are shown below.

Average speed of the 17LDT-118W was somewhat slower during this period of observation because of the larger payload being handled. However, the converter unit hauled 8½ percent more tons of raw coal per shift.

The new truck permits a direct comparison between converter and transmission units, and cost and performance records are being carefully kept to determine if the converter has advantage in performance, driver comfort and low-cost maintenance.

The Harmattan coal haulage fleet has established a record of 345 tons of raw coal hauled per mile, per operating hour, which is the highest of any of the Ayrshire mines. This "Operating Index" is considered by Ayrshire operating heads to be of prime importance within the 60-odd production and cost figures which are reviewed each month at the home office in Indianapolis. While the monthly records on maintenance and cost per ton-mile may vary from month to month depending on

Euclid Model	9LDT-104W	17LDT-118W
Type of Power	275 hp—5-Speed Transmission	300 hp—Allison Torque Converter
Capacity—Struck Measure	47 cu yds	55 cu yd
No. of Passes from 7½-yd Shovel	Six	Seven
Loading Time	2.07 Min.	2.40 Min.
Haul from Shovel to Hopper	5.71 Min.	6.28 Min.
Dumping Time	.14 Min.	.14 Min.
Return Empty from Hopper to Shovel	4.74 Min.	4.87 Min.
Delay Time at Shovel	.94 Min.	.94 Min.
Total Cycle Time	13.60 Min.	14.58 Min.
Trips per sixty-minute hour	4.4	4.13
Trips per 7¼ Hour Shift	32	30
Tons of Raw Coal per Shift, 1 Truck	1300 Tons	1410 Tons
Average Road Speed, Loaded	15.7 mph	14.3 mph
Average Road Speed, Empty	19.0 mph	18.4 mph

Well prepared and maintained roads are the rule at Harmattan

tire replacements, engine overhauls, and other such intermittent costs, the Operating Index remains fairly constant and any significant change in this figure is a matter calling for investigation.

Good Roads Essential

The high Index Figure at Harmattan is due not only to the 40-ton capacity haulers, but also to the well-maintained haul roads which permit high average travel speeds. Specialized equipment, in daily use for haul road maintenance, includes a Caterpillar Model D8 bulldozer for work in the pit. On temporary haul roads, a Caterpillar No. 12 motor grader is used for blading and to maintain crowned roads for drainage. A 4000-gal. sprinkler trailer is used to wet down the haul roads on dusty days.

Permanent haul roads are built with a base of plus 1½-in. mine refuse, spread to depths of 18 in. to 3 ft. Then plus 2-in. – 4 in. crushed limestone is spread 6 – 8 in. deep, and bound in by truck traffic. The final road surface is covered by minus 1¼-in. limestone. All roadways have a 60-ft. base including gob and clay shoulders, with a 40-ft. finished road surface of rock. The stone is purchased locally from a quarry about 15 miles from the mine and is hauled in and spread by light highway trucks.

Temporary haul roads in the pit are built if the trucks will be running over the fireclay for any long period of time, perhaps several months. River gravel is spread on the fireclay to keep the road from becoming slick, permitting better traction for the coal haulers. If the haul on fireclay is of limited duration, the pit road is only graded and drained.

The fireclay underlying the No. 7 Illinois seam is firm, and stands up under haulage units. Most mine pit roads "cut out," or rut when wet, but the fireclay at Harmattan does not squeeze out or flow beneath the 27.00 by 33 tire. These tires have a kneading action on the clay. This dries up a wet haul road very rapidly, compacting it into a hard, dry surface. As mentioned previously, the pits are kept well-drained by adequate ditching and portable pumps.

Mine Yield High

The pits are stripped to a width of 120 ft., and coal is taken out in three cuts of the loader, the length of the pit. Because of a tendency of the bank to slough off, the loader takes the first cut 40 ft. wide along the highwall. On this cut the trucks drive in on the fireclay in the excavated portion of the pit, up an incline onto the coal, then turn and pull in under the loading shovel on the center of the coal. On the second loader cut, the trucks come in on the fireclay, turn on the coal, and load on top of the coal. On the third loader cut, the trucks are on the fireclay con-

OPERATING SUMMARY
(May 1—October 30, 1950)

(1)	Operating Index (Raw Tons of Coal Hauled per Mile-per hr)	345
(2)	Average Tons per Load	36.2 Tons
(3)	Average Round Trip Distance	2.32 Miles
(4)	Miles per Hour of Coal Service	9.46
(5)	Hours of Coal Hauling Service, Fleet of Four	96.9 Percent
(6)	Hours of Operating Delays, not Chargeable to Trucks	2.9 Percent
(7)	Hours out of Service for Repairs	.2 Percent
(8)	Diesel Fuel, Miles per Gal, Average	1.62
(9)	Engine Lubricating Oil, Qt per 1000 Miles	41.7 Qt
(10)	Grease, Lb per 1000 Miles	7.37 Lb

COST SUMMARY

	Operating	
(11)	Drivers' Wages	$ .0071 Per Ton Mile
(12)	Diesel Fuel	.0020
(13)	Lubricating Oil	.0002
(14)	Grease and Miscellaneous	.0001
(15)	Total Operating Cost	$0.0094
	Maintenance	
(16)	Mechanics' Wages	.0056
(17)	Supplies, Ordinary Maintenance	.0003
(18)	Supplies, Major Repairs	.0004
(19)	Tires and Tubes	.0003
(20)	Total Maintenance and Repair Costs	$0.0066
(21)	Total Cost per Ton Mile	$0.0160

The total cost per ton mile shown above does not include social security and workmen's compensation, depreciation on haulage equipment, fixed charges and overhead assessed against mine haulage. Truck depreciation is set at 20 percent per annum, with complete write-off in five years.

tinuously, both loaded and empty. Fast loading time is maintained by the shovel since a bulldozer cleans up the spillage from trucks and on pit clean-up, 'dozes loose coal to the shovel for loading.

Modern open pit coal mining permits a very high rate of recovery and the industry has many examples of reclaiming coal from older underground workings or from strip fields which had been worked with small draglines and shovels, leaving large amounts of coal which can be economically mined with present-day equipment. Of the coal which is uncovered at Harmattan by stripping, 94 – 98 percent is loaded into trucks. Of the raw coal hauled to the tipple, about 80 percent goes into the rail cars as washed, graded and prepared coal ready for shipment. The remaining 20 percent is refuse, or gob.

Operating and Cost Summaries Analayzed

Item 1. Operating Index

A review of the Operating Index for the same six-month period at the other Ayrshire mines shows figures of 107, 152 and 165 for three mines using 20-ton coal haulers, and figures of 232, 294 and a maximum of 328 for three mines using 32-ton coal haulers. Comparison of the best index figure within each tonnage class shows an increase of almost 100 percent in the tons of raw coal hauled per mile, per hour, for the 32-ton machines over the 20-ton haulers. However, the increase in the index figure of 345 at Harmattan over the figure of 328 for 32-ton coal haulers is only about 5 percent.

In other words, mine records show that installation of 32-ton units compared with 20-ton units (a gain of 60 percent in payload) results in

Strip pit is well kept all year round

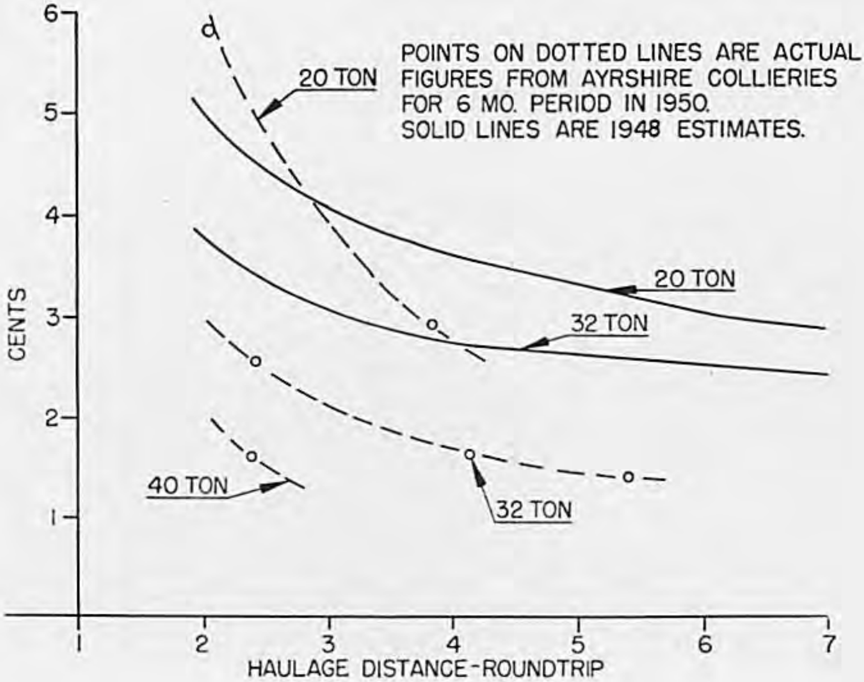
approximately 100 percent increase in raw tons of coal hauled per mile per hour, whereas a comparison between 32-ton and 40-ton haulers (an increase of 25 percent in payload) results in an increase in operating index of about 5 percent.

This would indicate that the point of diminishing returns is fast being approached. As has been pointed out in a paper on Strip Mine Truck Haulage in the April 1948, issue of MINING CONGRESS JOURNAL, large trucks give a lower cost per ton. Figure A is a reprint of chart prepared for that article, showing Gross Coal Haulage Cost per Ton-Mile, as estimated for various haul distances with the 20-ton and 32-ton coal haulers, based on Ayrshire Collieries Corp. operating experience at that time.

It is always interesting to compare estimates with actual results, and Ayrshire cost summaries of six months in 1950 show a definite correlation with the estimates of 1948.

The dotted lines show actual cost per ton mile, over the average round trip haul distance, recorded by those Ayrshire mines using 20 and 32-ton haulers. Note that cost per ton mile of the 40-ton hauler will fall on a curve below the 32-ton machine, but does not show as much savings as the improvement between the other sizes.

The cost estimate curves and actual curves are not directly comparable, as the 1948 estimates include overhead and depreciation which are not



a part of the 1950 operating summaries, and no adjustments have been made for the higher hourly rate paid truck operators since 1948.

Item 2. Average Tons per Load

The Operating Index at Harmattan should improve in the next six-month period, as sideboards are being added to the original 47-cu. yd. trailers to raise the present average of 36.2 raw tons per load. The latest trailer delivered has a struck measure capacity of 55 cu. yd. and a heaped capacity of 63 cu. yd.

Item 3. Average Round Trip Distance

Harmattan mine averages 2.3 miles per round trip haul. So far, the longest haul has been about 3 miles round trip.

Item 4. Miles per Hour of Coal Service

The figure of almost 9½ mph average road speed, including delays, loading and dumping, is the highest of any Ayrshire fleet — which is surprising, since some of the other mines have a longer haul distance which would favor a high average speed. This is an indication of the better performance, and power-weight ratio which is being provided in modern haulage equipment.

Items 5, 6 and 7. Hours of Service

Truck availability has been very high, with only 0.2 percent down time being charged against the fleet of four during a six-months' operating period.

Item 8. Diesel Fuel Consumption

Average fuel consumption throughout a six-months' period gives 5.83 gal. per hr. for the Cummins NHS 275-hp engine, 3.24 gal. per hr. for the Cummins NH 200-hp engine, and 2.4 gal. per hr. for the Model HB6 Cummins 150-hp engine, used in the 40-ton, 32-ton, and 20-ton coal haulers, respectively.

Item 9. Engine Lube Oil, Qt. per 1000 Miles

This is another key figure in the operating summary, since it indicates the condition of the diesel engines. An increase in lube oil used per 1000 miles shows that the engines are burning oil and are approaching need for overhaul. Oil is changed every 12 shifts, or approximately 90 operating hours and lube oil filters are replaced at every third change. Regular laboratory oil analyses are made, as a guide to oil change periods and as a check on engine condition.

Item 11. Drivers' Wages

Drivers are paid the regular union contract rate of $2.20 per hr. for 7¼ hr. per shift, or 43 percent of the total operating and maintenance cost per ton mile.

Item 19. Tires and Tubes

Only two of the large single tires have been changed to permit minor repairs in the 22 months of haulage up to October 31, 1950. Measured wear on the drive tires is ½ in. off the tread in 1900 hr. operation. There is no measurable wear on the trailer tires, which have not yet been rotated to the drive axle of the tractor. While total operating life is not yet known, it appears that the tires will exceed the 4500-5000 hr. life which was anticipated, and may go even higher than expected as there is no evidence of cutting or wheel spinning. The tires used are Goodyear 27.00 by 33 30-ply All-Weather Tread. Originally, each tire cost $1,661.80, but increased costs of crude rubber now brings the replacement cost per tire to $2,500. A record is kept of each tire, by serial number, showing the total hours of service, wheel position and repair costs throughout its entire service life.

Shop and heated storage space is provided for future expansion in the truck fleet. The garage is 64 by 100 ft., divided into four 16-ft. bays, which allows plenty of working space around each unit for preventive maintenance inspection and lubrication. Additional space, 32 by 50 ft. is set aside for repair bays, adjacent to the parts supply room.

Fuel is delivered as required by truck transport to an 8000-gal. storage tank above ground. Fuel is then gravity fed to a 1500-gal. underground tank, then pumped into the trucks. All refueling is done at the shop to avoid contamination of the diesel fuel by dust and dirt. Some 300 gal. of diesel fuel are used each day in all types of equipment. The 8000-gal. tank was installed to get the benefits of bulk fuel prices, and to add reserve fuel storage capacity.

Machine shop facilities can handle any major repairs, and include a welding and blacksmith shop. Maintenance of all rolling equipment is

135 REV. 2 1/50 A GEN 260 BKS.

DRIVERS & MECHANICS DAILY REPORT

TRUCK NO. ____________ MINE ____________

TRAILER NO. ____________ DATE ____________ 19____

COAL HAULAGE

	PIT NO. 1	PIT NO. 2	PIT NO. 3
NO. HOURS			
MILEAGE			
NO. TRIPS			
NO. LOADS			

OTHER HAULAGE

NO. HOURS ____________

MILEAGE ____________

USE ____________

NO. TRIPS ____________

OPERATING DELAYS

NO. HOURS ____________

CAUSE ____________

FUEL & LUBRICANTS

FUEL ____________ GALLONS

OIL ____________ QUARTS

GREASE ____________ POUNDS

DRIVER ____________

REPAIRS NEEDED

REPAIRS MADE

NO. HOURS ____________

TIRE CHANGES

	WHEEL	WHEEL	WHEEL
TIRE NO. REMOVED			
TIRE NO. APPLIED			
NEW OR USED			
SPEEDOMETER			
REASON			

MECHANIC ____________

FORM NO. 311

AYRSHIRE COLLIERIES CORPORATION AND SUBSIDIARIES

COAL TRUCK RECORD

TRUCK SERIAL NO. ____________ MINE ____________
TRAILER NO. ____________ MONTH ____________ 19____

	COAL HAULAGE SERVICE				OTHER SERVICE		OPERATING DELAYS	REPAIRS	FUEL	OIL	GREASE
DAY	NO. HOURS	MILEAGE	TRIPS	LOADS	NO. HOURS	MILEAGE	NO. HOURS	NO. HOURS	GALLONS	QUARTS	LBS.
1											
2											
3											
4											
5											
6											
7											
8											
9											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31											
TOTAL											

handled by one mechanic on the day shift, and one mechanic and a helper on the second shift. The two mechanics are highly trained in diesel maintenance, being former field service men for an engine distributor. They are responsible for preventive maintenance, and repair of some 19 major units:

- 5 Euclid coal haulers
- 4 Caterpillar D-7 and D-8 bulldozers
- 1 Caterpillar motor grader
- 1 Mack winch truck
- 1 Dodge power wagon
- 1 ½-ton pick-up truck
- 1 sprinkler-tractor-trailer
- 1 IHC 1½-ton dump truck
- 1 Euclid 13-yd. bottom-dump
- 1 Euclid 12-yd. rear-dump gob hauler
- 2 1½-ton refuse trucks

All coal haulage units are lubricated after every two shifts, as an average, which is performed in regular scheduled sequence on the second shift. At this time, each unit is given a mechanical inspection, including such items as fan belt and radiator hose connections, clutch pedal adjustment, brake adjustment, tight wheel lugs, and leaks in fuel and air lines. Tire pressure is checked every day on the second shift, when the tires have cooled off from the day run and tire temperatures have stabilized. In cold weather, all rolling equipment is filled with permanent anti-freeze.

The day mechanic makes a checkrun with the drivers each day, to check the operating condition of the truck engine, brakes, clutch, lights, instrument panel and steering. One simplified daily report is used by the driver and mechanic, forming the basis for all monthly and semi-annual operating records.

All automotive equipment at Ayrshire mines is under the general supervision of L. E. Briscoe, electrical and automotive engineer, for standardization of maintenance practices. Carl Walker is superintendent at the mine, with Roy Davis as master mechanic. Pit and haul roads are kept in good condition by George Wilson, pit foreman.

Faced with the increasing demands for coal, coupled with the economic pressure for low haulage cost per ton, strip mining operators throughout the United States are reviewing their equipment, and have added to or replaced older haulage trucks at an increased rate since June 1950. Predominantly, the 40-ton payload coal hauler is being selected.

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, provided 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.

Remember?

STARVED ROCK, JUNE 18, 1927

BOAT TRIP, 1935

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., President.......... Cardox Corporation, 307 North Michigan Avenue, Chicago 1, Illinois
BOWMAN, F. T., Gen. Mgr.....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.
CLARKSON, JOHN L., Pres..........Clarkson Mfg. Co., Nashville, Ill.
COLNON, STUART.......... Freeman Coal Mining Corp., 208 S. La Salle St., Chicago 4, Ill.
CROWDER, GORDON G.......... Peabody Coal Co., 231 S. La Salle St., Chicago 4, Ill.
CUNNINGHAM, M. F.......... Goodman Mfg. Co., 730 N. Catherine Ave., La Grange Park, Ill.
DEVONALD, D. H..........Route 2, Benton, Ill.
DORSEY, CHARLES H., Pres.......... R. G. Johnson Co., Washington Trust Bldg., Washington, Pa.
DUNCAN, W. M..........Duncan Foundry & Machine Co., Alton, Ill.
EMMONS, W. STUART, Asst. Vice Pres.......... Hulburt Oil & Grease Co., Philadelphia 34, Pa.
EVANS, O. M., V. P.......... Midwest-Radiant Corp., 220 N. Fourth Street, St. Louis 2, Mo.
FITZGERALD, P. H.......... Allen & Garcia Co., 204 S. Grand Ave., East, Springfield, Ill.
FULFORD, J. H., Pres..........The Jeffrey Mfg. Co., Columbus 16, Ohio
GARCIA, JOHN A..........Allen & Garcia Co., 332 S. Michigan Ave., Chicago 4, Ill.
GEROW, T. G., President.......... West Virginia Coal & Coke Co., Atlas Bank Bldg., Cincinnati, Ohio
GRADY, EDWARD L., President.......... E. L. Grady Coals, Inc., 307 N. Michigan Ave., Chicago 1, Ill.
GREEN, J. G..........Hooper-Green Co., 407 S. Dearborn St., Chicago 5, Ill.
HALBERSLEBEN, PAUL, G. S..........Sahara Col Co., Harrisburg, Ill.

HARRINGTON, GEO. B., Pres.....
Chicago, Wilmington, Franklin Coal Co., 332 S. Michigan Ave., Chicago 4, Ill.
HARRIS, ALLYN.....500 W. Union, Wheaton, Ill.
HARRIS, JOSEPH.....Russell Fork Coal Co., Inc., P. O. Box 173, Praise, Ky.
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KEELER, E. R.....Rockford Lumber & Fuel Co., Rockford, Ill.
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LEACH, B. K., Pres.....
Egyptian Tie & Timber Co., 1803 Railway Exchange Bldg., St. Louis, Mo.
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McFADDEN, GEO. C., Pres.....Carmac Coal Co., 20 N. Wacker Dr., Chicago 6, Ill.
McMASTER, D. H.....Macweir Coal Corporation, 20 N. Wacker Dr., Chicago 6, Ill.
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MURPHY, H. C., Pres.....
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NUGENT, FRANK .....
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PEABODY, STUYVESANT, JR., Pres.....
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PHILLIPS, EDGAR R., Gen. Mgr.....
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RYAN, JOHN T., JR., Gen. Mgr.....
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SCHONTHAL, JOSEPH, Sec...
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SCHUBERT, R. R., V. P. and Gen. Mgr...
Greensburg Mach. Co., Greensburg, Pa.
SCHULL, B. H., Pres........Schull-Moake Coal Corp., 607 N. Market St., Marion, Ill.
STEVENS, E. F.........Binkley Mining Co., Railway Exchange Bldg., St. Louis, Mo.
STOVER, HOLLY..Mayflower Hotel, Washington, D. C.
SULLIVAN, J. L., Oper. Vice Pres...
Freeman Coal Mng. Corp., Farmersville, Ill.
TAYLOR, H. H., JR., Pres...
Franklin County Coal Corp., 135 S. La Salle St., Chicago 3, Ill.
THOMAS, T. J..100 N. Delaplaine, Riverside, Ill.
TIGRETT, I. B., Pres..
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ULLOM, TOMMY........Benton, Ill.
WEBSTER, ROBERT J........501 E. Poplar St., Taylorville, Ill.

ACTIVE MEMBERS

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ALEXANDER, M. E........Ohio Oil Co., Springfield, Ill.
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ALVERSON, RALPH....Carney Coal Co., Harrisburg, Ill.
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ANDERSON, L. A., Repr....
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Bituminous Casualty Corp., Bituminous Bldg., Rock Island, Ill.
ANDERSON, S. L., Div. Supt....Peabody Coal Co., Marion, Ill.
ANDERSON, W. H....
Utilization Magazine, 1218 Board of Trade Bldg., Chicago 4, Ill.
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ARENTZEN, E. M., Pres....Lee-Norse Co., Charleroi, Pa.
ARENTZEN, R. F....Lee-Norse Co., Charleroi, Pa.
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ASKEW, WENDELL, Repr....Egyptian Powder Co., Marion, Ill.
AULT, ROY, Supt....Shasta Coal Corp., Bicknell, Ind.
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BAILEY, FRED J....Cardox Corp., 307 North Michigan Ave., Chicago 1, Illinois
BAILEY, WM. H., Mine Mgr....
Old Ben Coal Corp., 606 S. Thomas St., Christopher, Ill.
BAILIE, CECIL....Old Ben Coal Corp., 410½ N. Main St., Benton, Ill.
BAIN, ANGUS, Mech. Engr....
Ayrshire Collieries, Big Four Bldg., Indianapolis, Ind.
BAIRD, A. B....Ohio Oil Co., Robinson, Ill.
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BAKER, E. M., Supt....Delta Collieries Corp., Box 151, Marion, Ill.
*BALDWIN, RICHARD, Pres....
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BARCO, J. FRANK, V. P. & Gen. Mgr....Airmite-Midwest, Inc., Du Quoin, Ill.
BARKER, CHARLES W., Supt....Carmac Coal Co., Box 207, Marion, Ill.
BARNES, F. A., Industrial Serv. Rep....
Standard Oil Co., 1524 W. Wood St., Decatur, Ill.
BARR, ROY E., V. P. in Chge. of Traf....
Illinois Central R. R., 135 E. 11th Place, Chicago 5, Ill.
*BARROW, W. E....Joy Manufacturing Co., Franklin, Pa.
BARTHEL, HERMAN R., Sales Engineer....
American Steel & Wire Co., 208 S. La Salle St., Chicago 4, Ill.
BARTLETT, A. G....Austin Powder Co., West Frankfort, Ill.
BASKIN, E. D., Gen. Sales Mgr....
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BASS, A. C....I. B. Williams & Son, 180 N. Wacker Drive, Chicago 6, Ill.
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BATES, R. H....Standard Oil Co. (Ind.), Joliet, Ill.
BAYLESS, I. N., Pres....
Union Pacific Coal Co., Union Pacific Bldg., Omaha, Nebr.

BEACHAM, ROBT. K., Gen. Mgr.....
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BEAUMONT, G. L.....Box 3, Cowden, Ill.

BECK, CLARENCE V., President.....
Clarence V. Beck & Co., Inc., 1104 Fullerton Bldg., St. Louis, Mo.

BECK, CLARENCE V., JR., Mng. Engr.....
Little Dog Coal Co., 1103 Fullerton Bldg., St. Louis 1, Mo.

BECKER, FRED H., Electrician.....Peabody Coal Co., Taylorville, Ill.

BECKER, J. C.....
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BECKER, LESTER O., Owner.....
Utility Mine Equipt. Co., 620 Tower Grove Ave., St. Louis, Mo.

BEDA, P. W., V. P.....Old Ben Coal Corp., 230 S. Clark St., Chicago 4, Ill.

BEDDOE, A. H.....1102 Fullerton Bldg., St. Louis 1, Mo.

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BEGGS, JOE, Mine Mgr. .....Union Colliery Co., Dowell, Ill.

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BENISH, GEORGE P.....Joy Mfg. Co., 4235 Clayton, St. Louis, Mo.

BENNER, DALE A.....Gibraltar Equip. & Mfg. Co., Alton, Ill.

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BENNETT, MARVIN EARL, Load Mch. Oper.....
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BENOWICZ, CASMER A., Vice Pres.....
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BERCHER, ROBERT WALLACE.....
Peabody Coal Co., 231 S. LaSalle St., Chicago 4, Ill.

BERGSTROM, G. H., Chief Engr.....
Nelson L. Davis Co., 343 S. Dearborn St., Chicago 4, Ill.

BERNEY, W. HURLBURT, Resident Mgr.....
Walter Bledsoe & Co., 1481 Northwestern Bank Bldg., Minneapolis, Minn.

BEUSHAUSEN, F. W., Sec-Treas.....
Walter Bledsoe & Co., 700 Merchants Bank Bldg., Terre Haute, Ind.

BIELER, FRED, Supt.....
Snow Hill Coal Corp., 410 Merchants Natl. Bank Bldg., Terre Haute, Ind.

BIGGINS, J. P., Sales....National Cylinder Gas Co., 4700 W. 19th St., Chicago, Ill.

BIGLER, W. P.,.....
Mining Machine Parts, Inc., 2701 St. Clair Ave., Cleveland 14, Ohio

BIGLEY, P. W.....
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BILDERBACK, COURTNEY,.....Moffat Coal Co., Sparta, Ill.

BILDERBACK, JAMES E.....
Centrifugal & Mechanical Industries, Inc., 146 President St., St. Louis 18, Mo.

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Marion Power Shovel Co., 332 S. Michigan Ave., Chicago 4, Ill.

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BRADY, E. L.........Tool Steel Gear & Pinion Co., Township Ave., Cincinnati, Ohio
BRAGDON, JOHN E.................Goodman Mfg. Co., 507 S. Market St., Marion, Ill.
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GATELY, A. L.........Republic Coal Co., Fullerton & Southport Ave., Chicago 14, Ill.
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*HARRIS, JOSEPH.....Russell Fork Coal Co., Inc., P. O. Box 173, Praise, Ky.
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KELLY, E. F., JR...............................Central Ill. Pub. Serv. Co., Springfield, Ill.

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The Euclid Road Machinery Co., 1361 Chardon Rd., Cleveland 17, Ohio
McCLOSKEY, J. R., Repr. ....
Hercules Powder Co., 708 Donnelly St., Columbia, Mo.
McCLOUD, DON B., Pres. .... Airmite-Midwest, Inc., DuQuoin, Ill.
McCLUSKEY, RAY .... Freeman Coal Mining Corp., Carterville, Ill.
*McCOLLUM, H. C., Consulting Mng. Engr. ....
H. C. McCollum & Assoc., 307 N. Michigan Ave., Chicago 1, Ill.
McCORMICK, CURTIS .... Hallidayboro Coal Co., Elkville, Ill.
McCORMICK, E. F., Supt. .... Hallidayboro Coal Co., 701 S. Madison, DuQuoin, Ill.
McCOY, J. M., Mining Engr. ....
Robinson & Robinson, Mining Engineers, Union Bldg., Charleston, W. Va.
McCULLOCH, LAWRENCE H. ....
B. E. Schonthal & Co., Inc., Madison Hotel, Madisonville, Ky.
McCULLOCH, WM. C. .... Roberts & Schaefer Co., 130 N. Wells St., Chicago 6, Ill.
McCULLOUGH, E. W. ....
American Car & Foundry Co., 3095 S. Seventh St., Terre Haute, Ind.
McDIVITT, J. W. .... Fairview Collieries, 430 Big Four Bldg., Indianapolis, Ind.
McDONALD, H. F., Pres. ....
Bell & Zoller Coal Co., 307 N. Michigan Ave., Chicago 1, Ill.
McDOWELL, W. J. .... Nail City Bronze Co., 7005 Crandon Ave., Chicago 49, Ill.
McELHATTAN, B. P. ....
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McELWEE, R. M., Sales Engr. General Electric Co., 112 N. Fourth St., St. Louis 2, Mo.

*McFADDEN, GEO. C., Pres. Carmac Coal Co., 20 N. Wacker Dr., Chicago 6, Ill.

McFADDEN, NAT, Div. Engr. Peabody Coal Co., Taylorville, Ill.

McKAIG, C. E., Mgr., Wire Rope Sales. Gilmore Wire Rope Div., Jones & Laughlin Steel Corp., 135 S. La Salle St. Chicago 3, Ill.

McKEE, MELBOURNE A., Chemist. Northern Illinois Coal Corp., Wilmington, Ill.

McKEE, ROBERT, Superior Coal Co., Gillespie, Ill.

McLAREN, A. B. McLaren Fuel Co., Marion, Ill.

McLAREN, W. S. McLaren Coal Co., Marion, Ill.

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McMURRER, P. D. American Mining Congress, Ring Bldg, N. W., Washington 6, D. C.

McPHAIL, ROBT. Peabody Coal Co., 900 S. Fifth St., Springfield, Ill.

MEADE, E. D. U. S. Rubber Co., Rm. 352, Merchandise Mart, Chicago 54, Illinois

MEAGHER, GEORGE. C. W. & F. Coal Co., West Frankfort, Ill.

MEALS, C. D. Bethlehem Steel Co., Williamsport, Pa.

MEDILL, ROBT. M. Arrowhead Coal Co., Box 546, Steamboat Springs, Colo.

MEISSNER, JOHN F. John F. Meissner Engineers, Inc., 308 W. Washington St., Chicago 6, Ill.

MERCER, HUGH, Mng. Engr. Consolidated Coal Co., 304 S. Ninth St., Herrin, Ill.

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

MEYER, FRED. C. B. & Q. Railroad, Centralia, Ill.

MEYERS, EDMUND L., Asst. Ch. Elect. Superior Coal Co., Gillespie, Ill.

MIDDLETON, H. R., Gen. Mgr. Wilmot Engineering Co., Hazleton, Pa.

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, FRED. C. W. & F. Coal Co., 509 N. 11th St., Herrin, Ill.

MILLER, J. D. Westinghouse Elect. Corp., 2800 N. Adams, Peoria, Ill.

MILLER, J. W. National Electric Coil Co., 224 So. Michigan Ave., Chicago 4, Ill.

MILLER, JACK. General Electric Co., 112 N. Fourth St., St. Louis 2, Mo.

MILLER, PURDY. U. S. Rubber Co., Mechanical Goods Div., The Merchandise Mart, Chicago 54, Ill.

MILLER, RICE W. Nokomis Coal Co., Nokomis, Ill.

MILLER, THOMAS R. Jeffrey Mfg. Co., 307 N. Michigan, Chicago 1, Ill.

MILLER, WM. J., Vice Pres. Hawthorn Coal Co., 688 Arcade Bldg., St. Louis 1, Mo.

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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. ....
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MOLLOHAN, LLOYD .... Jeffrey Mfg. Co., Box 231, Beckley, W. Va.
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Equitable Powder Mfg. Co., 212 N. Pennsylvania Ave., Belleville, Ill.
MONSCHIEN, JOHN, Foreman .... Superior Coal Co., Staunton, Ill.
MONTGOMERY, N. L. ....
Templeton, Kenly & Co., 116 Edison Drive, Huntington, W. Va.
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MORGAN, J. W., Pres. ....
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MURPHY, J. T., Dist. Mgr. ....
Chicago Pneumatic Tool Co., 1931 Washington Ave., St. Louis, Mo.
MURPHY, LT. COMDR. JOHN J. S., USNR ....
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George Murray Tire Co., 100 Walnut St., Peoria, Ill.
NALL, ALFRED A. ....
Centrifugal & Mech. Industries, Inc., 146 President St., St. Louis 18, Mo.
NASH, J. J. .... Sligo, Inc., 1301 N. Sixth St., St. Louis 6, Mo.

NEAL, J. D.........Coal Mine Machine 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.........
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C. B. & Q. Railroad, 547 W. Jackson Blvd., Chicago 6, Ill.
NELSON, I. C., Mgr.........N. O. Nelson Co., Marion, Ill.
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NEWTON, H. W.........Barber-Greene Co., Aurora, Ill.
NICOLIN, GEORGE.........U. S. Steel Supply Co., 702 Hilldale, Washington, Ill.
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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
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NORTON, R. C.........1514 Merchants Bank Bldg., Indianapolis, Ind.
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OBERJUERGE, W. W.........
Oberjuerge Rubber Distributing Co., Third & Walnut Sts., St. Louis, Mo.
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OLDS, MARSHALL, III.........
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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.
ORLANDI, WILLIAM JOHN.........
Peabody Coal Co., 610 E. Main, 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.
O'SULLIVAN, JAMES J.........
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OTT, ROBERT.........
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OWENS, A. D., Lub. Engr..........................Ohio Oil Co., Robinson, Ill.
PAGE, FARRELL..................B. E. Schonthal & Co., Box 504, Sesser, Ill.
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PARKHILL, WAYNE A., Industrial Sales......Cities Service Oil Co., Marion, Ill.
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PATTERSON, MOSS..............West Kentucky Coal Co., Madisonville, Ky.
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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.
PENNYBACKER, M. W., Mgr., Mng. & St. Ry. Sales..........
I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia 30, Pa.
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PERRINE, NATHAN G. Asst. Purch. Agt..........
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PETERSON, C. A..............Bethlehem Steel Co., Wrigley Bldg., Chicago 11, Ill.
PETERSON, E. L..........
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PETTER, STANLEY D., Gen. Mgr..........
Henry A. Petter Supply Co., 117 S. First St., Paducah, Ky.
PETTY, PHILIP..........
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Tom Brown Supply Co., 36th & A. V. RR., Pittsburgh, Pa.
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Sunnyhill Coal Co., 3090 W. Liberty Ave., Pittsburgh 16, Pa.
PICKARD, A. E.............................The Tamping Bag Co., Mount Vernon, Ill.
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State Geological Survey, Natural Resources Bldg., Urbana, Ill.
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.
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POLLACK, HARRY.........Pollack Brothers, Herrin, Ill.
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PRICKETT, J. RALPH.........
Truax-Traer Coal Co., Burning Star Mine, Elkville, Illinois
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.........
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PURMORT, A. S.........Hewitt-Robins Corp., 4030 Chouteau Ave., St. Louis 10, Mo.
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PURSGLOVE, JOSEPH, JR., Vice Pres.........
Pittsburgh Consolidation Coal Co., Koppers Bldg., Pittsburgh 19, Pa.
QUENZER, RUSS.........D. D. Kennedy, Inc., 453 Colford, West Chicago, Ill.
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.
RAMSAY, SCOTTY.........Freeman Coal Mining Corp., Farmersville, Ill.
RASSIEUR, T. E., Pres.........
Central Mine Equipment Co., 6200 N. Broadway, St. Louis 15, Mo.
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RECHSTEINER, FRED, Dist. Repr.........
Link-Belt Co., 317 N. 11th St., St. Louis 1, Mo.
REECE, CARL.........Bell & Zoller Coal Co., 307 N. Michigan Ave., Chicago 1, Ill.
REED, FRANK H.........State Geological Survey, Urbana, Ill.
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REIBER, J. LOUIS......Mt. Olive & Staunton Coal Co., 806 LaClede Bldg., St. Louis, Mo.
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REUTER, WM. P., Constr. Engr......Peabody Coal Co., P. O. Box 311, Marion, Ill.
REYNOLDS, DOYLE C., Sales......Mack Motor Truck Co., 33rd & Wentworth, Chicago 16, Ill.
REYNOLDS, GEORGE J., Elec. Engr......Morgan Mines, Inc., 821 N. 18th St., Herrin, Ill.
REYNOLDS, HUGH M., Mgr., Mech. Sales......U. S. Rubber Co., 305 S. Broadway, St. Louis 2, Mo.
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RILEY, FRED W......John Fabick Tractor Co., 700 W. Cherry, Carbondale, Ill.
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ROE, WILSON, Engr......Pyramid Coal Co., Pinckneyville, Ill.
ROECKER, EARL, Sls. Engr......Bethlehem Steel Co., Bethlehem, Pa.
ROETS, FRANK W......Coal Age, Continental Bldg., St. Louis, Mo.

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SANFORD, J. H., Mgr.................Mining Division, Ohio Brass Co., Mansfield, Ohio

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SCHLITT, T. J.....Schlitt Industrial Supply Co., 422 E. Adams St., Springfield, Ill.
SCHMIDT, W. E..............Columbia Quarry Co., 107 S. Macoupin St., Gillespie, Ill.
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STARKS, LLOYD G. .... Peabody Coal Co., No. 7, Kincaid, Ill.
STARKS, ROY .... Freeman Coal Mng. Corp., Farmersville, Ill.
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TAGLIOLI, GENE .... Peabody Coal Co., Kincaid, Ill.

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WILSON, GEORGE M.....Ill. Geol. Survey, Natural Resources Bldg., Urbana, Ill.

WILSON, H. B., Owner..........H. B. Wilson Coal Co., Athens, Ill.

WILSON, JAMES R., State Mine Inspr..........107 W. Lindell, West Frankfort, Ill.

WILSON, ROLAND, Supt..........Freeman Coal Mng. Corp., Box 269, Herrin, Ill.

WINKS, C. R., Engr..........United Electric Coal Co's., Cuba, Ill.

WINNING, JAMES H., Inspr.........
U. S. Bureau of Mines, Box 889, Montgomery, W. Va.

WINNING, W. T..........Bituminous Casualty Corp., 704 N. Eighth St., Herrin, Ill.

WIRENE, W. A., Mgr. Materials Industries.........
General Electric Co., Schenectady, N. Y.

WOLFE, F. J.........Coal Mine Equipt. Sales Co., Beasley Bldg., Terre Haute, Ind.

WOLFE, SHELDON J.........
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WOLFF, A. W., Tech. Repr.........
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WOOD, NEAL SR., Foreman.........
Old Ben Coal Corp., 702 W. Cherry Ave., Christopher, Ill.

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Richard F. Wood & Associates, 340 N. Vandeventer, St. Louis 8, Mo.
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University of Illinois, Urbana, Ill.
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State Geological Survey, Natural Resources Bldg., Urbana, Ill.
YOUNG, A. M....................Sales Analysis Institute, 230 S. Clark St., Chicago 4, Ill.
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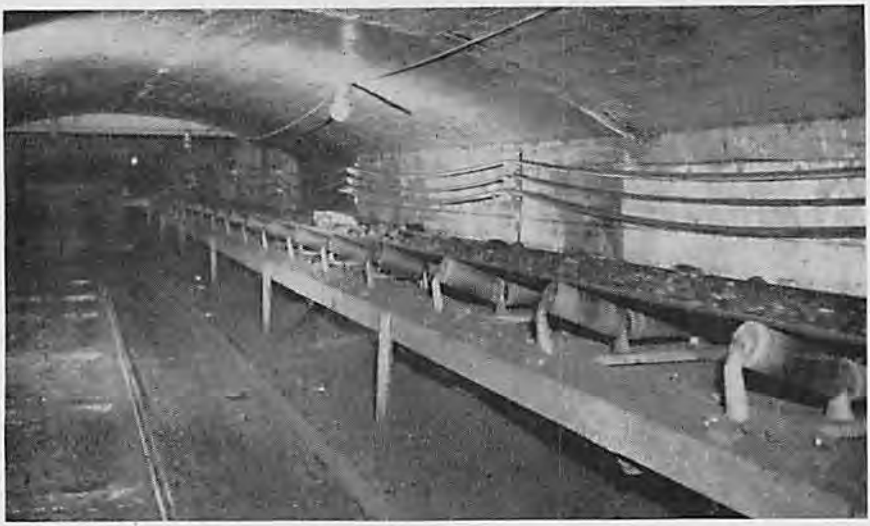
RAY-MAN CONVEYOR BELT

for Long-Lift Slope Tensions



RAY-MAN TENSION-MASTER is the original conveyor belt made with rayon strength members designed for the super-tensions of long-lift mining. The ideal slope belt for eliminating transfer points to cut down coal breakage and increase belt life. Has extremely low stretch, half as much as conventional belts. Mildew and moisture proof.

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RAY-MAN STYLE "F" meets the demand for a more troughable belt with greater flexibility over small terminal pulleys on underground coal conveying units. Exceptional fastener holding ability.

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MINE TROLLEY WIRE GUARD	MINE DUSTING HOSE
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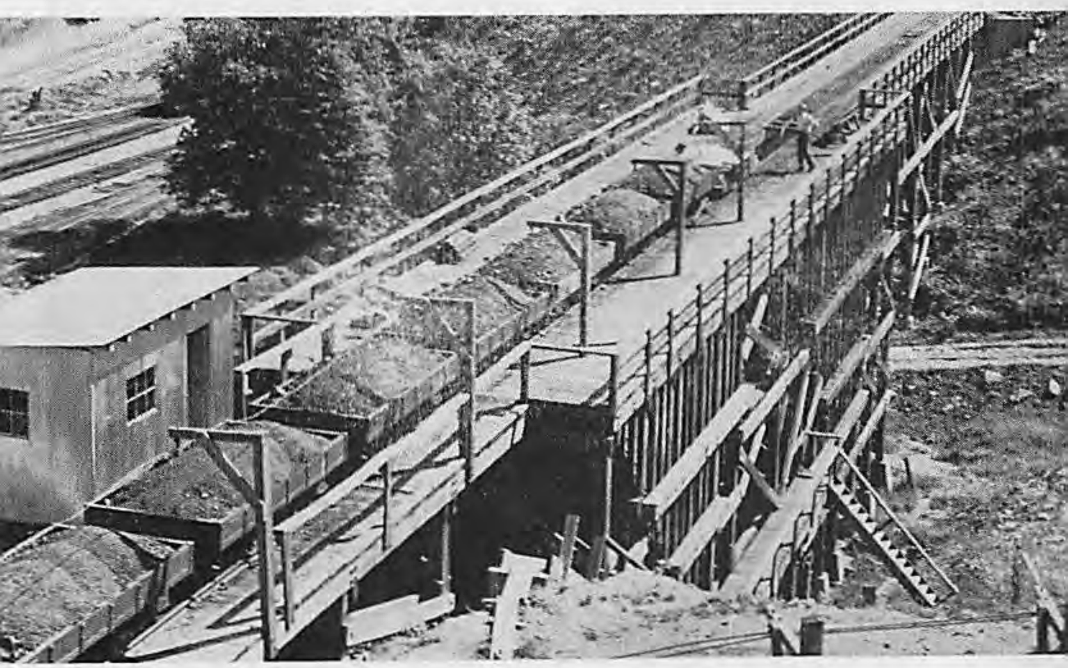
RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION

PASSAIC, NEW JERSEY

Chicago Office — 445 Lake Shore Drive



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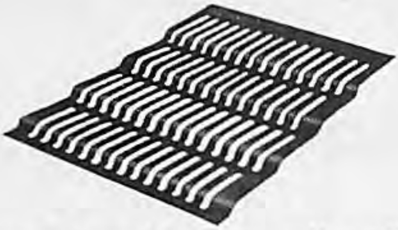
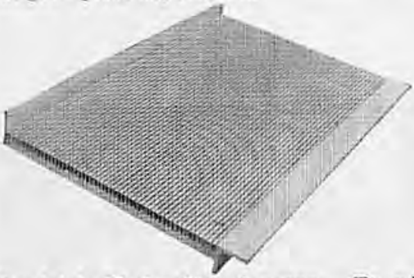
for every coal production requirement



Hendrick Flanged-Lip Screens—Unexcelled for screening and dewatering coal; furnished with short, medium or long slots, in a wide range of sizes of openings. The staggered slots are practically non-clogging; flanges speed separation.



Hendrick Wedge-Slot Screens—To adapt them most effectively to material to be dewatered and classified, they are constructed with varied types of profile bars, four of which are illustrated.

PROFILE C, for heavy-duty service on shakers and vibrators; in chutes, drags, sluiceways; dewatering of refuse and following washbox discharge.

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WEDGE-SLOT "GRIZZLIES" have heavy-duty bars for rough separation, dedusting and nut rinsing; assembled with stronger U-supports and rivets than standard Wedge-Slot Screens.

Other Hendrick products *include perforated metal screens, vibrating and shaking screens, elevator buckets, flights, conveyor troughs, shaker chutes and ball frames.*

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SURE SAVES TIME and TROUBLE IN HANDLING DUMMIES
SEAL-TITE TAMPING BAGS

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.

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***PREFORMED* WIRE ROPE**

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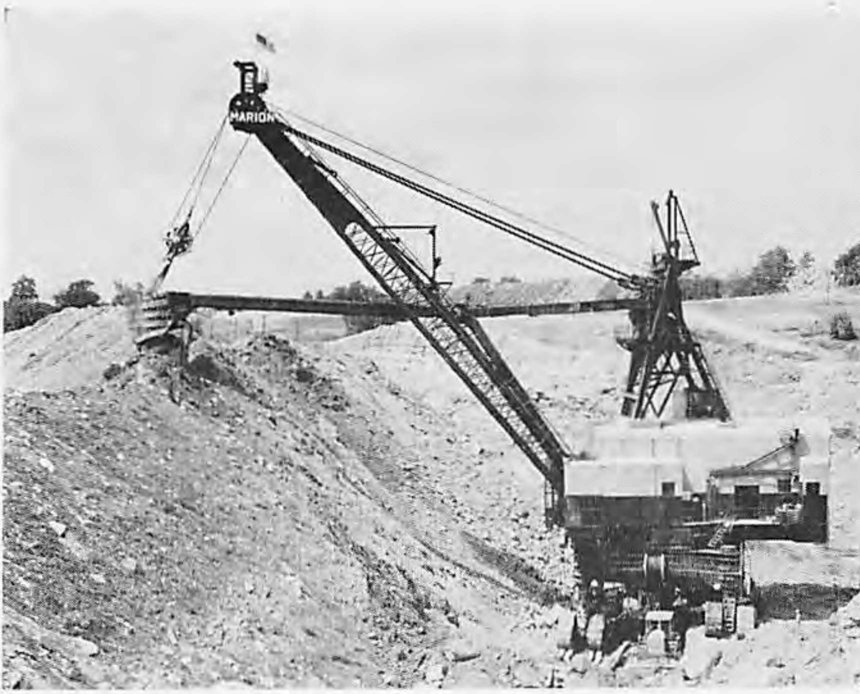

The world's largest shovel is now equipped with a 45 cu. yd. dipper.
Its new front end design gives it increased range.

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.
*111-M	3½-4 cu. yds.	**7400	8-13 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.

JOY MINING EQUIPMENT MOVES

CUTTING MACHINES

TRACKLESS CUTTERS

The JOY 11-RU, above, only 30″ high for work in thin seams, anc the 10-RU for thick seams, are highly maneuverable, fast tramming completely hydraulically controlled universal cutters for mechanizec mining. Both can make horizontal cuts, as well as shear cuts, any where in the face. The JOY 12-RB, for very low coal, is only 26″ high

SHORT WALL CUTTERS

The JOY 11-B, left, is a short-length, narrow ma- chine for conveyor mining Also available are the 7-B, a heavy-duty cutter for high capacity production; and the 5B-1, a uni for small mines. The 11-B and 7-B have a JOY Bugduster as standard equipment.

LOADING MACHINES

14-BU LOADER

JOY builds three loaders for thin seam mining—the 30″ high 14-BU, with a capacity up to 8 tons/min., the 12-BU, a 28½″ Loader of 1½ ton/min. capacity for conveyor mining, and the 20-BU-1, with a max. cap. of 8 tons/min. for very low coal. For thick seams, the 8-BU is designed for narrow places and exploratory work, and the 11-BU is a high-production Loader rated up to 10 tons/min. in 60″ seams.

SHUTTLE CARS

JOY Shuttle Cars are built in various heights and capacities to suit any requirements. They are available either battery-powered or with hydraulic cable reel, and may have fixed high, fixed low, or hydraulic adjustable elevating discharge. Models with 4-wheel steering and 4-wheel drive are the 6-SC, (right) only 29″ high for low coal, the 42″ Model 5-SC, and the high-capacity 10-SC.

MODELS FOR EVERY MINING NEED

SULMET COAL CUTTER AND AUGER BITS

with Tungsten Carbide inserts for lasting sharpness

Sulmet Bits have a field-proved cutting life many times greater than the hardest alloy steel bit. They consume less power, cut faster; cut more places with fewer bit changes.

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TONNAGE FAST...AT LOW COST

COAL DRILLS

The CD-26 is a self-propelled, hy-
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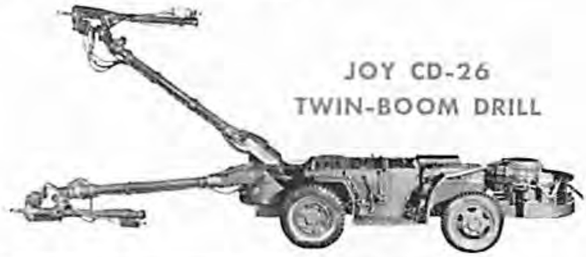
lrill that keeps ahead of any loader.
Rotation speed is variable independ-
ent of feed, and the feed can be varied
ndependent of speed, to suit drilling
conditions. JOY Mobile Coal Drills
re available in single or twin-boom
models, with hydraulic or electric
controls.



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.

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CONVEYORS

Troughed Belt Conveyors

Three series of belt conveyor de-
signs are available, each engineered
or the particular type of job re-
quired. JOY Tandem Pulley Drive Belt Conveyors
eature low belt tension and integral extended
lischarge suited to gathering and main haulage
nderground. JOY Single Pulley Drive Belt Conveyors are particu-
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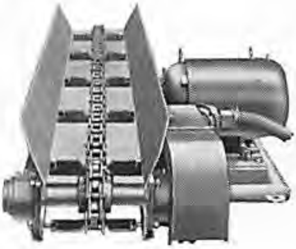
vet materials. JOY Type "C" Conveyors offer a complete line from
 to 20 HP with interchangeable parts. These units are adaptable
 multiple operations. All JOY Conveyors are furnished with sealed
recision bearings as standard equipment.

hain Conveyors



or mechanical mining in thin seams, JOY Chain Con-
eyors are available in a variety of sizes for face loading,
oom and gathering work. The new Model FA is the
ost modern chain conveyor on the market—simpler,
ghter, much more compact and efficient in every way,
ving far longer service and requiring less maintenance.

Shaker Conveyors

OY Shaker Conveyors will move coal in inclines up
 15%, over rolling and dipping mine bottoms without
illing. Cushion stroke reduces shock loads on all
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"Complete Line of Modern Mining Equipment"

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TRACK AND TROLLEY PRODUCTS

These MESCO products are part of our complete line of track and trolley products, which also include trolley taps, feeder switches, section switches and trolley wheels. All are carefully engineered to give you trouble-free service.

MOSEBACH ELECTRIC & SUPPLY COMPANY

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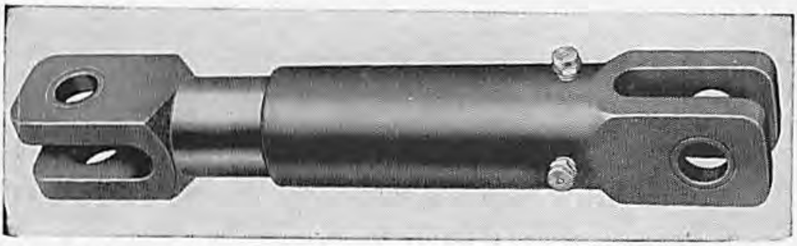
Distributor: Evansville Electric & Mfg. Co., Evansville, Ind.

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.



Mesco Hydraulic Brake adjustors are adaptable to most locomotives. Made in any desired length from 10" rod centers up. Can be instantly adjusted, anywhere, at anytime . . . wherever a grease gun is available. (Using any standard gun, motorman can handle adjustment.) Rugged . . . safe . . . eliminates sudden "let-down" . . . easy to install.

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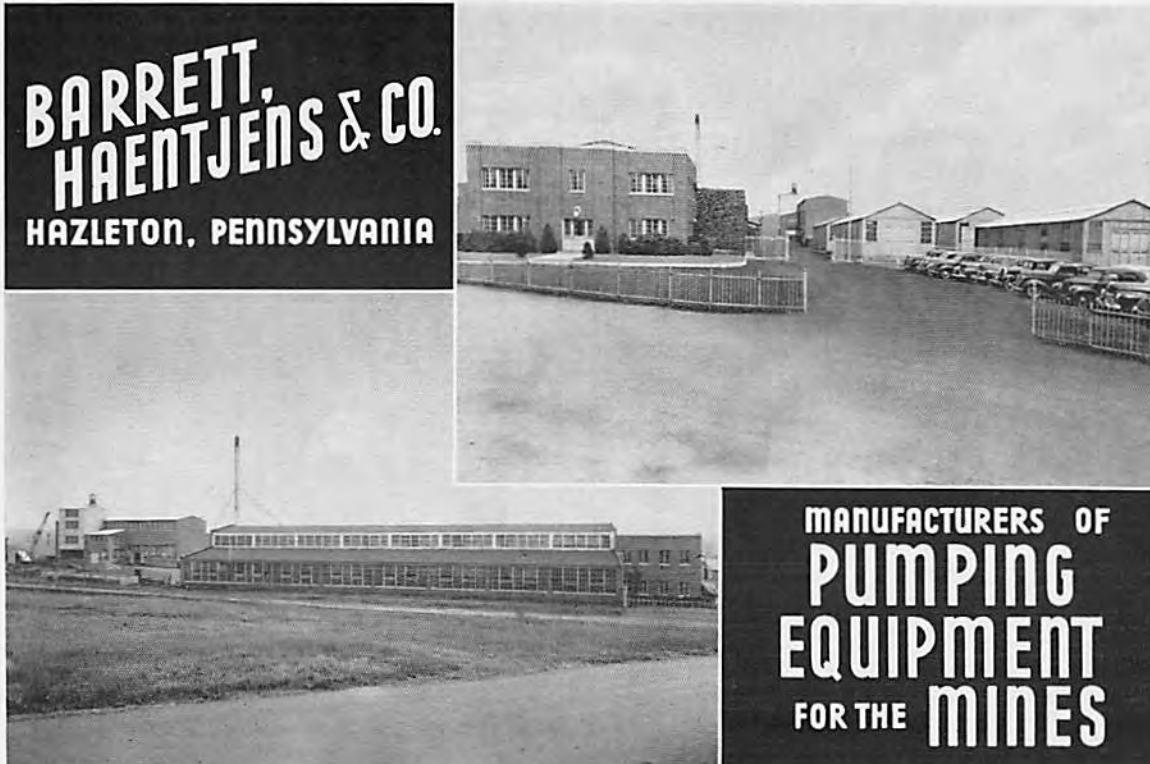
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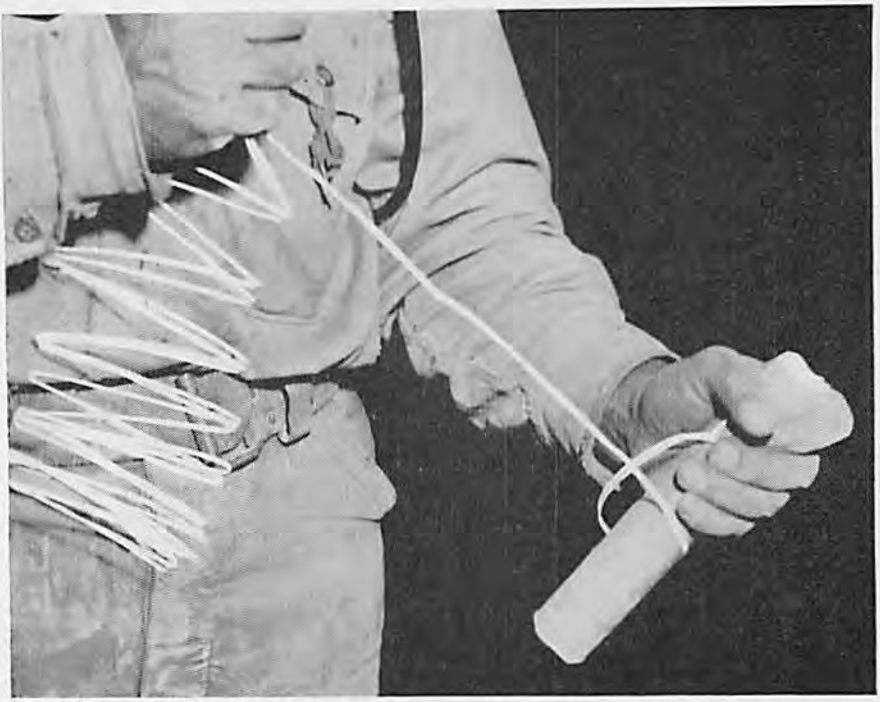

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These iron-wire caps have proved their efficiency and value in scores of mines. They assure dependable performance . . . help get the coal out on schedule, and they're economical.

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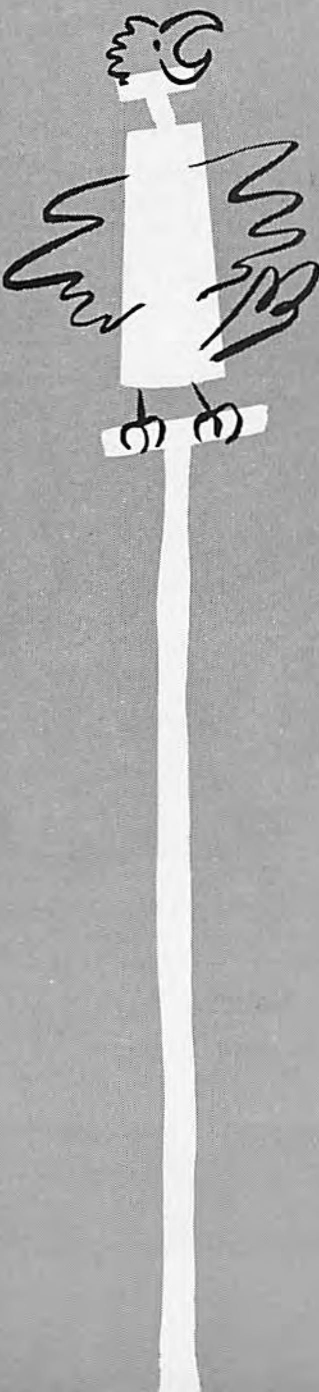
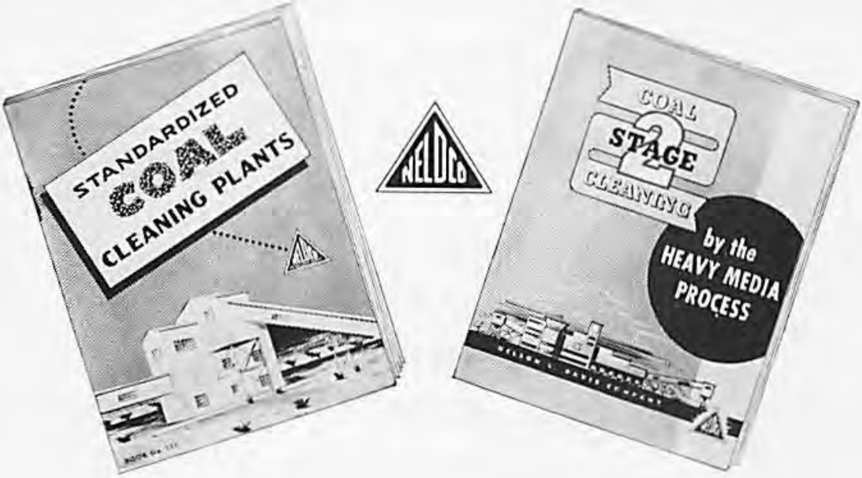
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*





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Let us show you how NELDCO Heavy Media Coal Cleaning will enable you to increase the clean coal yield per ton of run-of-mine feed; clean coal within any size range between 10″ and ¼″; eliminate hand-picking of coal and make your coal a better product and get a better market price.

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DESIGNERS AND BUILDERS OF COAL CLEANING PLANTS USING THE HEAVY MEDIA PROCESS

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The GOODMAN type 665
TRACTOR TREAD LOADER

For use with large shuttle cars in coal heights of 48″ and over

The action of the gathering arms on the Type 665 is fast and continuous, coal flow to the discharge end is constant The 40° swing of the loading head to either side permits good cleanup around timbers, breakthroughs can be driven at right angles in narrow work, coal is loaded out along the ribs with operator in a safe position. The vertical range of the loading head is from 11″ below bottom to 30½″ above — free coal is quickly loaded, tight coal can be attacked at the most effective height. All movements of the machine are smooth and positive through complete hydraulic controls. Maintenance cost is low.

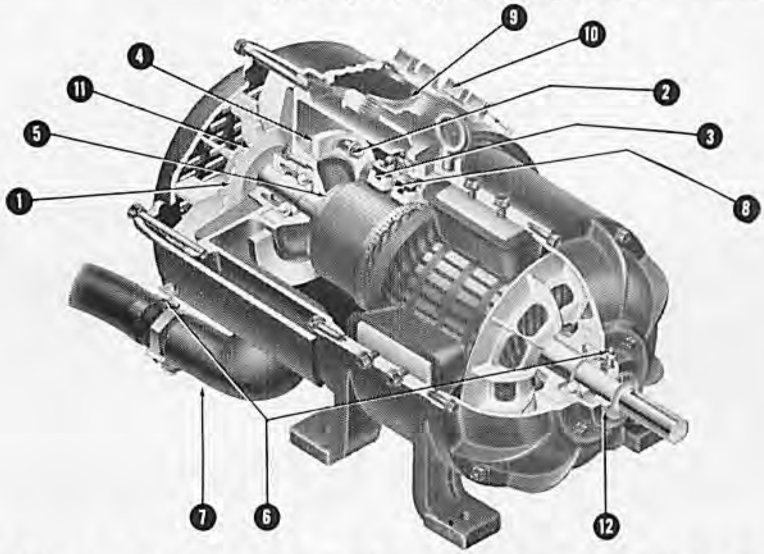
See this loader in action. A Goodman sales engineer will be glad to arrange for a mine visit

GOODMAN MANUFACTURING COMPANY

4834 S. Halsted St., Chicago 9, Illinois

NEW G-E MINE MOTOR

Explosion-proof, approved by U. S. Bureau of Mines



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1. Corrosion-resistant, non-sparking ventilating fan.
2. Brush yoke adjustment easily accessible through large hand holes.
3. Non-charring, non-hydroscopic brush stud insulation resists damage from flashovers, severe overloads.
4. Steel brush yoke and brass brushholders resist damage from shock and vibration.
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6. Pressure relief greasing system permits relubrication without dismantling motor.
7. Cable easily replaced because lead entry can be removed without pulling end shield, bearing, or working through commutator access openings.
8. Two stud brush construction—*all brushes are located in upper half* of commutator endshield, easily accessible through hand holes without removing motor from machine.
9. Hand hole cover design allows ventilation of entire surface of end shield and frame, keeps ports free from plugging.
10. Sturdy lugs on hand hole cover provide easy, quick removal without special tools.
11. Positive ventilation system assures uniform heat transfer for maximum hp in minimum space.
12. Brass non-rubbing seal prevents entry of water, dirt into bearing housing.

For more information about the new G-E mine motor, the motor designed with your maintenance costs—and maintenance men—in mind, consult your G-E representative TODAY! General Electric Company, 840 South Canal Street, Chicago 80, Ill.

GENERAL ELECTRIC

663-12

Two-Way Efficiency

The new plant at Peabody Coal Company's Pana Mine No. 17 is designed for maximum flexibility. It may be operated in either of two ways:

1. The 1½" X O coal may be diverted to railway cars for power plant use and the lump, egg and nut sizes retained for domestic fuel uses.
2. The entire mine output may be converted to 1½" X O for power plant use.

The plant has a capacity of 600 TPH of ROM coal. The plus 6" lump is hand picked and can be either delivered to cars or local trade bins for domestic use or crushed to pass 6" and returned to the natural 6" X O.

Out of this 6" X O the 1½" X O is screened by a Parrish-type shaker screen and loaded for power plant use. The 6" X 1½" is washed in a 72" wide single Tandem Hydro-Separator at the rate of 312 TPH, drained and sized. These washed sizes may then be loaded or crushed to 1½" X O.

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ROBERTS and SCHAEFER COMPANY

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Here's Help You Need NOW!

The GOULD PLUS-PERFORMANCE PLAN is just what you need to conserve and extend your shuttle car or locomotive battery power! In fact, you can improve battery performance as much as 50% if you use this plan to (1) buy batteries to fit the job; (2) charge and handle them properly; (3) maintain them systematically; and (4) know their condition at all times.

The GOULD PLUS-PERFORMANCE PLAN is a complete, integrated battery conservation program based on manuals, articles, specifications, bulletins, record cards, charts and graphs explaining and illustrating how to get more production and greater performance from your storage battery equipment.

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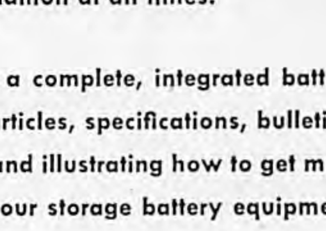
All material available under the GOULD PLUS-PERFORMANCE PLAN is free and without obligation. A request on your letterhead for information on any battery problem will bring by return mail appropriate literature and booklet explaining the complete plan. Write us, attention Field Engineering Department.



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Speaking of our people, may I remind you again that there are Charlie Duesing, Earl Quick and myself working out of the Chicago office, Don Coop in Quincy, and Ted Hopgood in Chester -- not to mention all the Atlas distributors in Illinois.

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Sincerely,

John F. Flippo

John F. Flippo
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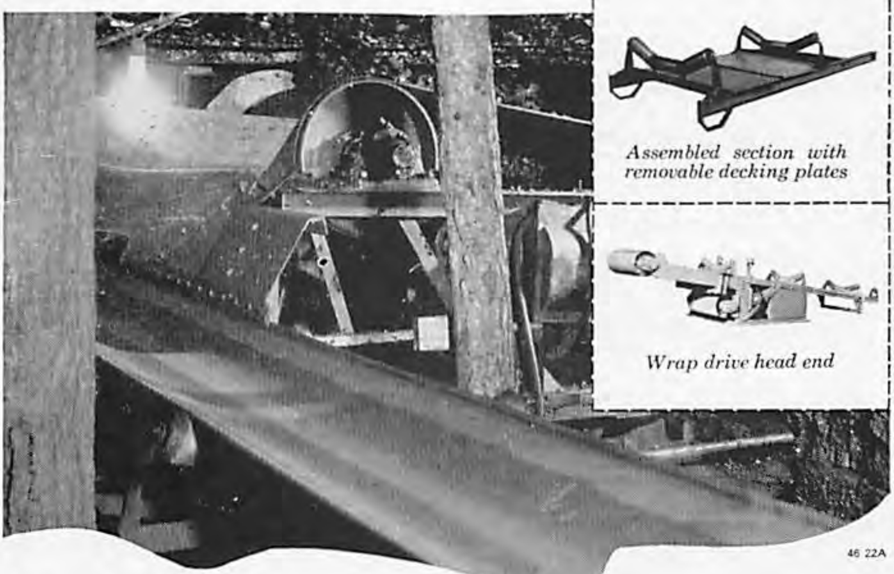

Assembled section with removable decking plates

Wrap drive head end

46 22A

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CARBOLOY

DEPARTMENT OF GENERAL ELECTRIC COMPANY
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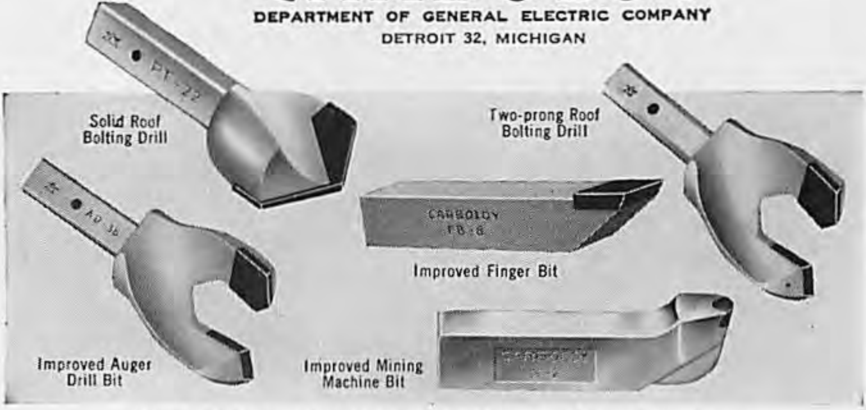

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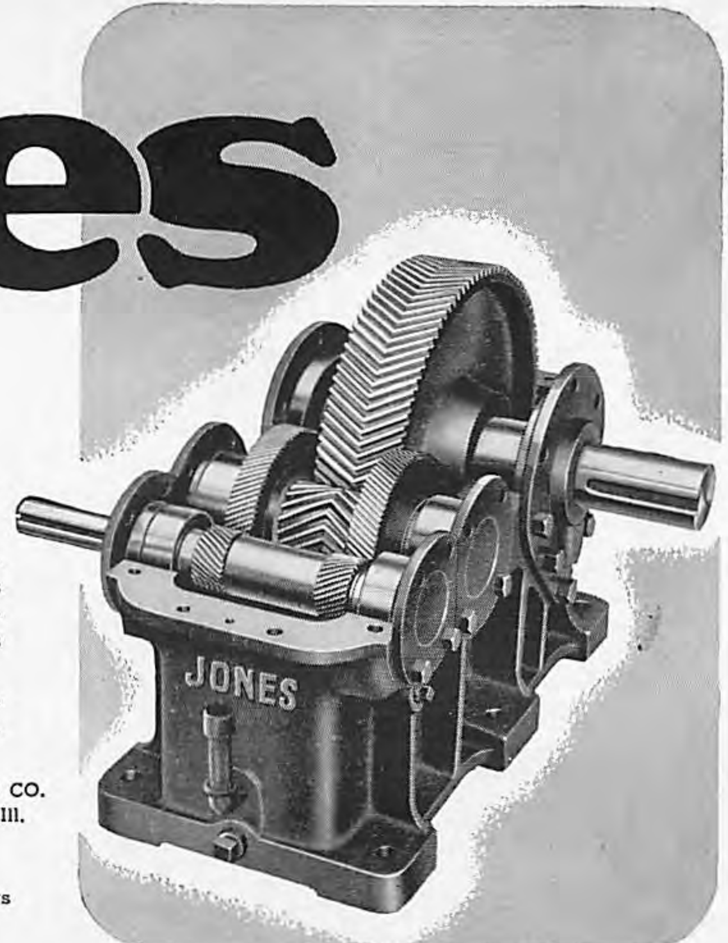

. . . are built in single, double and triple reduction types. Symmetrical gear arrangement provides balanced loads on liberally proportioned bearings. Housings are substantially constructed, well ribbed and have generous pads for foot bolts.

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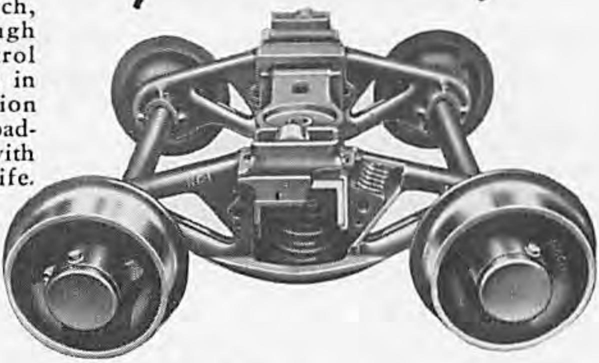
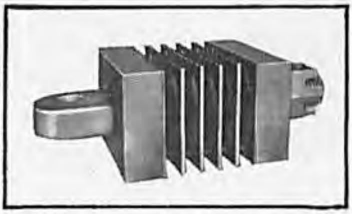
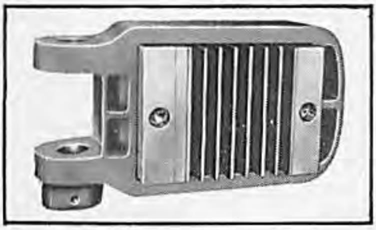


Willison Automatic Couplers save time with maximum safety . . . can be coupled at either end of car or locomotive . . . require no manual assistance. Close coupling eliminates damaging slack, permits high speeds with maximum stability.



National M-230 Rubber-Cushioned Draft Gear for cars operating through rotary dump. Soft initial-action, high-capacity rubber pads provide maximum impact protection, lengthen equipment life. Available in a range of capacities and design variations to fit individual requirements.



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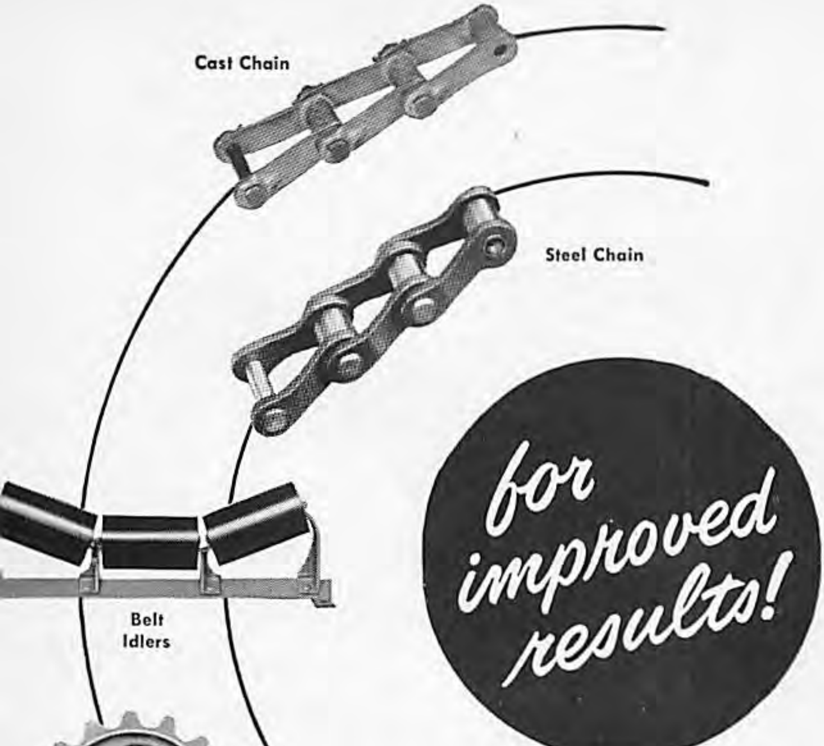

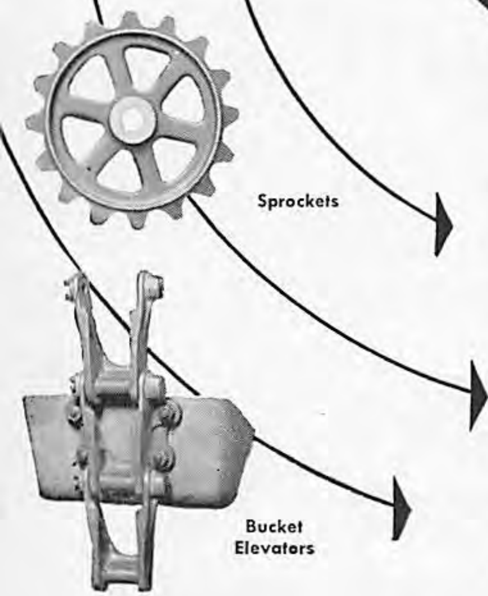

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