PROCEEDINGS

of the

ILLINOIS MINING INSTITUTE

FOUNDED FEBRUARY, 1892

Sixty-ninth Year

1961

Annual Meeting

SPRINGFIELD, ILLINOIS

October 20, 1961

Photo by Fabian Bachrach

STUART COLNON
President, 1961

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
C. J. SANDOE, Aug. 29, 1941
F. M. SCHULL, Aug. 20, 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
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
H. E. MABRY, Nov. 8, 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, June 7, 1946
OSCAR WINTER, Sept. 21, 1946
GEORGE HOOK, Sept. 29, 1946
E. J. KRAUSE, Sept. 30, 1946
J. R. PEARCE, Dec. 10, 1946
E. R. ARMSTRONG, Feb. 17, 1947
JOS. P. LENZINI, Feb. 20, 1947
JOHN H. BAUER, March 12, 1947
ARTHUR PHILLIPS, June 27, 1947
LEE HASKINS, Sept. 19, 1947
C. H. BURKHALTER, Oct. 18, 1947
JETT J. WEST, Nov. 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

* Killed in Action

In Loving Remembrance

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, Aug. 7, 1949
JOHN RODENBUSH, Nov. 1, 1949
R. G. LAWRY, Dec. 24, 1949
WALTER A. BLEDSOE, March 1, 1950
A. S. KNOIZEN, April 29, 1950
H. C. FREDERICKS, Aug. 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
A. D. BUSCH, January 1, 1952
F. H. SEYMOUR, February 20, 1952
C. M. O'BRIEN, April 16, 1952
JOHN L. CLARKSON, June 9, 1952
HARRY VOGELPOHL, June 15, 1952
HECTOR HALL, August 21, 1952
J. J. RUTLEDGE, September 11, 1952
NORMAN PRUDENT, September 18, 1952
WALTER WHITING, September 25, 1952
D. W. JONES, November 26, 1952
G. H. BERGSTROM, December 11, 1952
E. J. STERBA, December 31, 1952
W. J. JENKINS, January 12, 1953
FRED J. BAILEY, January 16, 1953
A. C. BASS, Feb. 10, 1953
A. R. JAMISON, Feb. 25, 1953
ANDREW JUNELL, March 4, 1953
HARVEY CARTWRIGHT, June 4, 1953
L. A. DUNBAR, July 30, 1953
R. W. WEBSTER, August 10, 1953
L. A. TROVILLION, Sept. 4, 1953
H. A. REID, October 20, 1953
GEORGE MEAGHER, November 6, 1953
WILLIAM J. McDOWELL, Dec. 12, 1953
L. E. YOUNG, Dec. 27, 1953
O. V. SIMPSON, March 25, 1954
CASPER D. MEALS, April 27, 1954
I. B. TIGRETT, May 2, 1954
T. W. PEARSON, May 11, 1954
HARRISON H. JOHNSON Jr., July 20, 1954
BEN H. FIRTH, October 21, 1954
JACK BULLINGTON, October 29, 1954
LOWELL T. MALAN, December 29, 1954
H. KENNETH VOGEL, January 4, 1955
CHARLES H. DUESING, January 8, 1955
JOHN LAND, June 5, 1955
C. W. BROOKS, September 21, 1955
JOE LITTLEFAIR, September 27, 1955
O. J. FLESCHNER, December 10, 1955
GLENN A. SHAFER
HENRY M. MOSES, April 1, 1956
CAPT. W. H. LEYHE, July 4, 1956
J. A. JEFFERIS, July 14, 1956
JOHN A. EMRICK, July 27, 1956
J. M. VANSTON, August, 1956
ROBERT M. MEDILL, January 27, 1957
JAMES W. MORGAN, February 1, 1957
W. E. VAUGHN, February, 1957
JOSEPH F. JOY, February 19, 1957
FRANK H. REED, April 27, 1957
J. W. STEWART, June 17, 1957
JOHN E. JONES, July 1, 1957
L. C. STRAWSER, July 23, 1957
F. A. CHAPMAN, October 6, 1957
N. C. McFADDEN, October 17, 1957
W. E. BARROW, October 28, 1957
GEORGE C. McFADDEN, Dec. 1, 1957
C. CHRISTIANSON, August 2, 1958
HUGH MERCER, Sept. 2, 1958
EDGAR R. PHILLIPS, Dec. 9, 1958
KIRK V. CAMMACK, December 26, 1958
L. BRUCE HOWARD, 1958
F. E. SNARR, Jan. 16, 1959
B. K. LEACH, January 22, 1959
BELA SCHONTHAL, March 10, 1959
EUGENE McAULIFF, June 2, 1959
LEE CONWAY, 1959
F. A. POWERS, February 3, 1960
W. M. DUNCAN, April 11, 1960
HARRY POLLACK, May 29, 1960
ARTHUR L. JEDLICKA, June 5, 1960
J. H. FLETCHER, July 18, 1960
W. H. BURKEY, Nov. 15, 1960
CLYDE H. JUSTICE, Feb. 12, 1961
A. J. BOYNTON, Aug. 17, 1961
JOHN C. ROLLO, Aug. 21, 1961
RUDOLPH G. WUERKER, Aug.30, 1961
CHARLES H. DORSEY, Sept., 1961
D. H. DEVONALD, Oct. 30, 1961
WALTER M. JONES, Dec. 4, 1961
C. M. DONAHUE, Jan. 15, 1962
RALPH BUDD, Feb., 1962
ARCH CROSS, March, 1962

OFFICERS 1961

PRESIDENT

STUART COLNON
Chicago, Illinois

VICE-PRESIDENT

ROBERT J. HEPBURN
Chicago, Illinois

SECRETARY-TREASURER

GEORGE M. WILSON
102 Natural Resources Building,
Urbana, Illinois

EXECUTIVE BOARD

C. C. BAILIE*
J. C. FRYE*
B. R. GEBHART*
HADLEY HARVEY**
GENE LONG*
H. E. MAUCK***
EUGENE T. MORONI***
MURRELL REAK**
R. H. SWALLOW***
G. H. UTTERBACK**
W. A. WEIMER***
J. P. WEIR**

*Term expires 1961
**Term expires 1962
***Term expires 1963

OFFICERS 1962

PRESIDENT

ROBERT J. HEPBURN
Chicago, Illinois

VICE-PRESIDENT

J. P. WEIR
Chicago, Illinois

SECRETARY-TREASURER

GEORGE M. WILSON
102 Natural Resources Building
Urbana, Illinois

EXECUTIVE BOARD

DAVID FLOTA***
HADLEY HARVEY*
H. E. MAUCK**
WM. C. MCCULLOCH***
EUGENE T. MORONI**
MURRELL REAK*
JACK A. SIMON***
R. H. SWALLOW**
H. M. TIBBS***
G. H. UTTERBACK*
W. A. WEIMER**
R. P. WILSON***

*Term expires 1962
**Term expires 1963
***Term expires 1964

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, Litchfield, Ill.
1923-24 D. D. WILCOX, C. E., Superior Coal Co., Gillespie, Ill.
1924-25 H. E. SMITH, Gen. Supt., Union Fuel Co., Springfield, Ill.
1925-26 E. G. LEWIS, Supt., Chicago-Sandoval Coal Co., Sandoval, Ill.
1926-27 WM. E. KIDD, State Mine Inspector, Peoria, Ill.
1927-28 JAMES S. ANDERSON, Supt., Madison Coal Corp., Glen Carbon, Ill.
1928-29 JOHN E. JONES, Safety Engineer, Old Ben Coal Corp., West Frankfort, Ill.
1929-30 PROF. A. C. CALLEN, University of Illinois, Urbana, Ill.
1930-31 JOSEPH D. ZOOK, Pres., Illinois Coal Operators Assn., Chicago, Ill.
1931-32 GEO. C. MCFADDEN, Asst. Vice-Pres., Peabody Coal Co., Chicago, Ill.
1932-33 CHAS. F. HAMILTON, Vice-Pres., Pyramid Coal Co., Chicago, Ill.
1933-34 HARRY A. TREADWELL, Gen. Supt., C. W. & F. Coal Co., Benton, Ill.
1934-35 C. J. SANDOE, Vice-Pres., West Virginia Coal Co., St. Louis, Mo.
1935-36 T. J. THOMAS, Pres., Valier Coal Co., Chicago, Ill.
1936-37 W. J. JENKINS, Pres., Consolidated Coal Co., St. Louis, Mo.
1937-38 H. H. TAYLOR, JR., Franklin County Coal Corp., Chicago, Ill.
1938-39 PAUL WEIR, Consulting Mining Engineer, Chicago, Ill.
1939-40 ROY L. ADAMS, Old Ben Coal Corp., West Frankfort, Ill.
1940-41 DR. M. M. LEIGHTON, State Geological Survey, Urbana, Ill.
1941-42 J. A. JEFFERIS, Illinois Terminal Railroad Co., St. Louis, Mo.
1942-43 CARL T. HAYDEN, Sahara Coal Co., Chicago, Ill.
1943-44 BEN H. SCHULL, Binkley Mining Co., Chicago, Ill.
1944-45 GEORGE F. CAMPBELL, Old Ben Coal Corp., Chicago, Ill.
1945-46 JOSEPH E. HITT, Walter Bledsoe Co., St. Louis, Mo.
1946-47 ROBERT M. MEDILL, Dept. Mines & Minerals, Springfield, Ill.
1947-48 HARRY M. MOSES, H. C. Frick Coal Co., Pittsburgh, Pa.
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.
1951-52 CLAYTON G. BALL, Paul Weir Co., Chicago, Ill.
1952-53 WILLIAM W. BOLT, Pawnee, Ill.
1953-54 HAROLD L. WALKER, M. & N Engineering Company, Alton, Ill.
1954-55 J. W. MACDONALD, Old Ben Coal Corp., Benton, Ill.
1955-56 EARL SNARR, Freeman Coal Mining Corp., Hinsdale, Ill.
1956-57 PAUL HALBERSLEBEN, Sahara Coal Co., Harrisburg, Ill.
1957-58 H. C. LIVINGSTON, Truax-Traer Coal Co., Chicago, Ill.
1958-59 A. G. GOSSARD, Snow Hill Coal Corp., Terre Haute, Ind.
1959-60 H. C. MCCOLLUM, Peabody Coal Company, St. Louis, Mo.
1960-61 STUART COLNON, Bell & Zoller Coal Co., Chicago, Ill.

CONTENTS

SIXTY-NINTH ANNUAL MEETING

MORNING SESSION

AFTERNOON SESSION

SPECIAL REPORT

PAGE

REPRINTS

Reprint from *Coal Age* through courtesy of McGraw-Hill Publishing Co., Inc.

Reprint from *Mining Congress Journal*

Reprint from *Mechanization*

PROCEEDINGS OF ILLINOIS MINING INSTITUTE
SIXTY-NINTH ANNUAL MEETING

Held in Springfield, Illinois

FRIDAY, OCTOBER 20, 1961

MORNING SESSION

The Opening Session of the Sixty-ninth Annual Meeting of the Illinois Mining Institute, held in the Grand Ballroom of the Abraham Lincoln Hotel in Springfield, Illinois, October 20, 1961, convened at 10:00 a.m., Vice-President R. J. Hepburn, presiding.

Vice-President Hepburn (The United Electric Coal Companies, Chicago, Illinois): Gentlemen, on behalf of Stuart Colnon, our president, who is unable to be with us today, I would like to welcome you to our sixty-ninth annual meeting. We have a fine program prepared and I know it will be most interesting to all of us. Directly after the morning session, after a short recess, we will have a luncheon program which will replace the usual evening banquet. I urge you all to plan to attend this luncheon and get your tickets as soon as possible. In this morning's session we have several fine papers. W. A. Weimer, Engineer, Peabody Coal Company, will preside as chairman.

Chairman Weimer: Thank you, Mr. Hepburn, and members of the Illinois Mining Institute. The IMI gives us all the opportunity to pause about this time of the year, lay down our tools, visit with all our friends, and talk over our problems with our competitors. You will notice in the program we've had quite a change from last year or the years before. We have tried to compact the program by eliminating the afternoon technical sessions and moving up the dinner banquet at 9:00 p.m. so we have a luncheon banquet. We think that we are substituting quality for quantity and you all will get to hear our distinguished speaker and we will get an early adjournment. Adjournment will be some time before 4:00, giving us an opportunity to spend the evening at home and of course go to the ball game tomorrow.

We want you to pay particular attention to the way we run the program. Some of you probably won't like the change. If you like it or dislike it, will you talk to mem-

bers of the Executive Board, whose names appear on the back of the program, and give them your reactions—or to the five new members who will be introduced during the business meeting shortly after the luncheon. The tickets for the luncheon are on sale now and should be purchased immediately. After we adjourn from the technical session, you will have about an hour or so, so the salesmen can sell and purchase a drink, and then we will meet back in this room at 1:00 for the luncheon.

There is another change that I woud like to tell you about while I have the opportunity here, and that is about the American Institute of Mining, Metallurgical and Petroleum Engineers Coal Subsection formed in Southern Illinois about a year ago or slightly more. A group got together, mostly with Gene Mauck as the driving force. He saw the need for a rather "grass roots" meeting of the fellows at the mines who needed to get together and discuss their problems. Some of you know about it, but even some AIME members don't know about the organization. We have had several meetings at Johnson City, and at Benton, and Kentucky Lake. We usually try in the summer to have an afternoon of golf, or of course Kentucky Lake fishing, if available. Some of you might think that you are not eligible to join. There is one requisite—that you be a member of the American Institute of Mining Engineers. Some of you may think, well, maybe you can't get in. But while there are some educational requirements, for the most part the AIME is perpetuated by the members themselves. Even if your education is very limited, if you have contributed to the coal industry and get three present members of the AIME to sign your application, you can become a member. I would be pleased to have you give me your name and address if you are interested in joining the AIME or the Coal Subsection. Talk to some of the present members; we would be happy to have you at our meetings.

Our first speaker this morning is Mr. Robert E. Greer, Mining Sales Engineer for the Jeffrey Manufacturing Company of Columbus, Ohio. Mr. Greer graduated from Ohio State University in Electrical Engineering in 1948; he was with the Inland Steel Company and became assistant mines superintendent in 1955 when he began his career in the mining manufacturing business, and is presently with the Jeffrey Company. He has had several technical papers in the AIME publications and elsewhere. He has recently returned from a trip around the world and work in India. Mr. Greer.

R. E. Greer: Thank you. Gentlemen:

AN EQUIPMENT MANUFACTURER LOOKS AT FUTURE CUSTOMER NEEDS

R. E. GREER
Mining Sales Engineer
Jeffrey Manufacturing Co., Columbus, Ohio

Some of the people in the Coal Industry may be due to meet a deadly fate—they may become a statistic.

In 1960 over 73% of the national total energy in the United States was supplied by oil and gas. Oil accounted for 41.5%, gas for 31.5%, water power 3.9%; coal accounted for only 23.1% of this energy. This 23.1% is not an enviable percentage, considering that in the last century coal supplied about 100% of the energy.

The Coal Industry has been built upon hardships. In King Edward the First's time it was a capital offense to burn coal in London. In 1619 Dudley was driven from Worchester County in England when he tried to burn coal in his blast furnace because wood was scarce. In fact, only 150 years ago it was against the law to sell coal in Philadelphia.

The facts of the coal market and the hardships of Coal's history were brought up because they affect everyone here and in the industry right where it hurts—in the sensitive organ called the pocketbook.

Action is being taken to assure the future of the industry.

The Government has signed The Coal Research Act into law and allotted a million dollars for starting this project.

Bituminous Coal Research, Inc., has approved an $875,000 expenditure for research.

Manufacturers, meanwhile, are developing new and better equipment, etc., etc., etc. The following classified items will give you insight as to just what one equipment manufacturer, The Jeffrey Manufacturing Company, is doing in meeting the future needs of their customers.

Customer's Needs as Designed For:

Past—Customers in the past, like many here, received coal mining machinery that was sometimes just assembled. In many cases the true design was made after the machine was built so that the next machine would perform to a "limited" extent. The old approach of "if it breaks, make it stronger" served as a design concept and filled a need at that time.

Present—Design engineers of mining equipment now study basic applications and needs of the ma-

chine before it is designed. Since every engineering design is a compromise, the ultimate compromise is the selling price. Is there a man here that would pay three quarters of a million dollars for a loading machine that would not breakdown between annual overhauls?

Think of your new Jeffrey underground equipment and consider the newer utilization construction with accessibility of all components as compared to equipment of a few years ago. The records show that the new machine can be put back into production much more rapidly and the replaced unit can be repaired in a shop under less stress, better working conditions and with enough time allowed to do the repair job right.

By refinement of electric motors and control, hydraulic components, etc., today's machine is vastly superior to its brother of a few years ago.

Future—Coal mining machinery of the future must be designed from the experience gained from past performance. If you were given the task of building a truck it would be folly to ignore the past history of trucks and not build upon the present state of the art.

Manufacturers of coal mining machinery of the future must build equipment that will operate with no down time between overhaul dates. This reliability in equipment is working every day in the airplanes that fly over your homes.

Mathematical formulas can be derived for mining equipment which will tell the operator when to overhaul the equipment and when it is time to replace a unit so as to save money by doing so.

Challenges of Future Mechanization

Methods, systems, equipment, labor, management and finance must all fit into any study of future mechanization as related to the preceding data.

Basically the most important future challenges for future mechanization are:

Transportation—If today's loaders and miners could operate continuously with no haulage problems, no down time and with good conditions, it is a well known fact that a small number of these units could produce all the 1¾ million tons per operating day of our coal production. This becomes a major future challenge, since the basic problem is continuous haulage.

Continuous vs. *Conventional Mining*—The test era of the continuous miner is over. As a paralleling example, about three or four years ago plastic trailing cable was given trials in the mines. By official interest in these cables they were given preferential treatment and these test results were that the cables were five to six times better than the standard cable, but in less than three years the operating tests became equal and now the ratio is only 1 to 1.7 favoring the new cable.

This example was given to show a principle.

Records now indicate that in certain conditions a continuous miner must operate 103% of available face time to produce as much coal as the conventional section. This cannot be done, so future trends show that each type of mining must be evaluated carefully.

Remote Control—"Moon Min-

ing might well be a future project. Adapting plans of extreme future dates is not to be totally ignored today, but the future equipment must bring dollars into the industry during our time. A "Tethered Area" concept *vs.* a true remote control is the first step in this program. This must come before a man inserts a taped or programmed plan into a "block box" at the portal in the morning and returns at night to shut the machine off and record the tonnages mined. The true "Tethered Area" idea will allow man to be near the machine and yet removed from the area where most of today's accidents happen. A need for remote control is recognized, but it must *not* be developed just because it is a "fashionable thing" to do. All the coal mining equipment must work together. To automatize just one unit gives no particular advantage —the teamwork of machines is as important as the teamwork of the men that run them.

Programmed Customer Needs—Basic Research

Basic to any and all research in a free economy is the profit idea. The cost of development of the product and the expected product life say how much value can be placed upon the product. By necessity, the market must be seen as it will exist five, ten or even fifteen years from today and plans laid accordingly.

Manufacturer's Responsibilities—The mining equipment of the future must sell for a price that will allow a reasonable profit and allow the purchaser to make the same reasonable profit by using the machine. Research must be paid for from the manufacturer's profit. Without research and new products, equipment manufacturers will cease to exist as such in a short time. By the same reasoning the customers of the manufacturer will face the same fate because of lack of new equipment from the manufacturer. If an entire industry decides on a level existence so that no one individual unit of the industry should advance, the entire industry can be by-passed, or may even cease to exist.

From the basic profit the manufacturer must provide service, parts supply, consultation and other services to the ultimate customer. The manufacturer, true, is interested in the basic fair profit, but he is the only one who can logically and practically furnish the previously mentioned items.

Customer's Responsibilities—The customer must aid the manufacturer as an ultimate service unto himself. Only he can return true information and data about complete performance of the equipment to the manufacturer to make sure the equipment is performing as designed and manufactured.

The customer must keep informed so as to know what is a reasonable performance from the equipment. He then has every right to demand and expect such performance from the equipment.

The responsibility of proper, justified records must be with the owner of the equipment. Accurate records are a "must" with present-day equipment and will be an economic factual basis for future designing of proper equipment.

How A Customer Can Select Future Mining Machines

The customer of tomorrow might well buy moon mining equipment or deep sea remote coal mining units that will bring the coal to the surface already washed and sized, but such sophisticated items are in the future. Meanwhile, back at the mine, a profit must be shown and progress must be gradual to tomorrow's mining machines.

Five factors in choosing future mining machines can be listed as follows:

1. Will the system integrate with the present system or will new mining plans have to be made?

2. Will the machinery be economical and produce a fair profit?

3. Can fair and accurate comparison with today's equipment be made so as to give an accurate comparison between present and future equipment?

4. What support in equipment or manpower is required or expected?

5. What effects on the market or what long-range economic results will be brought forth by use of the proposed equipment?

Recap of Future Customer's Needs

The manufacturer must have a working knowledge of every part of the design and manufacture of his mining equipment. His knowledge of the future mining equipment must be sometimes dead reckoning, but logical and sequential step-by-step development through research must guide this reasoning.

The manufacturer must still build on experience when considering future machines as to economic value, economic need and many other things that will result at a future date in a machine that a customer will want and be able to afford, and one that will allow the customer to make a profit by its continuing use.

By retaining a fair profit from present-day machines, the manufacturer can pay all the expenses such as service, consultation and advice to the customer, with still enough to pay for research and development of future machinery. Without progress all those concerned with design, manufacture and use of the equipment cannot continue.

Customer Responsibilities—The customer should have records and data on his equipment as to maintenance and performance. These are just as essential as his profit and loss statements and can sometimes reflect profit and loss much in advance of the financial records.

The correct use and maintenance of mining equipment must be done by the customer to insure that he will receive full value from use of the equipment. The customer again must make a fair profit from the use of the equipment or he cannot have any justifiable reason for its use.

Mechanics and Progress for Future Plans—The design for the new equipment in mining must be compatible with present day equipment so that progress is an evolution rather than a revolution.

Programmed maintenance for production with a minimum of down time to develop an exacting schedule is a necessary future development.

Planned equipment replacement that allows new equipment per-

formance will keep the coal mines abreast of all developments and at a profitable return for the investment.

Future New Equipment—The haulage is an important item to design for future equipment.

Conventional section equipment for mining machinery has not reached its ultimate. Both continuous and conventional units bear study in the future. Ideas and methods that could use equipment not yet built must be considered in the future by equipment manufacturers.

The equipment for the future could be almost universal in nature, *i.e.*, one machine to be very versatile and do almost anything under any condtion—or it could be of the compact concept which would allow low-cost specialized equipment to do specific jobs under given conditions.

In choosing the future equipment to mine over 58% of all the future minable coal in the world, which 58% is found in the North American continent, the best coal operators in the world will be those in the coal industry of today. Their records of production prove their worth.

For the best equipment manufacturers in the world, just look at the export records for this proof.

With all the foregoing facts, why would anyone not expect future cooperation between you, the customer, and us, the manufacturer, to maintain and better the past records?

* * *

Chairman Weimer: Do we have any questions? . . . We all know that as tight competition as we are in we can't buy good enough, or they can't make good enough, tools for us. We know that next year there will always be a better tool and we'll pay the money for it if it does the job. . . .Thank you, Mr. Greer.

Our next speaker is Mr. John A. Harrison, coal petrologist with the Illinois State Geological Survey at Urbana. Mr. Harrison was born in Arkansas, graduated from the University of Arkansas in 1940, and got his Master's degree at the University of Illinois in 1948. He was a geophysicist in foreign service in South America in 1936-37. He joined the Survey in 1941 and returned in 1946 after World War II. The past ten years he has been in charge of coal petrography. His paper is entitled Coal Petrography Applied to Coking Problems. Mr. Harrison.

COAL PETROGRAPHY APPLIED TO COKING PROBLEMS

JOHN A. HARRISON

Associate Geologist
Illinois State Geological Survey
Urbana, Illinois

ABSTRACT

Coal petrography classifications and methods of investigation, developed in various countries, are reviewed and compared. A procedure is described, in which one of these methods of investigation was used, whereby coke stability can be predicted from petrographic analyses of coal. An example is cited in which Illinois coals and blends containing Illinois coals have been tested using this procedure.

Introduction

The development of coal petrography during the last 50 years in various parts of the world has resulted in various methods of investigation and systems of classification. In the first part of this paper a number of classifications are discussed and their characteristics compared. The second part describes a procedure for predicting coke stability from petrographic analysis. This procedure combines certain previously developed methods of petrographic analysis with stability data obtained in standard A.S.T.M. test from pilot-scale coke tests. An example is given explaining its use in tests run on Illinois coals and blends containing Illinois coals.

Methods of Classification

Investigation procedures and resulting classifications in coal petrography may be divided into two main groups based primarily on the method of illuminating the coal sample used in microscopic studies, namely by transmitted and reflected light. The transmitted light method employs a process of passing light through a thin section of coal that has been ground to a thickness of normally less than 8 microns. In the reflected light method a beam of light is reflected off a polished surface of coal.

The microscope transmitted light method has been long associated with the Thiessen classification, which is based on a botanical concept (coal as an assemblage of plant remains). In like manner the microscope reflected light method has been associated with the Stopes classification, which is based on a lithologic concept (coal as a rock).

Stopes' description of hand specimens of coal (1919) was based pre-

dominantly on reflected light; however, she also made thin sections of the coal. Her classification, presented in 1935, in which she described the components that make up coal, was based predominately on microscope transmitted light method of study. For this reason the author has discussed the Stopes' classifications under the heading of microscope transmitted light method.

Since 1935 Stopes' classification generally has been accepted in Europe and throughout the world and microscope reflected light methods have been used to describe the components in her classification in many reports. This had resulted in the close association between her classification and the reflected light method.

The above does not preclude reflected light from Thiessen's classification or transmitted light from Stopes' classification, but general usage has established the relationship between classifications and methods of illumination.

Microscope Transmitted Light Methods

Thiessen (1920) stated that Henry Witham made the first thin sections of coal and reported on them in 1831-32. Many other workers, including J. W. Dawson (1859), W. Hutton (1883), C. W. von Guembel (1883) and H. Potonie (1906), have made significant contributions which greatly advanced the understanding of the nature of coal. The report of White and Thiessen (1914) was the first extensive, systematic description of thin sections of coal and original plants from which coal was derived, but no classification was proposed. R. Thiessen developed the classification and nomenclature based on thin sections of coal and transmitted light method of microscopic examination which are used at the U. S. Bureau of Mines and other laboratories in the United States. He defined his types and components over a period of years in numerous publications. One of his most systematic and detailed description of the types, subtypes and components was presented in 1937, but in this, as in previous publications, he failed to give specific quantities of components necessary to establish clearly the difference between coal types. Parks and O'Donnell (1956) reviewed Thiessen's work, designated percentages of components present in each of Thiessen's types and presented a formal classification (Table 1).

The two main components of coal defined by Thiessen were anthraxylon (1920) and attritus (1919). He accepted the term fusain, which had been defined by Grand'Eury (1882) and Stevenson (1911).

Anthraxylon is more than 14 microns thick, generally reveals some of the original plant structure and varies in color from orange to deep red, the depth of color increasing with increasing rank and thickness of the thin section. Microscopically similar material less than 14 microns thick is included with attritus in Thiessen's classification. The 14-micron lower limit was used by Thiessen and his coworkers for many years but was first published by Parks and O'Donnell (1948).

Attritus, a mixture of tightly packed plant remains of different morphological forms and origin, is subdivided into opaque attritus and translucent attritus. The predominant constituent in opaque attritus

TABLE 1 — TYPE CLASSIFICATION OF COAL ACCORDING TO THIESSEN* (TRANSMITTED LIGHT)

Types		Relative Amounts of Banded Components
Banded coals	Bright (20% opaque matter)	Anthraxylon more than 5 percent and usually predominant component. Attritus usually subordinate but occasionally predominant. Fusain often present but never abundant.
	Semisplint (20 - 30% opaque matter)	Anthraxylon more than 5 percent and occasionally equal to attritus. Attritus usually predominant component. Fusain often present but usually in minor amounts.
	Splint (30% opaque matter)	Anthraxylon more than 5 percent but usually in minor amounts. Attritus always predominant component. Fusain often present but usually in minor amounts.
Nonbanded coals	Cannel	Anthraxylon less than 5 percent and usually absent. Attritus always predominant component. Fusain rare.
	Boghead	Anthraxylon less than 5 percent and usually absent. Attritus always predominant. Fusain rare.

*Modified from Parks, B. C., and O'Donnell, H. J., 1956, Petrography of American Coals: U. S. Bureau of Mines Bull. 550, p. 17.

is opaque when viewed microscopically in a thin section by the transmitted light method. Translucent attritus contains varying amounts of translucent humic matter, spores, cuticle and resins, which are all translucent in thin section. Opaque matter may be present in minor amounts in translucent attritus. Figure 1 shows a thin section of coal containing both anthraxylon and attritus.

Fig. 1—Thin section of coal showing An (anthraxylon) and At (attritus).

Fusain generally shows the cell walls of some of the plant parts that made up coal. In thin section fusain is opaque or black, having attained a high carbon content during the early stage of coalification.

Marie C. Stopes (1919) proposed a classification for coal that included the four banded ingredients: vitrain, clarain, durain and fusain. Her classification was based on macroscopic observations of hand specimens of coal. She also prepared thin sections of the four banded ingredients and recognized certain plant components in these thin sections. The following descriptions are a modification of Stopes' original descriptions of the banded ingredients:

Vitrain occurs in uniform, bright, black, vitreous bands and lenses usually a few millimeters wide. An arbitrary lower size limit of from 3 to 5 mm. has been placed on vitrain in macroscopic description of coal beds (International Committee for Coal Petrology, 1957). Vitrain breaks with a conchoidal fracture and does not soil the hands. It may be crossed with numerous cracks perpendicular to banding.

Clarain is made up of thin to thick bands and lenses of predominantly bright coal constituents stratified parallel to the bedding plane; however, a minor number of dull bands may be present. It breaks rectangular to the bedding plane in contrast to the conchoidal fracture of vitrain. It has a satin to silky gloss or luster on a relatively smooth surface.

Durain is dull and may even be grayish in appearance. It is hard, occurring in fine bands and lenses with a close, fine texture, and breaks with irregular to granular surface.

Fusain is black to grayish black, has a silky luster and fibrous structure, extremely friable when not impregnated with minerals. It resembles charcoal. It generally occurs as thin bands and lenses, but on occasion the lenses may be up to 3 inches thick and several feet in horizontal extent. It blackens the hands.

Stopes later (1935) published a more detailed classification and description of the banded ingredients and introduced the term *maceral* to designate elementary coal-forming substances, analogous to minerals in rocks. This classification was based primarily on microscopic study of thin sections in transmitted light. The classification is quite detailed, giving the rock types, macerals,and in simple terms the original nature of that part of the plant from which the maceral was derived. A modified version of Stopes' classification is given in Table 2.

The group maceral vitrinite in bands more than 14 microns thick

TABLE 2 – STOPES-HEERLEN SYSTEM OF CLASSIFICATION* (CAN BE USED WITH EITHER TRANSMITTED OR REFLECTED LIGHT)

Lithotype	Maceral
Vitrain	Vitrinite 1. Collinite 2. Telinite
Clarain	Variable composition of 1. Vitrinite – Distinctive 2. Exinite a. Sporinite b. Cutinite c. Alginite d. Resinite 3. Inertinite – Less Distinctive a. Micrinite fine grained and massive. b. Sclerotinite c. Semifusinite d. Fusinite
Durain	Rich in 1. Inertinite – Distinctive 2. Exinite May be present 3. Vitrinite – Less Distinctive
Fusain	Fusinite

*Stopes, Marie C., 1935, On the Petrology of Banded Bituminous Coal: *Fuel*, Vol. 14, No. 1, pp. 4-13, with modifications based on information taken from the Glossary of the International Committee for Coal Petrology, 1957.

corresponds to the anthraxylon of Thiessen. Exinite and inertinite have no corresponding terms in Thiessen's classification, but these macerals are included in the attritus of Thiessen. Cady (1942) introduced the term *phyteral* to designate general botanical constituents in coal, such as spore coat, cuticle, resin, etc. The phyterals are botanical terms similar to maceral (mineral) terms; *e.g.*, the phyteral cuticle is similar to the maceral cutinite.

A more detailed classification

based on transmitted light microscopy was proposed by Spackman (1958). Macerals having similar chemical and physical characteristics are assembled into Maceral Groups. These Maceral Groups can also be combined to form Maceral Suites based on similar group characteristics. Spackman gave an example of possible grouping under the Vitrinite Suite or Anthraxylous Suite, but did not include a complete classification for all Maceral Suites.

Microscope Reflected Light Method

Seyler (1929) stated that Dr. H. Winter in 1913 was the first to apply metallurgical techniques to the study of coal. R. Potonie (1926) a German petrographer, used essentially the same lithologic concept as that of Stopes in the petrographic study of coal. He, like most German petrographers, applied the metallurgical or reflected light method of study to polished surfaces of coal. The English petrographer Seyler (1943) attributes the great advancement of this method of study to Stach and Hoffman, who utilized the oil immersion lens in 1929 for microscopic examination of coal. Spelling of English terms was changed by German workers to adapt them to their language, *i.e.*, vitrain became vitrit, vitrinite became vitrinit, etc. Abramski, Mackowsky, Mantel and Stach (1951) give this classification in detail.

Several official Russian organizations approved and published "Bituminous Coals, Method of Determining the Petrographic Composition 1960". Table 3, based on reflected light methods of micropetrographic analysis, shows the official classification and nomenclature used in Russia by coal petrographers. The classification is similar to that of the English and German schools. It will be noted that the term *leiptinite* is used instead of *exinite* in the other systems. A new term has been added to describe part of the intermediate material between fusinite and vitrinite. Other systems use the term *semifusinite* for all this intermediate material, but the Russians use *semifusinite* for transitional material more nearly like fusinite and *semivitrinite* for transitional material more nearly like vitrinite.

A classification based on polished surfaces and reflected light method was introduced recently by Schapiro and Gray (1960) for use in applied petrography (Table 4). In many respects this classification resembles that of Stopes, but there are a number of differences. Schapiro and Gray used the term *entity*, which is similar to *maceral* in that the stem of the word refers to the same component in coal, but the ending is different. The group maceral vitrin*ite* becomes the group entity vitrin*oid*. Reflectance values have been assigned to the group entities so that the reflectance values of vitrinoids, for example, vary from V0 to V70 and include all ranks of coal.

Correlation between Transmitted Light Method and Reflected Light Method

The need for an international understanding, if not an exact correlation, of coal petrography nomenclature was recognized at the Third Congress for the Advancement of Studies in Stratigraphy and Geology of the Carboniferous at Heerlen, Netherlands, in 1951. This led to the first meeting of the Interna-

TABLE 3 – RUSSIAN CLASSIFICATION* (REFLECTED LIGHT)

Names of the Groups	Symbols for the Groups	Microcomponents	Symbols for the Microcomponents
1. Vitrinite	Vt	Collinite	Vt_1
		Telinite	Vt_2
2. Semivitrinite	Sv	Semicollinite	Sv_1
		Semitelinite	Sv_2
		Mixtinite	Sv_3
3. Fusinite	F	Semifusinite	F_1
		Micrinite	F_2
		Fusinite	F_3
		Sclerotinite	F_4
4. Leiptinite (Exinite)	L	Sporinite	L_1
		Cutinite	L_2
		Resinite	L_3
5. Alginite	Alg	Algocollinite	Alg_1
		Algotelinite	Alg_2
6. Mineral impurities	Ml	Clay minerals	Ml_1
		Iron Sulphides	Ml_2
		Carbonates	Ml_3
		Other mineral impurities	Ml_4

*Bituminous Coal – Method of Determining the Petrographic Composition: GOST 9414-60, Moscow, 1960.

tional Committee for Coal Petrology in 1953, which compiled the first part of a glossary of terms in coal petrology, published in 1957. The author of each term and the reference for its first introduction into the literature are cited. A list of synonyms, analogous terms, description, properties, occurrence, and practical importance of the terms are included in the glossary. This glossary when completed will provide petrographers throughout the world with a clearer understanding of nomenclature used, regardless of the petrographic method employed.

A correlation between two basic classification, *e.g.*, the Thiessen-U.S. Bureau of Mines (transmitted light method) and the Stopes-Heerlen (reflected light method), was agreed upon at the Eleventh Meeting of the

TABLE 4 – CLASSIFICATION OF SCHAPIRO AND GRAY† (REFLECTED LIGHT) CLASSIFICATION OF COAL ENTITIES

General Entity Categories	Entity Groups	Entity Types* and Minerals
Vitrinite Suite	Reactive vitrinoids	V0 to V21
	Inert vitrinoids	V22 to V70
	Reactive semi-fusinoids	SF0 to SF21**
Leiptinite Suite***	Exinoids	E0 to E15
	Resinoids	R0 to R15
Inertinite Suite	Micrinoids	M18 to M70
	Fusinoids	F40 to F70
	Inert semi-fusinoids	SF22 to SF40**
	MINERALS	
Mineral Suite	Sulphides	Pyrite, Marcasite
	Carbonates	Calcite, Siderite, etc.
	Silicates	Illite, Kaolinite, etc.

*Organic types based on reflectance in oil.

**Estimated values, reactive group is about 1/3 and inert group about 2/3 of semi-fusinoid total.

***Leiptinite includes coal substances derived from spore exines, plant cuticles, resins, and waxes.

†Schapiro, N., and Gray, R. J., 1960, Petrographic Classification Applicable to Coals of All Ranks: Proceedings of the Illinois Mining Institute, 68th year, pp. 83-97.

International Nomenclature Committee on Coal Petrology held in Madrid, Spain, in June, 1960. Table 5 gives this correlation. As previously stated, Stopes' classification is based on a lithologic concept and Thiessen's on a botanical concept, making precise correlation of the two systems impossible.

Another comparison between British nomenclature (Stopes), U. S. Bureau of Mines nomenclature (Thiessen), and German nomenclature was given by Marshall (1955). Schopf (1956) also made comparisons between the petrographic entities of the two basic systems. Schopf stated, "Materials in coal that are identified or distinguished in coal petrology are here spoken of generally as coal petrologic entities." His entities consist of ingredients, con-

TABLE 5 – CORRELATION OF THE NOMENCLATURE THIESSEN-BUREAU OF MINES (THIN SECTION METHOD) WITH THE NOMENCLATURE STOPES-HEERLEN (POLISHED BLOCK METHOD)[1] *

Transmitted light system Thiessen-Bureau of Mines			Reflected light system Stopes-Heerlen	
Banded Components	*Constituents of Attritus*[2]		*Macerals*	*Groups of Macerals*
anthraxylon (translucent)			vitrinite more than 14μ in width	vitrinite
attritus	translucent attritus	translucent humic matter	vitrinite less than 14μ in width	
	opaque attritus	spores, pollen cuticles, algæ	sporinite, cutinite, alginite	exinite
		resinous and waxy substances	resinite	
		brown matter (semitranslucent)	weakly reflecting semifusinite weakly reflecting massive micrinite strongly reflecting resinite	inertinite
		granular opaque matter	granular micrinite	
		amorphous (massive) opaque matter, finely divided fusain, sclerotia	fusinite less than 37μ in width, strongly reflecting massive micrinite, strongly reflecting sclerotinite	
fusain (opaque)			fusinite and semifusinite more than 37μ in width	

	Types of coal	*Quantitative statements*	*Mikrolithotypes*	
banded coals	bright coal	more than 5 percent anthraxylon less than 20 percent opaque attritus	vitrit clarit	
	semisplint coal	more than 5 percent anthraxylon 20-30 percent opaque attritus	duroclarit vitrinertit	
	splint coal	more than 5 percent anthraxylon more than 30 percent opaque attritus	clarodurit	
nonbanded coals	cannel coal	less than 5 percent anthraxylon	durit[3]	cannel
	boghead coal	less than 5 percent anthraxylon		boghead

1. An exact correlation of the two systems is not possible.
2. For the recognizable botanical entities (for instance "spores", cuticle") the term "phyteral" may be implied.
3. Durite is part of banded coals with less than 5% vitrinite that would be placed to the (nonbanded) cannel coals by definition in the Bureau of Mines system.

*International Committee for Coal Petrology, Nomenclature Subcommittee, definitive table agreed to at Madrid (Spain) meeting, June, 1960.

stituents, organic components of coal, macerals and phyterals.

Advantages and Disadvantages of the Transmitted Light and Reflected Light Methods

The following list of the advantages and disadvantages of these two methods represents the writer's own view; it is probable, however, that this view is shared by most coal petrographers. The nature of any petrographic investigation and rank of coal should determine the method of microscopic study employed.

Microscope Transmitted Light Method:

Advantages associated with thin section use:

1. Phyterals or botanical components that transmit light are more readily examined.
2. Because of this fact the origin of coal is easier to comprehend.
3. Conditions of preservation may be informative with respect to environmental conditions.

Difficulties associated with thin section use:

1. Obtaining thin sections of equal thickness is difficult, and as thickness influences the color of the translucent coal components, the "true color" of the component is difficult to ascertain in successive sections.
2. Because of this fact it becomes difficult to assign to specific colors numerical values that can be used in evaluating the effects of coal components in applied coal petrography.
3. Even though coal sections are very thin, some components may overlie other components and obscure them from view. This is especially true of attritus.
4. As anthraxylon increases in rank the color changes from a light to dark red. In the higher rank coals it is opaque under ordinary conditions. When the anthraxylon is opaque, another method must be used to study the coal.

Microscope Reflected Light Method:

The reflected light method used on polished surfaces of coal can be advantageously used in carbonization, preparation, and other applied petrographic studies, as it can be applied to nearly all coals, including opaque coals that cannot be examined by transmitted light. The method is especially adaptable to studies of broken coal because polished surface briquettes having a flat, uniform surface are easily and quickly prepared. "Broken coal" refers to representative samples of any coal that has been broken during mining, as opposed to a column of coal cut from the coal bed. The representative sample is bound together by an adhesive to produce a briquette that can be polished and studied.

Disadvantages associated with the reflected light method are primarily those listed as advantages for the transmitted light method. Details of plant constituents and structures are not as easily observed and identified in coals by reflected light.

Combination of Transmitted and Reflected Light Methods

A method that uses a polished thin section of coal is advantageous because it utilizes the best features of both the transmitted and reflected light methods. This has been shown in basic coal research by Teichmuller (1954) and Kosanke

TABLE 6 – CLASSIFICATION USED BY THE ILLINOIS STATE GEOLOGICAL SURVEY* (REFLECTED LIGHT)

Macroscopic	Microscopic	
Lithotypes	Group Macerals	Macerals
Vitrain	Vitrinite	Collinite
		Telinite
Clarain	Vitrinite	
	Exinite	Sporinite
		Cutinite
		Alginite
		Resinite
		Waxes
	Inertinite	Fusinite
		Micrinite
		Semifusinite
		Sclerotinite
Durain	Inertinite	
	Exinite	
	Vitrinite	
Fusain	Inertinite	Fusinite

*Nomenclature as defined in Glossary of International Committee for Coal Petrology and based primarily on Stopes-Heerlen System of Classification.

and Harrison (1957). For this method of study a Leitz UAM microscope is equipped to illuminate the polished thin section of coal by passing light through it from below and reflecting a vertical beam of light off the surface of the sample from a light source above. The lights can be used singly or in a balance so that translucent and opaque components can be viewed simultaneously. Simultaneous viewing is important in making correlations between the two methods and in training technicians.

Classification used at the Illinois State Geological Survey

The nature of the project and rank of the coal being studied have

been determining factors in the classification and nomenclature used in microscopic studies at the Illinois State Geological Survey in recent years. In projects concerning genesis of coal or identification and description of specific plant components, the Thiessen classification employing thin sections of coal and transmitted light has been used. For projects in applied research in coal petrography the polished surface and reflected light method has proved to be more satisfactory. The classification used at the Survey is essentially the same as that of Stopes and the nomenclature is that defined in the "Glossary of the International Committee for Coal Petrology." Table 6 gives the nomenclature used for reflected light studies, including the names of the macroscopic banded ingredients or lithotypes used at the Survey, and of the microscopic macerals making up banded ingredients. Minerals present in coal are grouped under the sulphides, carbonates and silicates.

Illinois coal consists mainly of clarain, vitrain and fusain, in that order. Durain has been reported in Illinois coals but the quantity probably is very small. Finding durain in Illinois coals is an extremely difficult problem.

Figure 2 shows a block of coal with clarain, vitrain and fusain designated. No durain is present. Figures 3, 4, and 5 are photomicrographs of the group macerals and macerals that make up the banded ingredients.

For carbonization studies at the Survey, macerals have been divided into reactive constituents and inert constituents. The reactive macerals are those that will soften, deform, give off gas, or in some manner lose

Fig. 2—Block of coal showing C (clarain), V (vitrain) and F (fusain).

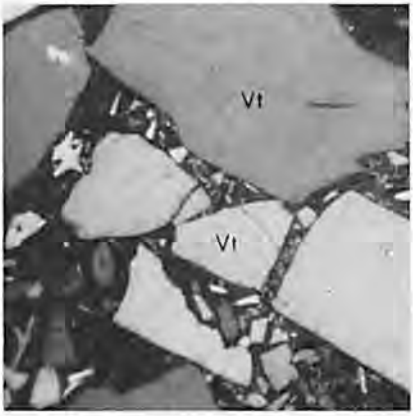


Fig. 3—Vitrinite in reflected light. Vitrinite from two ranks of coal is shown. The lighter vitrinite, which is from the higher rank of coal, contains a higher carbon content. Magnification approximately 200 ×.

their identity during the carbonization process. Inerts are not necessarily completely inert during carbonization, but they do retain their identity and can be recognized by microscopic examination of coke. Reflectance values have been as-

Fig. 4—Photomicrograph showing vitrinite, Vt, sporinite, S, and cutinite, C, in reflected light. Vitrinite and exinite (sporinite and cutinite) are the macerals that make up the banded ingredient clarain. Mag. approx. 200 ×.

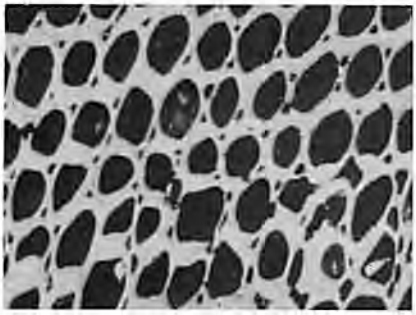


Fig. 5—Fusinite showing the cell wall structure, which appears white in this photomicrograph taken with reflected light. The white color indicates a high carbon content. Mag. approx. 200 ×.

signed to each group maceral and maceral throughout the entire range of coal rank (Table 7). The values are those used by Schapiro and Gray (1960) for their entity types.

Application of Coal Petrography to Coking

Coal petrography has been applied to preparation, hydrogenation, gasification and carbonization for many years. Usefulness of petrographic data has been limited, however, because of the difficulty of providing engineers with petrographic data that could be understood in specific terms that could be utilized. A number of known facts relative to this utilization are listed below:

1. Numerous workers have demonstrated that the difference in reflectance of the group maceral vitrinite denotes a difference in the rank of coals from which the vitrinite was taken. One of the first was Seyler (1943) of England. He demonstrated that as the rank of coal increased, the reflectance increased also. Other contributors to this phase of the science are McCartney (1952), Huntjens and van Krevelen (1954) and Siever (1957). Other workers have contributed to this study, but a detailed account of their work is outside the scope of this paper. The significant point is that this relationship has been fully demonstrated.

2. The effect of the rank of the coal upon the coke produceed has been known for many years, and coals of certain rank have produced a metallurgical coke acceptable to blast furnace operators at one location at a given time. Decrease in the amount of this rank of coal available in conjunction with an ever increasing demand for coke resulted in blending other coals to produce acceptable metallurgical coke.

3. Recognition that variations in the quantity of reactive coal components and inert coal components produced different coke characteristics came early in the science of coal petrography. Thiessen, Sprunk and O'Donnell (1931) recognized that coke produced from different parts of the Elkhorn coal bed would produce cokes of different characteristics as the result of differing petro-

TABLE 7 – MACERAL REFLECTANCE AND CARBONIZATION CHARACTERISTICS USED BY THE ILLINOIS STATE GEOLOGICAL SURVEY*

Reactives			Inerts		
Group Macerals	Macerals	Variety	Group Macerals	Macerals	Variety
Vitrinite		Vt 0 to Vt 21	Inert Vitrinite		Vt 22 to Vt 70
	Colinite	C0 to C21			
	Telinite	T0 to T21	Inertinite		I18 to I70
				Fusinite	F40 to F70
				Micrinite	M18 to M70
				Semifusinite†	SF22 to SF40
Exinite		E0 to E15		Sclerotinite	Sc22 to Sc70
	Sporinite	St0 to St15	Group Minerals	Minerals	
	Cutinite	Ct0 to Ct15			
	Alginite	At0 to At15	Sulphides	Pyrite, etc.	
	Resinite	R0 to R15	Carbonates	Calcite, etc.	
	Waxes		Silicates	Illite, etc.	
Fusible Inertinite	Semifusinite†	SF0 to SF21			

*Nomenclature as defined in Glossary of International Committee for Coal Petrology and based primarily on Stopes-Heerlen System of Classification. Reflectance values of maceral varieties based on reflectance values of Schapiro, N. and Gray, R. J., 1960, Petrographic Classification Applicable to Coals of All Ranks: Proceedings of the Illinois Mining Institute, 68th year, pp. 83-97.

†Estimated values, reactive group is about 1/3 and inert group about 2/3 of semifusinite total, Ammosov, I. L., Eremin, I. V., Sukhenko, S. I. and Oshurkova, L. S., 1957, Calculation of Coking Charges on the Basis of Petrographic Characteristics of Coke: Koks i Khimiya, No. 12, pp. 9-12.

graphic composition. Mott and Wheeler (1930) demonstrated that if the petrographic composition of the coke charge were changed by adding fusain in the proper amount and size, marked improvement occurred in the resulting coke. The literature contains many other reports to substantiate the fact that variation in petrographic composition of the coal will affect the coke produced.

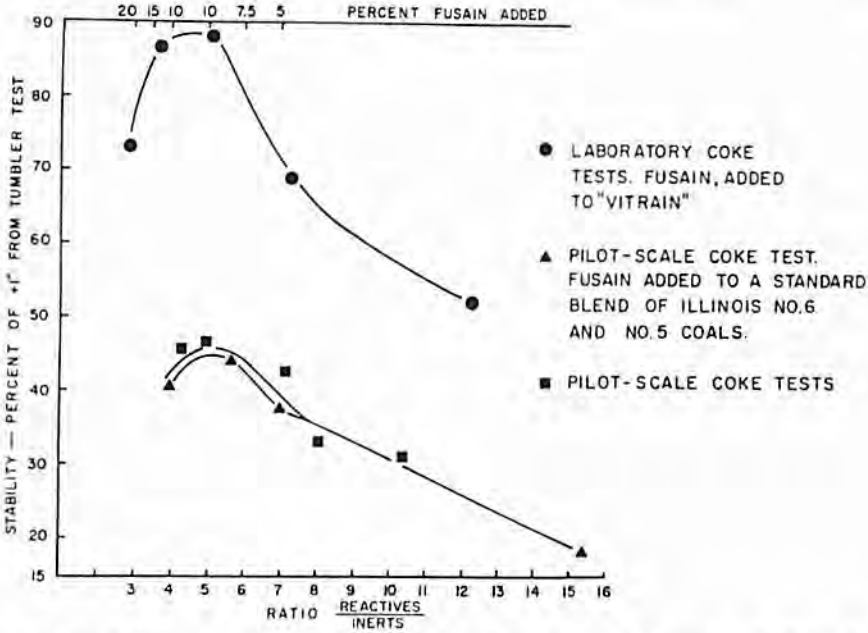


Fig. 6—Effect of petrographic composition on coke stability. In both laboratory and pilot-scale coke tests an optimum $\frac{\text{Reactive}}{\text{Inert}}$ ratio of about 5 produces the highest stability.

Use of Petrographic Analysis to Predict Coke Stability in One Rank of Coal

The basic problem in predicting stability of coke made from one rank of coal is obtaining the optimum ratio between reactives and inerts in the coal that will give the best coke, under standard conditions, and to express this ratio in usable numerical values. Conditions such as size of coal, charging temperature, final coking temperature and others affect the coke, and for a series of tests standards must be established.

A recent laboratory-scale investigation by Marshall, Harrison, Simon and Parker (1958) was conducted in which optimum conditions for the numerous variables of sample and coking conditions were established as standards. It was found that variations in petrographic composition, under standard conditions, does influence the character of coke produced. In one series of tests in this investigation the petrographic composition of the coke charge, in the laboratory-scale test, was varied by adding different amounts of fusain. The relatively pure "vitrain" had a ratio of $\frac{\text{Reactives}}{\text{Inerts}}$ of 12.3 and the stability index was 52, which was low for this series of laboratory tests. Minus 150-mesh fusain was added to this basic sample in increments of 5 to 20 percent. Optimum coke was obtained by the addition of 10 percent additional fusain, giving an $\frac{R}{I}$ ratio of 5.1 and a stability index of 88. As more fusain was added,

the optimum ratio was exceeded and instead of an inert-deficient mixture an excess of inerts resulted in the mixture. A curve was developed by plotting the ratio $\frac{R}{I}$ against the stability obtained in coke tests (Fig. 6). Essentially the same curve was developed by plotting results of pilot-scale tests, but the stability number was not as high throughout the tests. Although only 7.5 percent additional fusain was needed to give an optimum stability of 44, the $\frac{R}{I}$ ratio on these larger scale tests was 5.7 (Fig. 6).

Subsequent coke tests, on the pilot-plant scale, of fine coal from which the inerts had not been removed at the preparation plant gave an optimum stability of 46.6 and a ratio of 5. Although the magnitude of the stability varied according to the scale of the tests, the trend was the same in each case and the optimum ratio of $\frac{R}{I}$ was about 5.

In these tests basic petrographic analyses and coke stability determinations gave the information necessary to produce curves that could be used in predicting coke stability of future tests on this rank of coal. The lower scale of the pilot-plant test (Fig. 6) has been used in predicting the stability of coke produced from Illinois No. 6 Coal alone with ex-

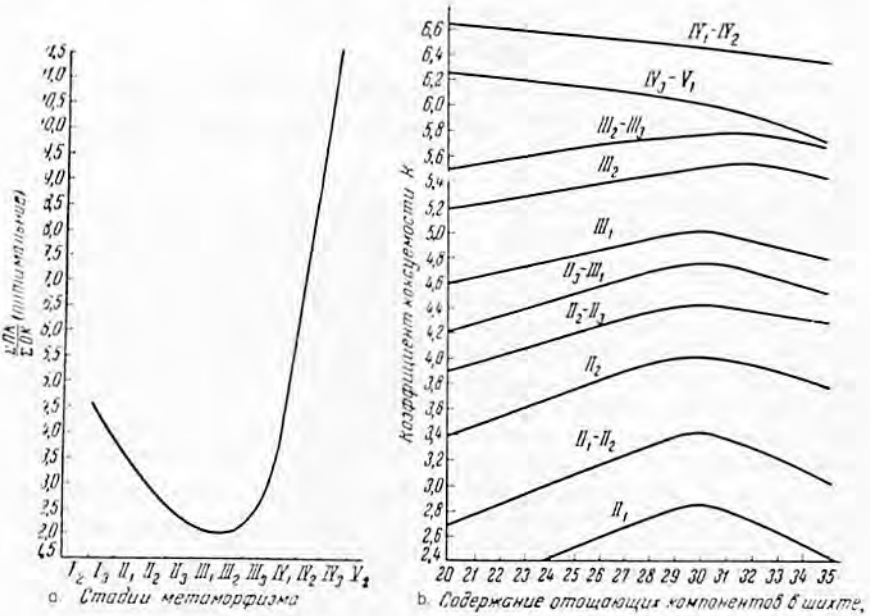


Fig. 7—Curves by Russian workers (Ammosov et al., 1957): (a) Optimim ratio between fusible (reactives) and inter constituents $\left(\frac{\Sigma\ nk}{\Sigma\ ok}\right)$ in coals of different stages of metamorphism (I_1, I_2, etc.). (b) Dependence of the coking capacity coefficient K (Strength Index) on the change in the metamorphic stages of the coal (II_1, II_1-II_2, etc.) and the inert constituent content in the blend (20, 21, 22, etc.).

cellent results. Stabilities predicted from petrographic analyses have not varied more than two stability numbers from the stability found in the A.S.T.M. stability tests.

Use of Petrographic Analysis To Predict Coke Stability from Blends Of Different Ranks of Coal

As previously stated, coal petrographers have encountered difficulty in providing petrographic data in numerical terms that could be applied directly to coking problems even though it has been well established that petrographic composition and coal rank affect the characteristics of coke. Ability to predict stability of coke produced from a single rank of coal on the basis of petrographic analysis has been demonstrated. Stability predictions become more difficult when coke is produced from a blend containing two or more ranks of coal. Each rank of coal that contains reactives will assimulate an optimum amount of inerts to yield a coke of optimum stability. This optimum amount will vary according to the rank of coals and according to the blend. The optimum amount of inerts for a blend is not necessarily the average of the optimum amount of inerts for each rank of coal in the blend. This difficulty of predicting stabilities from blends of coal has been overcome to a promising extent, as reported by Ammosov *et al.* (1957), Eremin (1959) and Schapiro, Gray and Eusner (1961).

By using the polished surfaces of briquettes made from broken coal, petrographic composition of the representative sample of coal can be determined. Reflectance data of vitrinite present are related to the rank of the coals present. These

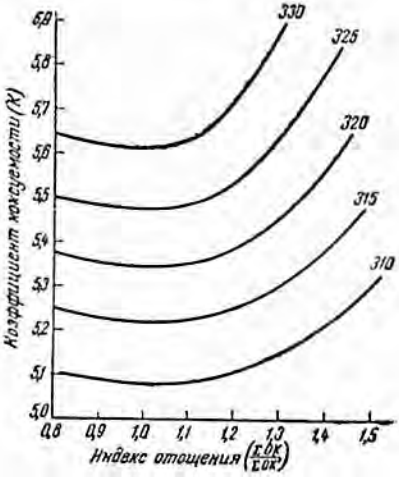


Fig. 8—Classification of coking blends for the Kuznetsk group of metallurgical works and the Cheliabinsh metallurgical plant, U.S.S.R. K is the Strength Index and $\left(\frac{\Sigma\ nk}{\Sigma\ ok}\right)$ is the Inert Index (Ammosov, *et al.*, 1957).

data plotted against coke data obtained from standard A.S.T.M. coke tests for stability will result in a series of curves that can be used in predicting coke stability from unknown coke blends. Curves established by Ammosov *et al.* (1957) are given in figures 7 and 8. Those published by Schapiro, Gray and Eusner (1961) are given in figures 9, 10, and 11.

Siever (1957) found from reflectance studies that a coal of a given rank may contain more than one vitrinite variety. Schapiro, Gray and Eusner (1961) also found this to be true and, in addition, found that each vitrinite variety (vitrinoid type) will have an optimum $\frac{R}{I}$ ratio for the production of the best coke. These vitrinite varieties are plotted against the optimum $\frac{R}{I}$ ratio as shown in figure 9.

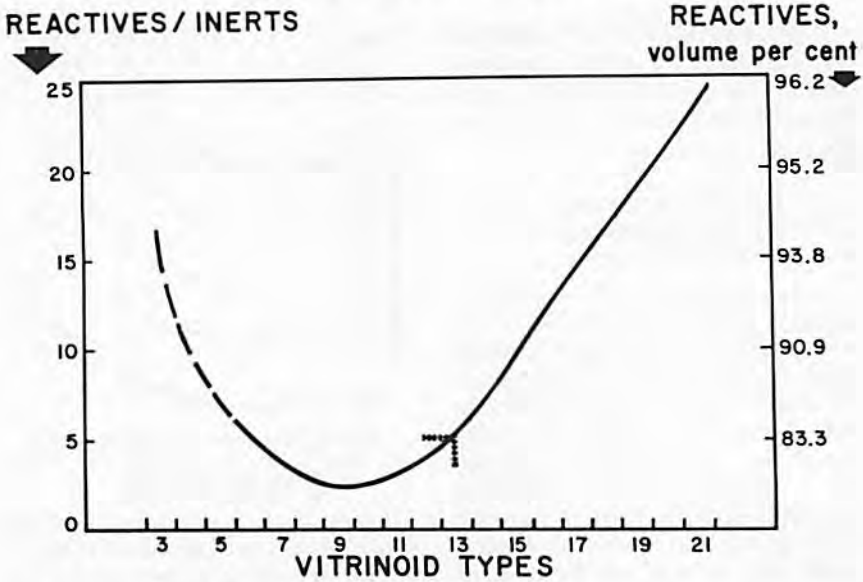


Fig. 9—Optimum $\frac{\text{Reactive}}{\text{Inert}}$ ratio for each vitrinite (vitrinoid) type (Schapiro, Gray and Eusner, 1961).

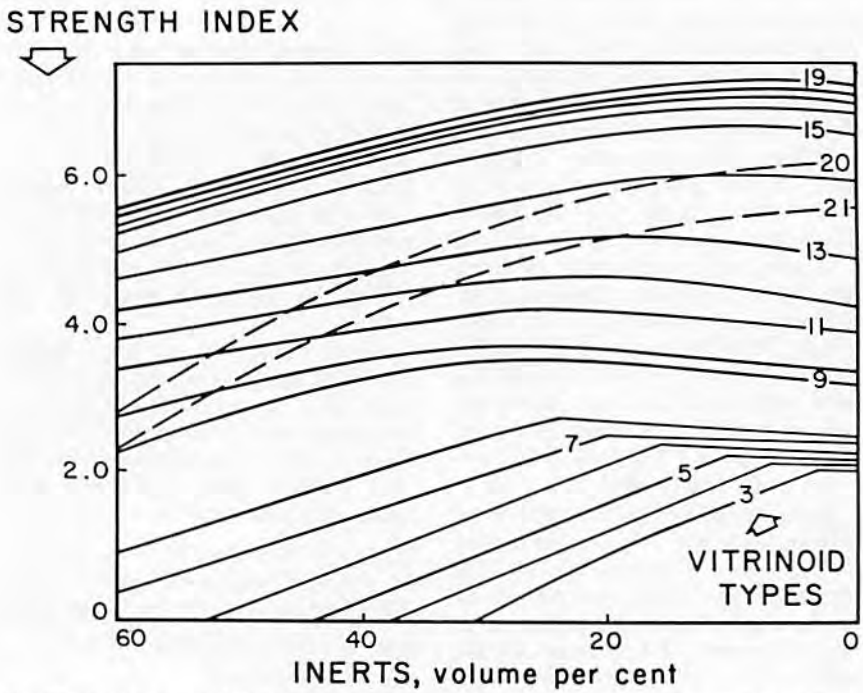


Fig. 10—Strength Index for vitrinite (vitrinoid) types depending upon the amount of inerts present (Schapiro, Gray and Eusner, 1961).

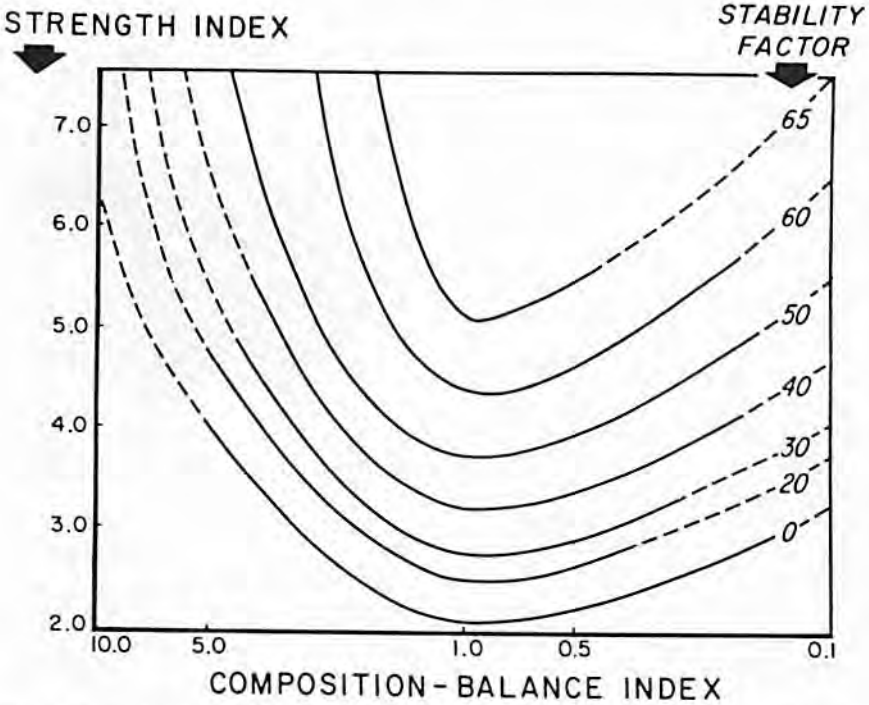


Fig. 11—Curves showing relationship between Strength Index, Inert Index (Composition-Balance Index) and Stability Factor (Schapiro, Gray and Eusner, 1961).

Inert Index:

In predicting coke stability from a coal blend, one of the factors required is the *Inert Index* of the blend. The Inert Index is a relation between the total amount of inerts in the blend and the amount of inerts required for each reactive vitrinite variety (vitrinoid type) present in order to obtain optimum coke from the blend. This relation is expressed in equation 1 (Ammosov *et al.*, 1957):

$$1.\ \text{Inert Index} = \frac{\text{Total Inerts in Blend}}{\dfrac{\text{Total Reactives (Vt 1)}}{\text{Optimum } \frac{R}{I} \text{ ratio (Vt 1)}} + \dfrac{\text{Total Reactives (Vt 2)}}{\text{Optimum } \frac{R}{I} \text{ ratio (Vt 2)}} + \cdots + \dfrac{\text{Total Reactives (Vt 21)}}{\text{Optimum } \frac{R}{I} \text{ ratio (Vt 21)}}}$$

where: (a) Total Reactives include all vitrinite, exinite, resinite, and about ⅓ semifusinite (Table 8); (b) Optimum $\frac{R}{I}$ ratio is the ratio between Reactives and Inerts that will produce the best coke from one rank of coal or from a vitrinite of one reflectance value; (c) Vt 1 is vitrinite of one reflectance value (Schapiro and Gray, 1960); (d) Vt 21 is vitrinite having the highest reflectance value of all vitrinites included in

the Reactives (Schapiro and Gray, 1960).

If the Inert Index is less than 1.0, the sample is deficient in inerts and a higher stability can be obtained by the addition of inerts to the charge. If the Inert Index is more than 1.0, the samples contain more inerts than can be assimilated by the reactives and more reactives must be added to the charge to improve the coke stability (Schapiro, Gray and Eusner, 1961). Harrison (1960) has shown that the effect on the coke produced by altering the petrographic composition of a charge depends also upon the nature, size and amount of inert added. If inerts or reactives are added to the charge, it must be thoroughly mixed to obtain the proper relation between the macerals if the desired results are to be attained.

Strength Index:

The second factor needed for predicting coke stability is the *Strength Index (K)*. A family of curves is obtained by plotting stability data for each vitrinite variety with varying amounts of inerts. Strength Index is determined from those curves. Curves developed by Schapiro, Gray and Eusner (1961) are shown in figure 10. The Strength Index for a coal blend is calculated by multiplying the Strength Index of each vitrinite variety (vitrinoid type) by the amount of the vitrinite variety present and dividing by the total reactives in the coal blend. This calculation is expressed in equation 2. Ammosov *et al.* (1957):

Fig. 12—Buehler Automet automatic polisher used in preparing broken coal samples.

where: (a) K is the Strength Index; (b) Reactives include all vitrinite, exinite, resinite, and about ⅓ semi-fusinite; (c) Vt 1 is vitrinite of each reflectance value (Schapiro and Gray, 1960); (d) Vt 21 is vitrinite having the highest reflectance value of all vitrinites included in the reactives (Schapiro and Gray, 1960).

Figure 11, from the work of Schapiro, Gray and Eusner (1961), is a plot of Strength Index against Inert Index (called Composition-Balance Index by Schapiro, Gray and Eusner) to produce a family of curves. Solution of equations 1 and 2 can be plotted on these curves and the coke *Stability Factor* read from these curves.

Current Use of these Principles at the Illinois State Geological Survey

The Survey is currently using the petrographic methods of analysis

$$2.\ K_{(\text{Blend})} = \frac{\left(K_{(\text{Vt 1})} \times \text{Reactives}_{(\text{Vt 1})}\right) + \left(K_{(\text{Vt 2})} \times \text{Reactives}_{(\text{Vt 2})}\right) + \cdots + \left(K_{(\text{Vt 21})} \times \text{Reactives}_{(\text{Vt 21})}\right)}{\text{Total Reactives in Blend}}$$

in conjunction with data obtained from cokes produced in a pilot-scale coke oven (Jackman *et al.*, 1955) to gather more information about Illinois coals and coals blended with Illinois coals to be used to predict coke stability. The following is a brief description of the procedures used in petrographic studies.

A sample of a coal blend is first crushed in stages by mortar and pestle, to prevent excessive grinding of small sizes, until 100 percent of the coal passes a 28-mesh Tyler screen. A representative sample is briquetted with Armstrong C 7 as a binder and the briquette is then polished on a Buehler Automet Automatic polisher (Fig. 12).

Quantitative petrographic analyses are made with a Leitz BMe microscope, using an oil immersion objective at a magnification of 320×. Group macerals and macerals tabulated in a point count analysis are vitrinite, exinite, resinite, semifusinite, micrinite and fusinite. Mineral matter content also is determined. Reflectance petrographic analysis is made on a Leitz UAM microscope with an oil immersion objective at a magnification of 600×. A photoelectric cell is attached to the monocular tube of the microscope, which is in turn at-

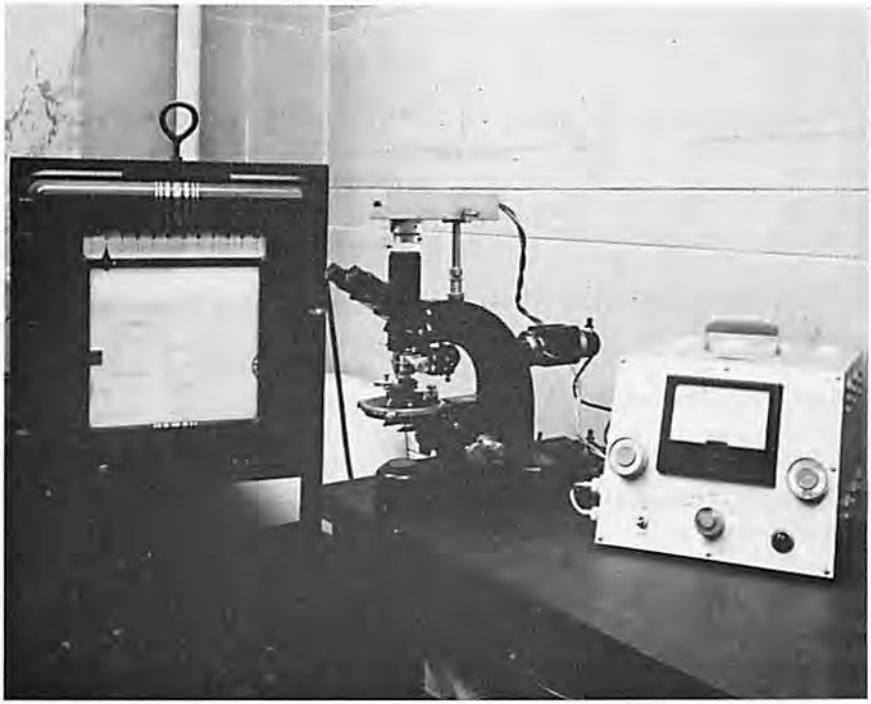


Fig. 13—Leitz microscope, Photovolt photometer and Leeds and Northrup recorder used in making petrographic reflectance analyses.

tached to a Photovolt photometer (Fig. 13). A filter to give monochromatic light and a pin hole diaphragm is placed in the ocular of the monocular tube. The filter is a combination of two Eastman Kodak Wratten filters, numbers 58 and 77. The sample can be viewed through the binocular eyepieces and reflectance can be measured through the monocular eyepiece. Polished glass standards of definite reflectance values are used to standardize the Photovolt photometer throughout the entire range of reactives. The amount of light reflected from the polished surface of the coal sample is registered by the photometer or on a recorder. Reflectance of the vitrinite is related to the rank of the coals present.

The actual calculations, based on the petrographic information, are demonstrated below by the results of an actual test on a blend of two different coals.

To fulfill the requirements of equations 1 and 2, the following information is needed; the source of the information is indicated:

Information Needed	*Source of Information*
1. Total inerts in the blend	Petrographic analysis of inert constituents plus about ⅔* of the semifusinite
2. Total reactives in the blend	Petrographic analysis of reactive constituents plus about ⅓* of the semifusinite
3. Vitrinite variety	Measured reflectance
4. Total reactives for each vitrinite variety**	Petrographic and measured reflectance analyses
5. Optimum $\frac{R}{I}$ ratio for each variety of vitrinite	Curve in Figure 9
6. Strength Index (K) for each vitrinite variety	Curves in Figure 10

*Ammosov *et al.* (1957).

**Each vitrinite variety is determined by measured reflectance values. The amount of exinite and resinite is prorated on the basis of the quantity of each vitrinite variety present. The total reactive for each vitrinite variety includes the vitrinite of one reflectance plus the prorated exinite and resinite.

TABLE 8 – PETROGRAPHIC ANALYSIS OF SAMPLE

Group Macerals, Macerals, and Minerals	Reactives (%)	Inerts (%)
Vitrinite	80.62	
Exinite	3.63	
Resinite	0.53	
Micrinite		9.01
Fusinite		3.03
Mineral Matter		2.50
	84.78	14.54
⅓ Semifusinite	.23	
⅔ Semifusinite		.45
Total	85.01	14.99

TABLE 9 – DATA FROM PETROGRAPHIC ANALYSIS AND CURVES IN FIGURES 9 AND 10 (IN PERCENT)

Vitrinite Varieties	6	7	8	9	15	16	17	18	19	% Total
Vitrinite %	5.15	38.65	13.99	0.37	1.48	9.94	8.83	1.84	0.37	80.62
Exinite + Resinite prorated throughout Vt	0.27	2.00	0.72	0.02	0.07	0.51	0.46	0.09	0.02	4.16
⅓ Semifusinite					0.28					
Total Reactives for each Vitrinite variety	5.42	40.65	14.71	0.39	1.78	10.45	9.29	1.93	0.39	85.01
Optimum $\frac{R}{I}$ ratio for each Vt variety taken from Fig. 9	5.3	4.2	3.4	2.5	10.2	12.0	13.8	16.0	18.8	
Strength Index for each Vt variety taken from Fig. 10	2.4	2.6	2.8	3.5	6.7	7.0	7.1	7.2	7.3	

The above petrographic analysis in Table 8 gives us our first two requirements: (1) Total inertinite in the blend=14.99 percent; (2) Total reactives in the blend=85.01 percent.

Table 9 gives the remaining information needed to fulfill the requirements of the equations. Substituting these data into the equations 1 and 2 we calculate the Inert Index and the Strength Index:

$$1.\ \text{Inert Index} = \frac{14.99}{\frac{5.42}{5.3}+\frac{40.65}{4.2}+\frac{14.71}{3.4}+\frac{0.39}{2.5}+\frac{1.78}{10.2}+\frac{10.45}{12.0}+\frac{9.29}{13.8}+\frac{1.93}{16.0}+\frac{0.39}{18.8}}$$

$$= \frac{14.99}{17.04}$$

$$= 0.88$$

The Inert Index is less than 1, indicating that the blend does not contain a sufficient amount of inerts to obtain the best possible coke.

$$2.\ \text{Strength Index} = \frac{2.4\,(5.42)+2.6\,(40.65)+2.8\,(14.71)+3.5\,(0.39)+6.7\,(1.78)+7.0\,(10.45)+7.1\,(9.29)+7.2\,(1.93)+7.3\,(0.93)}{85.01}$$

$$= \frac{329.02}{85.01}$$

$$= 3.9$$

If these values are plotted on the curves in figure 11, the predicted stability for coke produced from this blend would be **54.** The actual (tumbler) stability, obtained by coking the coal in the Survey's Pilot-Scale Oven and testing it according to the standard A.S.T.M. tests, was **55.8.**

In the limited number of comparisons made to date the difference between the calculated stability and tumbler stability has not exceeded two stability numbers. These tests, however, have been restricted to only two southern Illinois coals. As stated previously, our present efforts are directed toward gathering information relative to other Illinois coals so that we can evaluate and add to the present curves.

Conclusions

Various classifications used in coal petrography have been reviewed and the advantages of each, for use in specific types of coal research, have been noted. The transmitted light method using thin sections of coal is most advantageous for the study of the botanical components that make up coal and for investigating problems related to coal genesis and environmental conditions during deposition and coalification.

The reflected light method using polished surfaces of coal is the better of the two basic methods of study for applied petrography, especially in carbonization.

Direct correlation between these two basic methods is impossible be-

cause the transmitted light method is based on a botanical concept and the reflected light method on a lithologic concept. A comparison of the two methods is helpful, however, in understanding the nomenclature used in each.

Coal petrographic data from one rank of coal have been combined with stability data obtained from coke produced from this rank of coal, to provide a method whereby coke stability can be predicted if this rank of coal is coked alone.

In Russia and the United States two well known facts related to cokability of coal have been used in developing a process by which coke stability can be predicted if blends of two or more coals of different ranks are coked. Preliminary tests at the Ilinois State Geological Survey using Illinois coals and blends containing Illinois coals have shown that this process is applicable to Illinois coals. Further tests are needed in a wider range of Illinois coals, but the process has great potential value in the field of carbonization.

* * *

REFERENCES

ABRAMSKI, C., MACKOWSKY, M. TH., MANTEL, W. *and* STACH, E., 1951, Atlas für Angewadte Steinkohlenpetrographie: Verlag Gluckhauf G.m.b.H., Essen, Germany.

AMOSOV, I. L., EREMIN, I. V., SUKHENKO, S. I. *and* OSHURKOVA, L. S., 1957, Calculation of Coking Charges on the Basis of Petrographic Characteristics of Coke: Koks i Khimiyn, No. 12, pp. 9-12.

Bituminous Coals, Method of Determining the Petrographic Composition, 1960: USSR State Standard (GOST 9414-60).

CADY, G. H., 1942, Modern Concepts of the Physical Constitution of Coal: Ill. Geol. Survey Rpt. Inv. 82, pp. 337-356 (Reprint from *Jour. Geol.*, Vol. 50, No. 40, pp. 337-356).

DAWSON, J. W., 1959, On the Vegetable Structure in Coal: Quart. Jour. Geol. Soc. London, Vol. 15, pp. 626-641.

EREMIN, I. V. (or Yeremin), 1959, The Petrographic Characteristics of Coals in Relation to their Use in Coking Industry: Trans., Fossil Fuel Inst., Vol. VIII, Acad. Sci. USSR, pp. 14-20.

GRAND'EURY, C., 1882: Annales des Mines, Vol. 1, series 8.

VON GUEMBEL, C. W., 1883, Beiträge zur Kenntniss der Texture Verhältnisse der Mineralkohlen: k.-b. Akad. Wiss. Munich, Sitzungsber, math-phys. Klasse, Bd. 13, pp. 111-216.

HARRISON, J. A., 1960, Effect of High-Carbon Components and other Additives on Cokes: Ill. State Geol. Survey Circ. 289, 30 p., 16 figs.

HUNTJENS, F. J. *and* VAN KREVELEN, D. W., 1954, Chemical Structure and Properties of Coal, II.—Reflectance: *Fuel*, Vol. 33, No. 1, pp. 88-103.

HUTTON, W., 1883, Observations on Coal: *London and Edinburgh Mag. and Jour. Sci.*, Vol. 2, pp. 302-304.

JACKMAN, H. W., HELFINSTINE, R. J., EISSLER, R. L. *and* REED, F. H., 1955, Coke Oven to Measure Expansion Pressure-Modified Illinois Oven: Blast Furnace, Coke Oven and Raw Materials Conf. Proc. A.I.M.E., Vol. 14, Ill. Geol. Survey Reprint Ser. 1955E.

International Committee for Coal Petrology, 1957, Glossary of Coal Petrological Terms: Published by Cerchar, France.

KOSANKE, R. M. *and* HARRISON, J. A., 1957, Microscopy of the Resin Rodlets of Illinois: Ill. Geol. Survey Circ. 234, 16 p., 4 pls.

MCCARTNEY, J. T., 1952, A Study of the Seyler Theory of Coal Reflectance: *Econ. Geol.*, Vol. 47, No. 2, pp. 202-210.

MARSHALL, C. E., 1955, Coal Petrology: *Econ. Geol.*, Fiftieth Anniv. Vol., pp. 757-834.

MARSHALL, C. E., HARRISON, J. A., SIMON, J. A. *and* PARKER, M. A., 1958, Petrographic and Coking Characteristics of Coal: A Laboratory Study of Illinois Coal Seams Nos. 5 and 6: Ill. State Geol. Survey Bull. 84, 120 p., 90 figs., 9 pls., 36 tables.

MOTT, R. A. *and* WHEELER, R. V., 1930, Coke for Blast Furnaces: Iron and Steel Industrial Research Council Technical Report No. 1, being the First Report of the Midland Coke Research Committee, The Colliery Guardian Co., Ltd., London, 267 p.

PARKS, B. C. *and* O'DONNELL, H. J., 1948, Determination of Petrographic Components of Coal by Examination of Thin Sections: Trans. A.I.M.E., No. 177, pp. 535-555.

PARKS, B. C. *and* O'DONNELL, H. J., 1956, Petrography of American Coals: U. S. Bur. Mines Bull. 550, 193 p.

POTONIE, H., 1906, Klassification und Terminologie der Regenten Brennbar Biolithe und ihre Lagerstatten: Abh. K. Geol. Landesant., Bd. 48.

POTONIE, R., 1926, Zur Kohlenpetrographie und Kohlenentstehung, Zeits. Deuts. Geol. Gesell., Vol. 78, No. 3, pp. 348-380.

SCHAPIRO, N. *and* GRAY, R. J., 1960, Petrographic Classification Applicable to Coals of all Ranks: Proc. Ill. Mining Inst., 68th year, pp. 83-97.

SCHAPIRO, N., GRAY, R. J. *and* EUSNER, G. R., 1961, Recent Development in Coal Petrography: Blast Furnace, Coke Oven and Raw Materials: A.I.M.E., Proc., Vol. 20.

SCHOPF, JAMES M., 1956, Petrologic Methods for Application to Solid Fuels of the Future: Mining Eng. Trans. A.I.M.E., Vol. 205, June, pp. 629-639.

SEYLER, CLARENCE A., 1929, The Microscopical Examination of Coal: Fuel Research Paper No. 16, Dept. of Science and Industrial Research, Great Britain.

SEYLER, C. A., 1943, Recent Progress in the Petrology of Coal: *The Inst. of Fuel*, Vol. XVI, No. 90, pp. 134-141.

SIEVER, RAYMOND, 1957, Variation in Coal Reflectance: Ill. Geol. Survey Circ. 241, 11 p.

SPACKMAN, WILLIAM, 1958, The Maceral Concept and the Study of Modern Environments as a Means of Understanding the Nature of Coal: New York Acad. Sci., Ser. II, Vol. 20, No. 5, March, pp. 411-423.

STEVENSON, J. J., 1911: Proc. Amer. Phil. Soc., Vol. 50, pp. 55.

STOPES, MARIE C., 1919, On the Four Visible Ingredients in Banded Bituminous Coals: Proc. Roy. Soc. London, Ser. B. 90, pp. 470-486.

STOPES, MARIE C., 1935, On the Petrology of Banded Bituminous Coal: *Fuel*, Vol. 14, No. 1, pp. 4-13.

TEICHMULLER, M., 1954, Combination of the Current Methods of Coal Petrography by Examination of Polished Thin-sections, or Means for Better International Cooperation in Coal Petrography: Proc. Internat. Comm. Coal Petrol., No. 1, pp. 25-29.

THIESSEN, R., 1919, Constituents of Coal through a Microscope: Proc. Coal Mining Inst. Amer., pp. 34-35.

THIESSEN, R., 1920, Compilation and Composition of Bituminous Coals: *Jour. Geol.*, Vol. 28, No. 3, pp. 185-209.

THIESSEN, R., 1920, Structure in Paleozoic Bituminous Coals: U. S. Bur. Mines Bull. 117, 296 p.

THIESSEN, R., SPRUNK, G. C. *and* O'DONNELL, H. J., 1931, Microscopic Study of Elkhorn Coal Beds at Jenkins, Letcher Co., Ky.: U. S. Bur. Mines Tech. Paper 506, pp. 1-30.

WHITE, DAVID *and* THIESSEN, REINHARDT, 1914, Origin of Coal: U. S. Bur. Mines Bull. 38, 390 p.

WITHAM, HENRY, 1833, On the General Results of Botanical Investigation Concerning the Character of the Ancient Flora which by its Composition has furnished the Material of Coal Seams: Rept. 1st and 2nd Meeting, British Assoc. Adv. Sci., p. 78.

* * *

Chairman Weimer: Thank you, Mr. Harrison. After working around the mines all year, I enjoy being exposed to some of these big words. When he got into the Russian alphabet there with the n's upside down and the h's backwards, I was glad that somebody can work with the Russians.

Do we have any questions of Mr. Harrison?

Ralph Gray, (U. S. Steel Corporation, Monroeville, Pennsylvania): John, in your opinion, what significance do you attach to your test evaluation method in prospecting?

Mr. Harrison: There are several facets to the use of coal petrography. To answer your question specifically, if a company is interested in a block of coal they put down test holes. They will obtain a sufficient quantity of coal from these diamond drill cores so that an idea, and a fairly accurate idea, can be obtained about the type of

coke that can be produced from the block of coal even before the shaft or the slope is sunk. Also, the petrographic evaluation will be quite advantageous because it would release some of the time now being spent in pilot oven scale studies and permit additional research more exclusively suited to pilot scale. In other words, a good deal of time at present is used in making routine runs on pilot scale ovens. This petrographic technique will release some of the time so that other factors can also be tested.

The petrographer will make an analysis, he'll make his calculations and this in turn can be compared with the results that we get from a pilot scale. In fact, this is what we are doing at the present time.

William Berry (Bituminous Coal Research, Monroeville, Pennsylvania): John, you went into nomenclature, etc., considerably. Can you give us an idea of the length of time required to take a sample of coal and come up with a prediction on the performance of the sample in coking?

Mr. Harrison: Well, this will vary, of course, depending upon how many people you have in your laboratory and whether you have to prepare your own samples and whether you have someone to polish, to do the study, help with the calculations, etc. In any case, however, your time is going to be much less on the petrographic evaluation than it will be on regular routine procedures commonly used at the present time. In other words, if I can get a sample, I have a boy working half-time preparing the sample; I get it under the microscope for reflections and measurement, etc., and within five to six hours I can have an answer for you.

Mr. Gray: There is application of petrography with reference to Mr. Greer's paper; something which has not been thought of a great deal, but may be found desirable. These petrographic combinations of coal have a very great effect on equipment, wear of parts and on hydraulic pressures. Both rank and composition affect this and may appreciably affect it. This might be something that equipment manufacturers may care to look into.

Mr. Harrison: That's a good idea, Ralph. Actually the subject of my paper this morning has been on coking. However, coal petrography is very important to other fields too. The composition and physical makeup of coal is a very important factor in many coal uses, and I think that applications to problems other than carbonization are important.

H. W. Jackman (Ilinois Geological Survey, Urbana, Illinois): John, to your knowledge has petrography been applied to any of the properties of coke other than stability?

Mr. Harrison: I might give an answer as to what I think; then I will turn it over to someone else. As you have noticed here, coal petrography has been used in conjunction with empirical tests and these tests have considered the stability factor as something we want to determine. If you accumulate these empirical data for other properties, such as hardness, petrography can be used for that, too. In other words, it can be used for predicting other coke qualities, but if it has

been to date I don't know about it. It is my understanding that stability is one of the main things in which you are particularly interested, but petrography can be used for other properties.

G. H. Cady (Illinois Geological Survey, Urbana, Illinois, emeritus): Coal petrography has been used in evaluating coal hydrogenation; that is, there are certain portions of the coal which will hydrogenate, certain portions which will not. I think that this is another application of petrography. Then there is a further application in the case of coal which has been subjected to ordinary cleaning processes. We have here at our speakers' table a man (Dr. McCabe) who has done quite a little work in the application of coal petrography to cleaning processes, in which it is quite apparent that under certain conditions these processes produced in certain sizes of the coal an abundance of vitrain and in other sizes of the coal an abundance of fusain, and it has been applied in that connection. Petrography has been used somewhat to control the composition of stoker coal so that in the study of performance it was found that when the coal is produced under certain conditions we have a superabundance of vitrain which tends to make the coal swell in the stoker. And we found that if other components of coals produced in other fractions of the cleaning process were added to those portions which were tending to swell, there was a tendency to overcome that swelling property of the coal. I think a good deal can be said for the understanding of coal petrology in various fields of coal preparation and utilization.

Mr. Harrison: Thank you, Dr. Cady. This is what I was trying to say but he says it so much better than I do. He has been working with coal petrography for many years.

Chairman Weimer: Thank you again, John. These fellows really get into the details of things. I think they help us all in that we can understand coal a little bit better. Maybe out of it will come some more markets.

Our third speaker is Dr. Louis C. McCabe, President of Resources Research, Inc., Washington, D.C. Dr. McCabe was also born in Arkansas, graduated from the University of Arkansas in 1931, has Master's and Ph.D. degrees from the University of Illinois, receiving the latter in 1937. He also started with the Illinois Geological Survey. It looks as if John Harrison was following Dr. McCabe, a few years later. Dr. McCabe went to work for the Mississippi Coal Corporation in 1928-30. He was with the Ilinois Survey in 1927 and 1930-1941 before entering on active duty with the army. After that he became chief of the Coal Branch, U. S. Bureau of Mines, 1947-49. Later he was Director of the Los Angeles County Air Pollution Control District, in 1951-1955. He was Science Director of the U. S. Public Health Service in 1955 and is presently President of Resources Research, Incorporated, Consultants. He had foreign service during World War II and holds many decorations from both the United States and abroad. His topic is "Trends in Air Pollution Activity." From the foregoing you can see that he is well qualified to speak on this. Dr. McCabe.

TRENDS IN AIR POLLUTION ACTIVITY

LOUIS C. McCABE, *President*

Resources Research, Inc.
Washington, D. C.

This subject of air pollution is controversial and one in which there are many experts. Almost every citizen considers himself an expert in the field so there are some rather vigorous discussions pro and con about the proper interpretation of many of the problems in air pollution. This morning I would like to illustrate some of the more common and some of the less common problems. You may remember that in 1938, here in Illinois, the coal industry first became aware that air pollution was a serious matter when Ray Tucker, now Mayor of St. Louis, put through regulations setting the sulphur and ash content of coal burned in St. Louis. For many of the operators in the Illinois coal fields this was a severe blow.

Yesterday I visited the Missouri Botanical Gardens, where I conferred with Dr. F. W. Went, the Director. He said that they have now brought back many of their plants from the country, where they had to take them before the coal regulations were adopted. This includes orchids and other pollution-sensitive plants. It is Dr. Went's conviction that St. Louis has one of the cleanest atmospheres in the United States now.

The sources of air pollution are many and varied; that is the reason there are difficulties in control. There is always a tendency to oversimplify problems of this sort and an individual experiencing one of the air pollution problems in one area is inclined in think that the cause and the solution are the same in another area. This isn't so. The natural sources of air pollution are always with us. Volcanic dust, dust storms, forest fires and plant pollen are some of these. Plants give off literally millions of tons of organic compounds largely in the gaseous state which may condense to liquid droplets that scatter light, producing the blue color of many mountain and desert areas and the red of the sunset. All our major fuels can cause air pollution if burned improperly. At the Missouri Botanical Gardens I saw a gas burner under test in a greenhouse. The manufacturer had in mind operating the gas furnace and exhausting directly into the greenhouse, but it was found that whatever is done, exhaust gases injure the plants. It has been suggested that a dual chamber furnace might provide complete combustion, but this is probably unrealistic.

In recent years, certainly the last fifteen, everyone has become very much aware that there are more problems in air pollution than simply smoke. The coal industry bore the brunt of smoke prevention initially since users of coal were considered the main source of air pollution. St. Louis and Pittsburgh were known as smoky cities. The equipment manufacturers and the users of coal have since made great strides in burning coal. We no longer see coal bearing the full burden of air pollution. The chemical industry is receiving attention as a source of air pollution. Gob pile fires are a source of complaint; aluminum reduction, reduction of other metals and petroleum refining require control. Perhaps the most recent source of pollution to receive attention has been the automobile exhaust.

In Los Angeles County, California, a very thorough job of controlling dust, chemical plants and petroleum refinery effluents has been done, and now the problem appears to be reduced to one source. The exhaust from some 3-4 million automobiles is now the major problem. Those of you who have been in Los Angeles realize the significance and urgency of the air pollution problem.

The diesel bus, of course, comes in for a considerable amount of criticism because persons standing on the curb get the full effect of the exhaust. From the standpoint of air pollution, the diesel is not as serious as the automobile itself.

Power plants burning sulphur-containing gas from refineries in the Los Angeles area once discharged blue plumes of SO_3. This no longer occurs because the refinery gases are scrubbed free of hydrogen sulphide, which was the principal source of sulphur compounds. Los Angeles County requires control of dust, fumes and smoke but the automobile exhaust is still to be controlled and Los Angeles still has smog.

The Jersey meadows are known by their smell to all travelers to New York. In 1958 I directed a survey of the New York metropolitan area. At that time there were regulations prohibiting burning dumps in New Jersey, but enforcement was not too effective. This is a sore spot in many communities.

When I first went to Los Angeles as the Air Pollution Control Officer in 1947, combustible rubbish was burned in 55 or 60 public or private dumps. Some of them burned 400-500 tons of combustible rubbish a day. They were closed out rather rapidly. Many operators

Fig. 1—Smoke and fly ash discharge from an apartment house incinerator.

Fig. 2—Tire burning operation.

went to sanitary fill, which is a good answer if cheap land is available. Los Angeles has now largely run out of land to bury waste and has built public incinerators to end the burning of rubbish in home and other small incinerators.

Boxcar burning was a source of smoke that was quite common in the Buffalo area four or five years ago. It is now abated. The company which retrieved the trucks and iron from worn out boxcars would turn over about six to eight of these cars each morning, set them on fire and lay down a terrific smoke screen.

A common air pollution problem in New York City is the apartment house incinerator (Figure 1). Anyone living on the thirtieth floor of an apartment building complains of the air pollution from the incinerator discharging from an adjoining twenty-five story building. There are 11,000 apartment house incinerators in New York and they are a major source of air pollution.

There were sixty grey iron foundries in Los Angeles in 1947 and they discharged excessive quantities of dust. In the beginning they had trouble financing control equipment. Capital investment in the plant may have been $100,000 when built, but at that time it cost $25,000 to put in a bag house for control. The big cost was in bag house fabrics which were in development and had short life. High temperature cloth is now available and in-

Fig. 3—Smoke from an automobile wrecking yard.

stallations cost from $8,000 to $10,000. All the foundries have them now. The fumes from asphalt plants cause damage to vegetation when they are discharged near gardens or greenhouses. The burning of old rubber tires is particularly objectionable (Figure 2). Burning of automobile bodies (Figure 3) has been a problem in many cities. In New York City two incinerators have been built to burn eight or ten cars at a time on continuous conveyors. These incinerators have dual combustion chambers and precipitators.

On the sidewalks of New York on the west side near 59th Street and Henry Hudson Parkway a few years ago there was a heavy fallout of cinders from one of the city's power plants (Figure 4). Nothing was done to control the fly ash and it covered the sidewalks and cars with heavy deposits. Periodically the city sent men around to shovel off the cinders from roofs within eight or nine blocks of the power plant. There were two such old power plants, one on the east side and the other on the west side of Manhattan, producing electric power for the subways. Last year the Consolidated Edison Company bought the plants and put in precipitators to control the fly ash.

There has been some difference of opinion between New Jersey and New York City officials whether or not the air pollution moves across

the common state boundary. Figure 5 is a picture of smoke from a smelter in New Jersey which very well illustrates that the plume does travel for miles and miles under certain atmospheric conditions. There is no doubt about the movement across the state line.

Figure 6 illustrates what happens on a clear day when there is no inversion. The plume rises and produces the effect of greater stack height. This is termed a lapse condition. Normally under daytime conditions the temperature will decline from the earth outward at about 5.4°F per 1,000 feet because of the decrease in barometric pressure with height. If lapse conditions always prevailed, there would not be severe difficulties with air pollution.

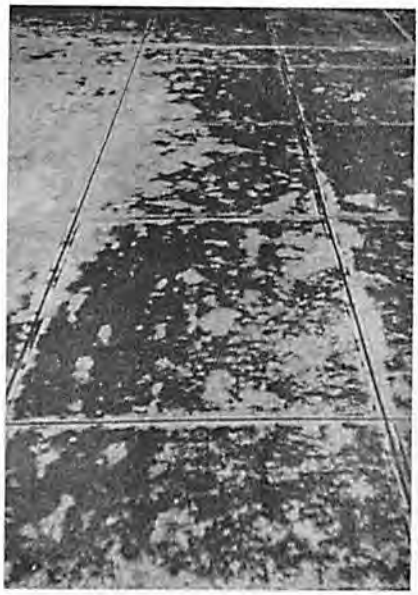


Fig. 4—Soot and fly ash cover sidewalk near a power plant on Manhattan's West Side.

Fig. 5—Interstate transport of air pollution: fumes being carried across Arthur Kill to Staten Island, New York.

Fig. 6—Smoke from power plant and a public incinerator under lapse conditions.

Figure 7 illustrates inversion due to radiation of heat from the earth. In this particular situation the air at ground level is cold and the air represented by the bright upper fifth of the photograph is warm. Under these conditions the pollution is held in the cold dense air layers near the earth. As soon as the sun has been up for a few hours, warming the ground, turbulent mixing will occur and the pollution will dissipate.

Smog in Los Angeles causes eye irritation and injury to sensitive leafy crops such as lettuce and spinach. A few years back the crop injury in Los Angeles County was estimated to be $3,000,000.00 a year. By the change of crops for the substitution of less sensitive varieties this difficulty has to some extent been overcome. Another factor in relieving the crop loss in Los Angeles County has been the encroachment of subdivisions in the groves and truck garden areas.

Now, I wish to take just a few minutes to discuss some of the things that appear to be developing in air pollution. Los Angeles County was the first county to impose rather comprehensive regulations regarding all types of air pollution. As early as 1948 a limit was placed on the sulphur dioxide that could be discharged from stacks. This was .2 per cent or 2,000 parts of SO_2 per million parts of air. This was to prevent injury to truck gardens in the refinery and sulphuric acid plant areas.

The Pubilc Health Service entered the air pollution field in 1955

by an act of Congress which provided funds for research, collection and dissemination of information, and for surveys in certain demonstration areas. The appropriation the first year was about $3 million. Since 1955, the appropriation has grown to $8 million for 1962. There is $5 million available for general air pollution and $3 million is earmarked for specific research on the automobile exhaust. The Public Health Service must report to Congress in two years on the effect of auto exhaust upon health.

The California State Legislature a little more than a year ago, passed a law requiring that afterburners be put on automobiles when they are available. The statute has required all 1962 model automobiles to have a blow-by device. This device recycles the gases from the crankcase back into the carburetor where they are fed to the cylinders and burned. It is reported to remove about one third of the objectionable unburned gases. It is rather interesting that the research in California has shown that normally about seven per cent of the gasoline goes through the automobile engine unburned.

It may not be too long before Los Angeles County and the State of California particularly will adopt a regulation requiring some sort of control device for all the gases from

Fig. 7—Air pollution held near ground under inversion conditions. New Jersey-New York; Hudson River in center.

the exhaust as well as from the crankcase. However, the public is very alert to the development difficulties. If they are required to put on a device that costs $150 and its life is three months, there will be a lot of unhappy people. At this time seventeen devices are being tested. For the most part they employ a catalytic oxidation process but there are a few of them that use a burner or spark plug to ignite the exhaust. It would not be surprising if some such device or a new approach to the exhaust control becomes a universal requirement in the years ahead.

The Federal Government is requiring blow-by devices to be put on all government purchased cars. The Secretary of Health, Education and Welfare has called on the automobile industry to put the blow-by device on all new cars within two years.

In 1960, about $11 million was spent for research in air pollution. It has been estimated by the National Air Pollution Advisory Committee that by 1965 the United States will be spending $30 million a year for research on air pollution. This does not include the control equipment installed by industry but does include research by the Federal Government, by the states, counties, cities and industry.

Los Angeles County has in recent years put in an alert system for warning the public when there is an excessive amount of air pollution. The alerts apply to carbon monoxide, oxides of nitrogen, sulphur dioxide and ozone. The system provides for first, second, and third alerts depending on the levels of contamination that are found in the atmosphere. There are six or seven instrument stations around the country that record and transfer the data into the central headquarters. When the first alert is indicated, which is infrequently, certain processes are directed to stop operating and the county has the authority to enforce the regulation. At the second alert, there is a provision for stopping other operations, including the reduction of automobile traffic. In the event of a third alert, the Governor is requested to declare a state of emergency and take certain actions provided by the California Disaster Act.

The U.S. Public Health Service is financing research to the limit of its funds and will continue to do so. The states are interested more and more in the problem. I do not know just how many of the states have passed laws on the subject but probably twenty to twenty-five of them have done so. As I see the problem as it affects the coal industry, there are some things you might be concerned about. If, like Los Angeles and other areas, your state shows an interest in limiting sulphur dioxide in the air, your coal market will suffer.

The Government Industrial Hygienists have set maximum allowable concentration of five parts per million of sulphur dioxide for eight hours as being safe for workmen. An individual who is unaccustomed to sulphur dioxide will experience eye burning at five parts per million. The odor is first observed by most individuals at three parts per millions parts of air. Los Angeles County now limits the sulphur content of fuel in the seven worst smog months to one half per cent. If that were introduced any place where

coal is burned, the upset in markets would be drastic. I do not know of any coal in this country that could consistently meet such a standard.

There is a lot of medical work now being done. There is some indication that small amounts of sulphur dioxide reduce the volume intake in the respiratory tract of small animals. Whether SO_2 affects man in the same manner is not known. In spite of the extensive work that has been done with the significance of sulphur dioxide, more research is needed on the effects, if any, on man from very low concentrations in the ambient air.

It is very probable that air pollution will follow the same pattern that developed in pollution of water 100 years ago. We did not have knowledge of the organisms causing yellow fever and typhoid but it was suspected that sewage dumped untreated was the cause. Sewage and water treatment was initiated and these diseases almost disappeared.

* * *

Chairman Weimer: Thank you, Dr. McCabe. Does anybody have any questions for Dr. McCabe? I had one on the automobiles and trucks but he answered it very well, in that they are trying to find some kind of after burner for the fumes of the trucks and automobiles. I have another one that is coming to our attention: With Mr. Kruschev setting off bombs that are going to rattle his own windows, and in St. Louis the radio tells us how many counts of micro-curies are in the air every day and that the cows are giving atomic milk and mothers are afraid to let the babies have the milk, I wonder if Dr. McCabe can tell us just what the danger is, and how much danger there is, in something like that. We are all so confused about it that I would be glad to know what he thinks.

Dr. McCabe: I didn't touch on radioactive fallout at all; generally, that is not in the area in which we work. But I take the fundamental view that any radiation is bad for you. Experts, of course, allow a certain amount of radiation that may be safely accumulated in a man over his lifetime. The radiation of long life, when deposited in the bone marrow of man, has caused a type of cancer. In addition to that, any radiation which you get all the time from the sun, and so on, may cause changes in the cell. Some experts in the field predict there will be an increase in the birth rate of abnormal children if there is exposure to excessive radiation.

Chairman Weimer: Thank you. Any other questions for Dr. McCabe?

W. C. McCulloch (Roberts & Schaefer Co., Chicago, Illinois): Louie, you showed the plume coming out of the Consolidated Edison plant. You had the United Nations building in the background. I was in New York one day in December when that plume turned over horizontally and went into the intake of the ventilating system in the ventilating system in the United Nations Building.

Dr. McCabe: That problem has been with the United Nations for several years. I remember that protests came to Mr. Truman at one

time. He said it was not American property and that it was an international problem. Since then Consolidated Edison has tried to get an allocation of natural gas and that was turned down by the Supreme Court. On the other hand, Los Angeles received approval for natural gas to reduce the smog. Los Angeles during seven months of the year cannot burn residual fuel oil because of the sulphur limitation.

Chairman Weimer: Any further questions for Dr. McCabe? Mr. Greer has just returned from India, I understand, and I want to ask him if he sold any machinery and if it is true that they carry out coal in baskets on their head over there.

Mr. Greer: Yes, they do carry it out on their heads. We saw one fellow who had a great big dragline out there working and another one right beside him. The one beside him was down and there was a whole bunch of little women around him with baskets on their heads carrying the coal out and we asked him why he couldn't fix it and he said he couldn't afford to—those women were cheaper than fixing the dragline. They have some seams that make your eyeteeth water because of the fact that they are up on end but are extremely thick. The seams will run 120 to 150 feet in thickness and you are standing on the edge of the pit; as far as you can see, there is coal.

Chairman Weimer: Are there any other questions of any of the speakers? . . . . Then, on behalf of the Illinois Mining Institute, we want to thank the three speakers here this morning. It will take three-quarters of an hour to clear the room and set it up for a banquet. Now, most of the papers this morning have pointed toward our distinguished speaker for the luncheon. He is going to speak on "Coal's Potential," and there are still tickets for sale downstairs. If there is nothing further to come up, we'll stand adjourned until 1:00 p.m.

AFTERNOON SESSION

The business meeting was convened following Luncheon held in the Grand Ballroom of the Abraham Lincoln Hotel. Mr. Gene Moroni (Old Ben Coal Corp., Benton, Illinois) presided in the absence of the Institute President.

Chairman Moroni: Because of several items on the agenda we want to get our program under way. After that fine luncheon, we have the order of business for the Illinois Mining Institute and after that, of course, we have the real dessert of the day. The Illinois Mining Institute presently has gone from the long to the short in the organization, I think, from Stuart Colnon, who is six feet four, to Gene Moroni, who is five feet five. However, to get the business going, it is fine to see so many fellow members of the Illinois Mining Institute here and we welcome each and every one of you.

The first order of business is usually the reading of the minutes of the last session. Those minutes have been published and we will dispense with the reading with your permission. At this time we'll have the Secretary's report to be given by Jack Simon for George Wilson.

SECRETARY'S REPORT

Acting Secretary-Treasurer Jack A. Simon (Illinois State Geological Survey, Urbana, Illinois): Mr. Chairman, I'll try to make this very brief. Membership last year: There were 719 paid members of the Institute, 80 life members and four honorary members. This is a total membership of 803 which was seven less than the preceding year. At the annual meeting this year, there was a total registration as of noon today of 417, which is about the same as last year. With those comments, I'll conclude the Secretary's report and move into the Treasurer's report.

Copies of the Treasurer's report have been furnished to the members of the Executive Board and a number of additional copies are available for anyone wishing to examine the report. The Institute continues to hold U. S. Government bonds in the amount of $19,000 and a $1,000 Missouri Pacific bond, for a total of $20,000 worth of bonds, which is unchanged from last year. The cash balance in the bank is $2,000.61, which is $1,547.60 less than last year. This represents in part a deficit, but is partially due to payment to the University of Illinois scholarship fund, the Institute's contribution for 1960-61 and also for 1961-62 within this past fiscal year, the previous year's payment

having been made after the annual meeting last year. The actual deficit has resulted from continually rising costs of publication of the Proceedings and continually declining revenue from advertising. This has been at least partially corrected for the future by the first increase in advertising rates in many years. Indications are that this will mean no decline in our advertising support, and the indications are excellent that the Institute will be operating well in the black.

I would like to make a brief statement on the activities of the advertising committee, of which the Secretary's office is just an assisting facility. Members of this committee normally get into high gear on the advertising for the Proceedings after the annual meeting. As of Thursday of this week, on an automatic return from ad solicitations by mail there were 41 pages of advertising on hand, which happens to represent 41% of the number of pages in the 1960 Proceedings. We are hopeful again to be able to get out the Proceedings as early in 1962 as we possibly can and every effort will be made to do that. As most of you know, the advertisers in the Proceedings have made possible the operation of the Institute and we say it often, but we say it very meaningfully, that they certainly deserve our support. The advertising committee of the Institute has been working harder every year, as I'm sure you can fully appreciate, because as the advertising gets a little harder to get, they've had to work a little harder and they really have done a magnificent job. These men are listed in the advertising section of the Proceedings, but it is felt their names should be recorded as part of the official record:

John Broadway, *Chairman*
W. D. Butts
Wm. Campbell
R. A. Dodds
Ray L. Fiedler
Carl T. Hayden
R. J. Hepburn
L. B. Hyett
W. A. Patty
R. Y. Spikings
Norman Syljebeck
R. A. Taucher

I know that George Wilson and I, acting as the Secretary's secretary, have been very appreciative of the magnificent effort that these men make. Working with George Wilson this past year, Joe Schonthal and John Broadway have been particularly helpful in making affairs of the Institute go along the line and we all appreciate that effort. I would like to bring to your attention the fact that Gene Moroni agreed on very short notice to take over the job of Master of Ceremonies or Conductor of Business at this meeting and we're very appreciative of that also. That's all I have, Mr. Chairman.

Mr. Moroni: Thank you very much, Jack. Our next order of business is the report of the Nominating Committee. I think Joe Schonthal is chairman of the committee and will make the report.

REPORT OF THE NOMINATING COMMITTEE

Mr. Schonthal: This is the report of the Nominating Committee. We, the undersigned, constituting the Nominating Committee, offer the following nominations for officers for the ensuing year and for mem-

bers of the Executive Board to serve three years:

OFFICERS

President: Robert W. Hepburn, The United Electric Coal Cos., Chicago, Illinois.

Vice-President: J. P. Weir, Paul Weir Co., Chicago, Illinois.

Secretary-Treasurer: George M. Wilson, Illinois State Geological Survey, Urbana, Illinois.

EXECUTIVE BOARD

David Flota, Sahara Coal Co., Harrisburg, Illinois.

Jack A. Simon, Illinois State Geological Survey, Urbana, Illinois.

H. M. Tibbs, Truax-Traer Coal Co., Chicago, Illinois.

R. P. Wilson, Bell & Zoller Coal Co., Johnson City, Illinois.

Wm. C. McCulloch, Roberts & Schaefer Co., Chicago, Illinois.

Respectfully submitted,

Wm. C. Campbell
L. B. Hyett
Jos. Schonthal

Mr. Moroni: Thank you very much, Joe. Are there any other nominations from the floor? If not, the chair will entertain a motion to elect the officers as proposed by the nominating committee. (Moved, seconded and approved.)

Gentlemen, you have elected by acclamation the new slate of officers as proposed by the Nominating Committee. I think they should have a good round of applause to send them off on their mission. (Applause.)

As you notice, I have an excellent ghost writer here on my left. I have to refer to the notes in the book. The next order of business is the report of the scholarships and the introduction of the students who are attending school under these scholarships. At this time, I would like to call on Dr. T. A. Read, Head, Department of Mining and Metallurgy at the University of Illinois. Dr. Read.

SCHOLARSHIP REPORT

Dr. Read: It is a great pleasure to be here again to present the scholarship report. First I would like, as usual, to express our great gratitude to the Illinois Mining Institute for continuing this financial support to needy students that makes it possible for them to obtain engineering training at the University of Illinois. First, I would like to introduce Mr. Lanny L. Richter, holder of an IMI scholarship, a senior; another IMI scholarship holder, Mr. Edwin L. Klasser, a sophomore; Mr. Larry T. Tabaka, also a sophomore. Another scholarship holder, with a scholarship supported by the Sahara Coal Co., is Mr. Thomas E. Finch, a junior. Finally, the Old Ben scholarship is held by Mr. Donald W. Gentry, a freshman who was not able to be here because of academic requirements.

Last year, perhaps not many of you know, your Executive Board took a very generous action in making available to the Mining Department at the University of Illinois some funds for the support of coal mining research. And I would like to make a brief report on the research work that this has gone to support. First of all, I would like

to introduce the people who are responsible for this research: Prof. Fred D. Wright and Prof. George Eadie. I'm very sorry to have to report that we lost the services of Prof. R. J. Wuerker who was a long time member of the Illinois Mining Institute and who passed away last August in California after an illness of several months.

The research program which has been supported by the Institute falls into three main categories: Mine ventilization research, operations research, and research in the field of rock mechanics. The ventilization program has been concerned with the study of air flow through gob areas and in bleeders around the gob by the use of a plexiglas scale model of part of the underground workings of a mine. Another phase of the ventilization research has been the development of a program for use on a digital computer for solving ventilization problems, which previously had been handled by the less powerful techniques of analog computers. In the field of operations research, we have developed or are in the process of developing a digital computer program for predicting jig performance from washability studies. Thirdly, the rock mechanics studies are aimed primarily at the problem of roof control. That consists of two phases: First, an analytical study for relating the strength of roof materials to physical property measurements made on diamond drill cores. Secondly, the study for relating the strength of roof rock and the strength of pillars. We are very grateful for this financial support, which together with financial support by the University, has made it possible for us to initiate and partly carry out these programs. We would like very much, however, to be able to accelerate the rate of this research and are very eagerly looking for additional support for these programs. We would certainly appreciate anything any of you could do to help us in obtaining support from other agencies. Thank you.

Mr. Moroni: Thank you, Dr. Read. Is there anyone here to represent Dr. George B. Clark of the Missouri School of Mines in Rolla? Well, if not, I think mention should be made of the fact that the Illinois Mining Institute does support one scholarship at the Rolla School of Mines which has been awarded. Also attending the session today are some students sponsored as guests of the Sahara Coal Company. Maybe these young fellows would rise also, please.

Gentlemen, the next order of business is the introduction of guests seated up here at the head table. And I beg your indulgence and forgiveness for having to refer to the notes to introduce them because I'm not acquainted with all of them. At the left end of the table, Fred Wilkey, long time Secretary of Illinois Coal Operators Association; next to him is John Broadway, Chairman of the Illinois Mining Institute Advertising Committee; Dr. R. A. Glenn, Manager of the Chemical Division of Bituminous Coal Research, Inc.; Bill Weimer, Peabody Coal Company, session chairman this morning; R. D. Greer, of Jeffrey Manufacturing Company, and John A. Harrison of Illinois Geological Survey. I think we all know our faithful Secretary, George Wilson, Secretary of the Institute,

and Jack Simon. Beginning at the right end of the table is the young man who has come a long way in the Coal Industry. He is a newly appointed Director of the Department of Mines and Minerals in the State of Illinois, William J. Orlandi. Next to him is Vice-President of Operations of Freeman Coal Company, Gene Mauck. We have next one of our honorary life members, well known in the Coal Industry, Dr. Gilbert H. Cady. Next to him is Dr. T. A. Read, whom you just heard, Head of the Department of Mining and Metallurgical Engineering at the University of Illinois; next to him is Robert J. Hepburn, Vice-President of the United Electric Coal Companies and newly elected President of the Institute. We have next Dr. Louis C. McCabe, Resources Research, Incorporated. The gentleman to my right will be the speaker of the day, Mr. George Lamb, and I'll tell you a little more about him in just a few moments.

Gentlemen, is there any old business to come before the Institute at this time? Is there any new business to anyone's knowledge that should be brought before the meeting? Under new business we have a presentation to be made and I would like to call on Mr. Bob Hepburn to make that presentation.

Mr. Hepburn: This is indeed a pleasure for me, to be asked to bestow upon Mr. Fred Wilkey an honorary life membership in the Institute. This award is made occasionally to men who have served the coal industry of the State and the honor is being bestowed on Fred in recognition of his thirty-four years of service as Secretary of the Illinois Coal Operators Association. Fred has been a member of this Institute since 1929. He was born in Sullivan, Indiana, and is now retired to an Indiana farm. It is certainly a pleasure to confer this honor of the Institute on Fred for his many years of service to the Illinois coal industry. I think this time, Fred, you can't argue back at us.

Mr. Wilkey: I'm afraid not. Well, I don't have much to say except that this is a great honor and I'm truly grateful. I have enjoyed my thirty-odd years as a member of this Institute and I'm glad that they didn't read off anything about me that so many of you men know about me, but I shall cherish this and never forget my many, many years in the Illinois coal industry. A great many changes have taken place, especially in the labor front. Of course, I have to say that because that's been my particular forte, but that is true of selling and production and everything else. When I like many others, started in, everything was hand loading. Today, everything is highly mechanized. We have fewer men and the industry is continuing to change in productive methods and sales methods and so on. The uses of coal are changing. So time marches on. I'm very grateful to you, gentlemen. Thank you.

Mr. Moroni: Thank you, and congratulations again to you, Mr. Wilkey, and thank you, Bob.

Gentlemen, we'll move along now to what, as I said, is the dessert of the day. We are very fortunate in having with us a gentleman who is well known in the coal industry. He comes originally from Idaho. To give you a little of his past history,

I'll go back only to the war years. He was chief economist of the Solid Fuels Administration during the World War II period. During 1944-46 he was Assistant Director at the United States Bureau of Mines. From that time, for the next fifteen years he was with Consolidation Coal Company in Pittsburgh, Pennsylvania, as Manager of Business Surveys, and as of April of this year, by request of the Secretary of Interior, Mr. Udall, in a personal request to the President of the United States, the office of Director of Coal Research was created and Mr. George Lamb was appointed to be that Director. It is a very great pleasure, at this time, to introduce Mr. George A. Lamb.

COAL'S POTENTIAL

GEORGE A. LAMB

Director, Office of Coal Research
United States Department of Interior
Washington, D.C.

It is a pleasure to speak before the Illinois Mining Institute at its 69th Annual Meeting. I feel honored to be on your program. In addition, I am grateful for the opportunity to tell you about the activities of the Office of Coal Research.

More important than my talk, however: I have a message to convey. This is from a man who a few years ago as a congressman was on a special committee of the Interior Committee in the House which held hearings on the coal situation. It was called the special coal research committee. As a result of the findings of this committee, we have the Coal Research Act under which our office operates. I refer to Secretary Udall. He asked me to convey a brief message on his behalf:

"When I learned recently that George Lamb, Director of Coal Research in the Department of Interior, was scheduled to address your meeting, I asked that he convey my greetings and a message to you.

"Yours is one of the oldest and most active among organized trade groups in the entire country. I firmly believe that much benefit can accrue to an industry which has banded together under the principles of a free society and functioned so ably over these many years.

"It is a genuine pleasure to convey my greetings through Mr. Lamb and to express through him the hope that the efforts being made by individuals and organizations like yourself, as well as others associated with the coal industry will bring substantial results in the future.

"We are confident that the government, acting in cooperation with the coal industry and organizations like yours, will be able, through their combined efforts, to do much toward alleviating the present conditions which prevail in the industry and to bring about a new level of prosperity to the industry nationwide. This will enable the industry to cope with the increasing energy demands which will be made upon it in the years ahead by the requirements of our expanding economy in a free and growing America.

"As President Kennedy said in his special message on natur-

al resources. 'Wise investment in a resource program today will return vast dividends tomorrow, and failures to act now may be opportunities lost forever. Our country has been generous with us in this regard —and we cannot now ignore her needs for future development.' "

Stuart Udall
Secretary of the Interior

Six months back, my appointment as Director of Coal Research was announced by President Kennedy and Secretary Udall. It was the middle of the summer before most of our staff were on hand; thus, the Office has had limited time to gain operating experience. However, there has been exciting activity during this short period, not only in performing day-to-day tasks, but also in attempting to visualize how this young Office will develop to aid the coal industry's progress as it moves toward its expanding market potential.

Most encouraging has been the wide interest shown in OCR. Proposals on coal research began to appear not long after the President's signature was affixed to the coal research bill in July 1960. Sixty proposals had been filed by the time I was appointed in April. More than one hundred fifty proposals have now been received, including several from the University of Illinois.

The four slides I am going to show indicate the broad source and subject matter of these proposals.

These proposals, coming from many organizations and individuals, represent a cross section on research thinking and provide an indication of how coal may have to move to better its place in the energy market. They indicate three major utilization fields that offer additional tonnage volume. First is power generation, which is followed by gasification and liquid fuels, with related proposals on chemical and other uses. I shall comment later on projects in the field of mining

DEPARTMENT OF THE INTERIOR
OFFICE OF COAL RESEARCH

TABLE I—SOURCES OF THE FIRST 130 RESEARCH PROPOSALS RECEIVED

COLLEGES AND UNIVERSITIES	54
PRIVATE RESEARCH ORGANIZATIONS	30
COAL-SPONSORED RESEARCH ORGANIZATIONS	29
PRIVATE-INDUSTRY COMPANIES	11
PRIVATE INDIVIDUALS	5
THE COAL INDUSTRY	1

DEPARTMENT OF THE INTERIOR
OFFICE OF COAL RESEARCH

TABLE II—RESEARCH AREAS SUGGESTED BY THE FIRST 130 PROPOSALS
FIELD OF UTILIZATION

	Number of Proposals
COAL GASIFICATION AND CARBONIZATION	18
COMBUSTION METHODS AND EQUIPMENT	11
ELECTRICAL APPLICATIONS (Mine-mouth Power, RR Electrification, High-voltage Transmission, Heat Pumps, etc.)	8
COAL CHEMICALS	6
IMPROVED COKING METHODS AND FUELS	5
LIQUID FUELS (Includes Adding Fine Coal to Oil, Gasoline, etc.)	5
FLY ASH UTILIZATION	5
NEW USES (Includes Fuel Cells, Sewage, and Soil Treatment, etc.)	5
AIR POLLUTION	3
	66*

*51% of all proposals received.

and preparation, as well as those in marketing and economics.

A large part of the future increase in the use of coal is expected to come from the expansion of the industry's two largest growth markets —steel and the electric utilities. And the optimists would have us believe that coal need merely bide its time to be carried to prosperity by the demands of these two basic customers!

But we all know from bitter experience that even "assured" markets—as the railroads and domestic consumers once were—can be lost through lack of progress and lack of research. And coal's projected growth markets are not "assured"; instead, they are potentials that will require development.

The electric utilities can and will use the energy fuel that results in the lowest generated cost of electricity. Any appreciable change in the relative costs of coal, oil, gas, and nuclear energy would result in the gain or loss of millions of tons of market!

Processes are now available or under development to make steel directly without the use of coal.

Even in conventional steel-making methods, improved procedures reduce the quantity of coal required to produce a ton of steel each year. And, for that matter, the projected growth of the steel industry itself is not the assured matter it once appeared. For the first time in history, the American steel industry is facing external competition—from aluminum, from plastics, and from imported steel from other countries. Its future growth and its increased use of coal will depend on its own ability to meet this competition and upon the ability of the coal industry to supply a better and cheaper product.

Thus, a vital function of the Office of Coal Research is to aid in finding better and cheaper ways of mining and preparing coal, delivering it to the consumer at lower cost, and improving the efficiency and convenience of its utilization. The increase of from one-half to one billion additional tons per year forecast by many prognosticators is largely dependent on results of research which must be done now and in immediate as well as more distant years.

During the past three years, bituminous production has stayed around 410 million tons. This figure is considerably below the 500 million tons which the industry has stated it must produce in order to maintain its plant and equipment and to meet the needs of an emergency demand. The need to raise anthracite output is clear. To assist in the development of a stronger coal market in the immediate years, the Congress created the Office of Coal Research. Although this tremendous assignment is shared with the industry itself and with other agencies of Government and private business, the eventual success or failure of the Office of Coal Research will be measured by its contribution to the development of expanded coal markets.

The duties of the Office of Coal Research are defined in very broad terms by Public Law 86-599 as being "To encourage and stimulate the production and conservation of coal in the United States through research and development by authorizing the Secretary of the Interior to contract for coal research, and for other purposes."

Although basic research may be required in certain areas of investigations, we fully intend to concentrate in the areas of applied research (research directed toward practical applications of science) and development (systematic use of scientific knowledge directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes).

This Office will diligently follow the intent of Congress in contracting for scientific, technical and economic research and its practical application. Emphasis is on getting research developed to the point of commercial realization within the shortest time possible. In this sense, our contract effort has an immediacy about it which goes beyond the bounds of a normal program of applied research.

However, it is not possible to engage in scientific research, even applied research, in a field so broad as coal, without being confronted with the need for some possible basic research in a specific area, or tied to a specific piece of work in progress or contemplated.

DEPARTMENT OF THE INTERIOR
OFFICE OF COAL RESEARCH

TABLE III—RESEARCH AREAS SUGGESTED BY THE FIRST 130 PROPOSALS
FIELD OF MINING AND PREPARATION

	Number of Proposals
PREPARATION, TREATING, BRIQUETTING	10
CRUSHING, GRINDING, PULVERIZING	7
MINING METHODS	7
SAMPLING AND TESTING	6
SULFUR AND ASH REMOVAL	6
NEW MINING EQUIPMENT	4
NEW PRODUCTS FROM ADJACENT STRATA AND REFUSE	3
UNDERGROUND GASIFICATION	2
MINE SAFETY METHODS AND EQUIPMENT	1
	45*

*35% of all proposals received

There is no conflict between this Office and the Bureau of Mines, as the three basic differences listed below indicate:

1. OCR's major effort will be directed toward short-range research and development.

2. OCR will direct its major contract research effort to areas in which the promise of success can be measured by the most immediate economic impact on the coal industry.

3. Office of Coal Research work is performed solely by contract at this time. In the future there may be some merit in a limited program of grant-aid for specific work. No laboratories or other facilities will be operated for "in-house" research.

Because of these basic differences in program and method of approach, the Office of Coal Research will complement the research activities of the USBM.

What are the objectives of the Office of Coal Research and how do we propose to achieve them? Broadly stated, our prime objective is to maximize the value of the coal industry to the national economy. These words can be clarified by saying that we want to see new uses of coal developed and present uses expanded. Potential is to be exploited. In large measure, our suc-

cess will be measured by the volume of tonnage expansion, and our efforts will be shaped accordingly. But if commercial markets for other products associated with coal can be developed, this is another measure of success.

One example in the field of mining and preparation would be the development of a use for mine refuse. Another would be the recovery of valuable minerals from coal and the surrounding strata. Still another could be the commercial removal of methane from the Coal Measures themselves.

I am sure we can agree that increased research in the bulk utilization of coal is highly desirable. But transportation, marketing, and other economic aspects of the coal-producing and coal-consuming industries are also important and require research consideration.

Some fear has been expressed that mining and preparation would be neglected in the research program. This is not the case. Any proposal that improves the position of coal in the energy market—through lowered production or preparation cost—or through product up-grading, which permits its usage in new market areas—will be considered. But I repeat my statement made before the Southern Research Institute. The Office of Coal Research offers no subsidy. It offers instead an investment in coal's future, and an opportunity to make the fullest possible use of a most valuable natural resource—just that and no more. OCR does not offer a panacea for the private ills of individual groups.

Although increased coal volume is a major consideration in our program, this does not mean that we are not interested in projects that offer little or no tonnage potential. Some projects may correlate with or be vital to other projects that do offer such potential. As an example, a proposal concerning coal chemicals might offer prospects of only limited tonnage increase—but it might result in a profitable undertaking that could help support a proposal of appreciable tonnage impact—or it might develop a new product of special importance to the nation.

Thus the concept of an integrated program or complex is developed. Each proposal will be considered as a probable component in the complex, and some will necessarily precede others in the development of the integrated program. Proposals which must be passed over for the present may be again considered at a later date.

The Office of Coal Research will conduct no projects with its own staff. Instead, it will provide funds for research and development projects through contractual arrangements with universities and colleges, research organizations, mining and manufacturing firms, qualified and equipped individuals, and with other Government agencies. When appropriate, OCR may also cosponsor projects with other agencies or organizations. Work is to be done under contractual arrangements covering particular activities and time for accomplishment, as differentiated from grants sometimes made to nonprofit institutions.

While all information, uses, products, processes, patents, and other developments resulting from research under Public Law 86-599 must be held available to the public, the spirit of the legislation dictates

DEPARTMENT OF THE INTERIOR
OFFICE OF COAL RESEARCH

TABLE IV—RESEARCH AREAS SUGGESTED BY THE FIRST 130 PROPOSALS
FIELD OF ECONOMICS AND MARKETING

	Number of Proposals
STUDIES OF U.S. MARKETS	11
STUDIES OF EXPORT MARKETS	4
MINE-TO-CONSUMER TRANSPORTATION STUDIES	4
	19*

*14% of all proposals received

a considerate treatment of patent policy. Therefore, the decision on patent title will be determined with reference to the equities of the situation. Title to all patents developed as a result of contractual research will be decided on an individual basis. Where justified by unique experience, qualifications or background knowledge, the contractor may be allowed to obtain title to the resulting patents and royalty rights thereto, subject to issuance of royalty-free licenses to the United States Government and issuance of licenses to domestic users for reasonable royalties. The interests of individuals and organizations proposing a program for contract research will be protected. Information contained in contract proposals will be held in strictest confidence by OCR and its employees.

The function of the OCR staff involves making such studies and investigations as are necessary to evaluate the merits of proposed success of a given proposal, the validity of cost, the impact of success, and a minimization of any duplication of effort. Those proposals which meet the requirements of the OCR program will be negotiated and recommended to the Secretary of the Interior for final contract approval.

All proposals received will be given a careful evaluation by the technical staff of OCR, utilizing, in many cases, the technical competence and knowledge of our general advisory committee and the professional consultants in each area of interest appointed for this purpose. Several of these consultants and committee members are here today.

Evaluation of some projects may require a considerable degree of study. A prime factor in the evaluation of any proposal will be its effect, if successful, on improving the position of the coal industry in the national economy. As previously mentioned, the correlation of the proposal with other OCR projects

will also be considered, as will the time required to obtain results. Those evaluated as likely to produce the earliest practical results will receive primary attention. At the same time, a proposal that fails to appear promising today might be the key to a sure-tonnage project next year because of certain developments in the meantime. Other factors given consideration include, but are not limited to, the competence of the contract proposer and members of his staff, the availability and completeness of the required facilities, compatability with other research work now going on or conducted in the past, and cost of the work to be performed.

Following the award of a contract, the Office of Coal Research will maintain close liaison with the contractor to assure quality of work, progress toward contractual objectives, cost control, avoidance of duplication of effort, integration with other contract work, and development of new areas for research, and finally will seek ways to insure the application of the end results of such research.

The General Technical Advisory Committee, composed of top-flight representatives of coal and associated industries, has suggested the following areas of impact, and programs presently in development closely correlate with their suggestions: (a) transportation of coal; (b) recovery of chemicals from coal; (c) exploitation of steel-making market; (d) development of smaller industrial heating plants; (e) gasification and liquid fuels; (f) coal preparation as it affects "a" through "e"; and (g) promotion of coal use in electric power generation.

While increased coal production and use are major considerations in the over-all program, OCR may consider projects that offer only limited tonnage potential—if they correlate with or are vital to other projects which do offer greater potential.

No initial research and development program can be pinpointed precisely as to its final outcome, but by fiscal 1963, research accomplished should show the feasibility of initial projects. This will permit greater concentration of effort in promising areas and a more comprehensive integration of respective programs in the mining, preparation, marketing, transportation, and utilization areas.

Our staff will do a painstaking job in contract evaluation. The need for coal research is great, and our budget is limited. We want to buy the greatest possible benefit to the national economy, to the coal industry, and to the American taxpayer with every dollar spent.

As Secretary Udall very appropriately stated on March 2, 1961, "We view the activities of this Office as an action program designed to bring about the expanded use of coal, and in so doing to promote the economic health of the nation and materially assist in meeting the economic and social problems currently existent in the depressed coal mining areas of our country," and toward this end "our nation should make the fullest and best possible productive use of the abundant heritage we possess in our rich coal resources.

"Here, we feel, is a challenge to test the ingenuity and abilities of the industry, our educational and research institutions, and individuals throughout this broad land. I have every confidence that, given the necessary tools with which to

work, we will meet the challenge and in so doing accomplish the outstanding objectives of the President's natural resources program to the lasting benefit of the coal industry and coal miners of America."

A larger market for coal is a potential; it will be realized through hard work on the part of the coal industry together with vision reflected in research and development.

* * *

Mr. Moroni: Thank you very much, Mr. Lamb. Are there any questions that anyone would like to ask? Mr. Lamb has indicated to me that perhaps as a result of his visit and his message here today, the Office of Coal Research would be pleased to entertain more proposals than have been received from this area. So, gentlemen, you and the organizations which you represent may have ideas, some which may be way out in left field. We all have some time or another had preconceived notions of what we think coal could or could not be used for. If you have an idea, these people are here to serve us and you. So don't hesitate in the least bit to send them your ideas whether or not you think they are acceptable. Thank you very much.

Before we go into the conclusion of the meeting, we are supposed to hand the gavel over to the new president but we don't have the gavel so I guess we'll just have to shake hands.

Mr. Hepburn: Mr. Chairman, Directors, and Members, I want to thank you for this honor and I'll certainly do everything I can to have a successful 1962. I think this will end our proceedings and we'll see everybody again tonight, and next year. The meeting is adjourned.

(The meeting was adjourned at 3:00 p.m.)

NOTE ON CHARGING TEMPERATURE AND COKE QUALITY—REPRESENTATIVE STUDY RESULTS OF AMERICAN, AUSTRALIAN AND JAPANESE COALS*

C. E. MARSHALL, D. K. TOMPKINS, D. F. BRANAGAN, J. L. SANDERSON

Department of Geology and Geophysics
University of Sydney
N.S.W., Australia

ABSTRACT

A laboratory-scale investigation of the carbonization characteristics of a group of American, Australian and Japanese coals has revealed a significant relationship between oven charging temperature and coke quality. The latter appears to be particularly related to the rate of heating up to and within the plastic range of the coal. It is suggested that coke-strength variations are in part conditioned by rate of heating in relation to plasticity and gas evolution characteristics of the coal, which in turn reflect the petrographic constitution, type distribution and rank of the seam.

Oven charging at temperatures within or above the plastic range has a markedly deleterious effect upon the mechanical strength of coke produced from some of the coals; others yield superior cokes when charged at higher temperatures. Much may be achieved in the control of coke quality through careful selection and preparation of the raw coal.

INTRODUCTION

During the past few years, the Coal Research Group of the Department of Geology and Geophysics, University of Sydney, has been engaged upon studies designed to assist in the better development and more economic utilization of the solid fuels. One of the most comprehensive fields of investigation in which studies are still proceeding is that of carbonization; the principal concern has been to investigate the factors affecting carbonization and to improve coking characteristics in

*Presented before the Symposium on Preparation and Properties of Coals, Division of Fuel Chemistry, American Chemical Society, 138th National Meeting, New York, N.Y., September 11-16, 1960.

relation to metallurgical coke production. The seams studied to date include both established coking coals and some generally regarded as poorly coking and unsuitable for industrial use; they have been drawn from American, Australian and Japanese coalfields.

In 1955, the senior author, with a group of American coworkers from the Illinois State Geological Survey, carried out an intensive laboratory-scale investigation of the petrographic and coking characteristics of the Illinois No. 6 and No. 5 coals (1). Subsequently, the Sydney research group embarked upon an extended project of utilization studies of some Australian seams which are of similar character to the Illinois coals; interim statements of certain early results were submitted to the Institute of Fuel (Australian Membership) Symposium at Newcastle, N.S.W., in 1959 (2,3). More recently the project has been greatly expanded to cover a wider range of both individual and blended coals, particular emphasis being placed upon the blending potential of selected Australian and Japanese seams.

In all this work, it is recognized that the laboratory-scale study results cannot be integrated directly with those of full scale industrial practice, but experience has shown that they may be correlated. Consequently, the laboratory methods permit a relatively rapid, economic and critical assessment of the factors affecting coking characteristics, and establish trends which may serve as useful guides to improved industrial practice.

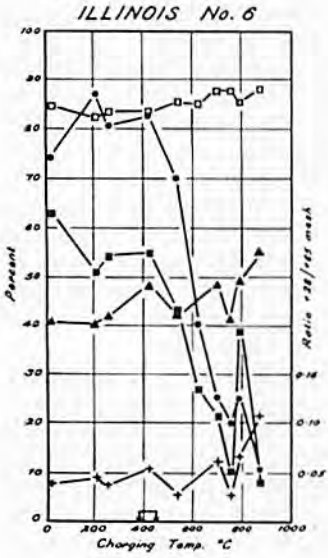
Coking Potential

Broadly, the many related and mutually modifying factors which appear to affect the coking potential of a coal may be grouped as (a) inherent petrological, physical and chemical characteristics of the raw material; (b) induced modifications of these characteristics brought about in the preparation of the oven charge; and (c) conditions under which the coal is carbonized. Within and between these groups all factors are subject to mutual variation; consequently critical assessment of coking potential demands comprehensive, exhaustive and controlled studies.

The present paper deals only with one limited aspect of the influence of carbonization conditions upon coke characteristics, namely, the effects of charging temperature upon the mechanical properties of the resultant coke. Other conditions and standards adopted for these tests have been based upon much more comprehensive studies, discussion of which is beyond the scope of the present paper.

However, it should be stated that detailed studies have shown that coal particle size consist is often a very significant factor in determining the physical qualities of the coke produced. Under the conditions of study developed, the majority of normal, medium- to high-volatile bituminous coals which have been investigated to date appear to yield most satisfactory cokes when the raw material is reduced by controlled breakage to pass 1/8" mesh, with the minimum production of finer sizes. Standardized procedures of size reduction, however, do produce differences in final consists, a response to variations in the physical and petrographic characteristics of the seam material.

Figure 1.



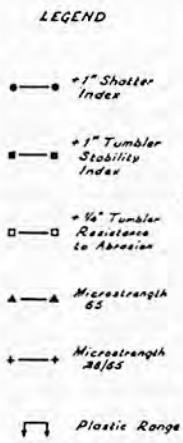


Figure 2.

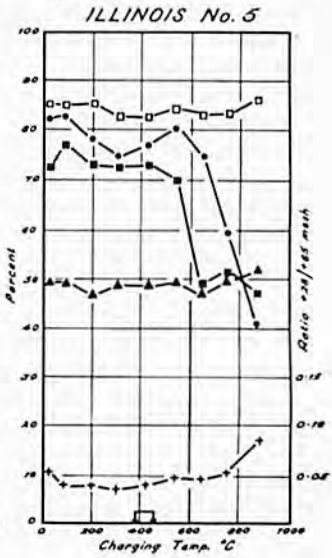


Figure 3.

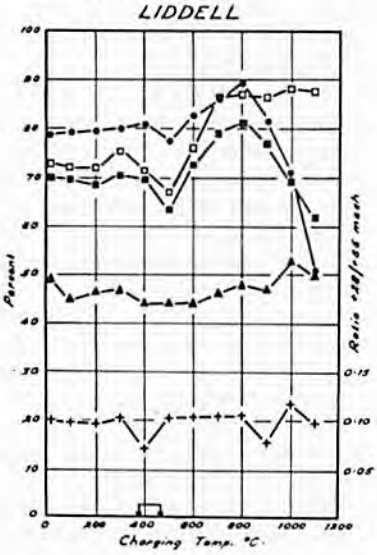


Figure 4.

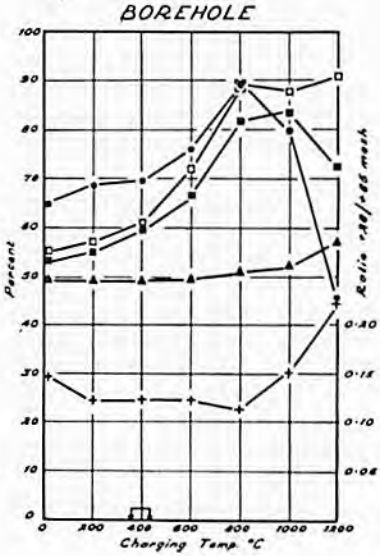


Figure 5.

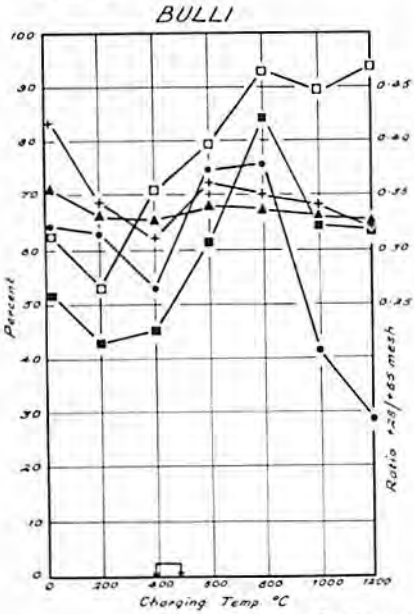
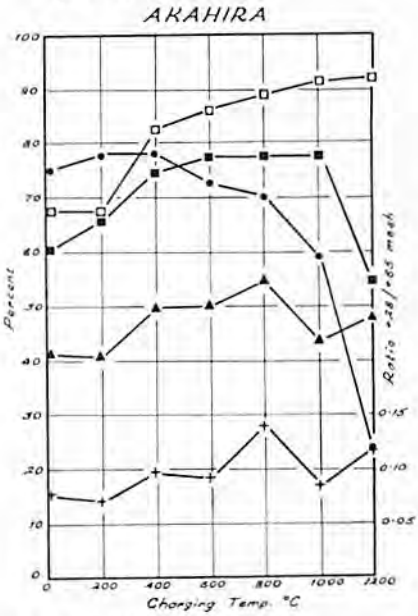


Figure 6.



For Legend, see previous page

Figure 7.

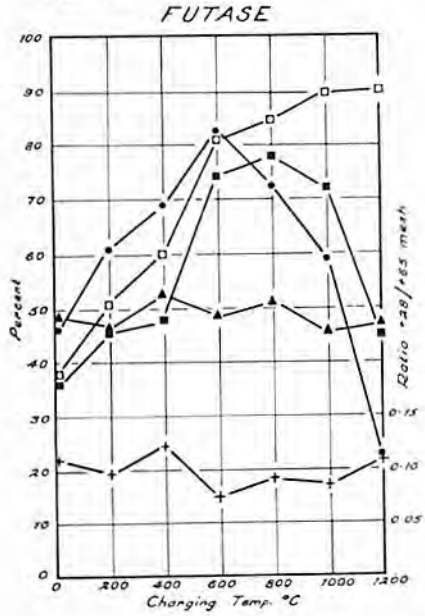
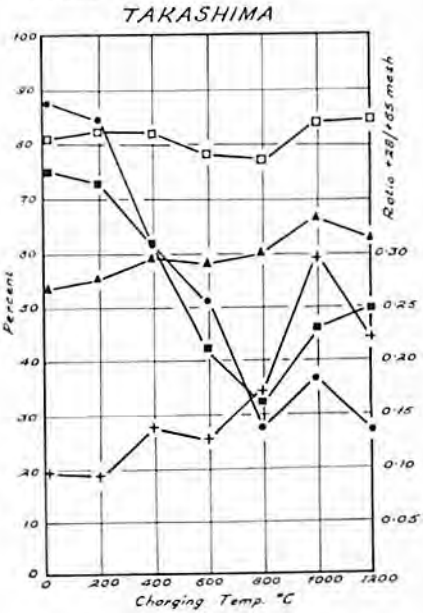


Figure 8.



Coke Production and Testing Methods

The methods of laboratory-scale production testing and evaluation developed for the coking studies of the Illinois seams have been described elsewhere (1), and compare closely with those more recently applied to similar investigations of the Australian and Japanese coals. For the purposes of the present study, coal charges of approximately 700 grams, prepared according to a standard procedure, were coked under various conditions of charging temperature, final soaking temperature, and length of coking period. The coal charges, contained in closed, cylindrical refractory retorts, were heated in a silit-rod (Globar) type of electrical furnace with accurate thermostatic and program control. All coke runs were made in quadruplicate. The "strength" characteristics of the resultant cokes were examined by laboratory-scale adaptations of the industrial shatter, tumbler and micro-mechanical tests.

The combination of "strength" tests used was considered to be most suitable in the circumstances, as shatter and macro-tumbler stability index results are conditioned largely by the macro-structure of the coke (joints, cracks, pore-dimensions and "wall"-thickness) while micro-mechanical strength and macro-tumbler hardness largely indicate the strength of the coke substance itself. That these laboratory tests were adequately discriminatory is evident from the study results summarized in figures 1-8.

In the following discussion, "optimum" as referred to coke quality implies maximum attainable values for the mechanical strength indices. Unfortunately it is seldom that all these strength indices attain their respective maxima under precisely similar conditions. Consequently the "optimum" of quality in any coke must represent a compromise, most suited to the consumer's particular requirements. Similarly, "optimum" conditions of coking are described by those particular circumstances in the thermal cycle which appear to contribute to the development of the highest mechanical strength indices.

Factors in the Thermal Cycle of Coking

The factors considered to be of importance in the thermal regime include (a) oven temperature at charging, (b) rate of heating (both particularly in relations to the plastic range of the coal), (c) final coking temperature, (d) period of coking, both overall and at final temperature of carbonization.

Limitations of space preclude any adequate discussion of all these factors, although they are certainly important and mutually disturbing. However, as an essential introduction to the main theme (the effects of oven temperature at charging upon mechanical strength characteristics of the coke produced), the following brief and qualified résumé of the general effects of the other factors in the thermal cycle is included.

Final Coking Temperature

For the majority of "normal" bituminous coals examined so far, increased final coking temperature is accompanied by improvements in coke quality in respect of both macro- and micro-mechanical indices, until a particular "optimum" tem-

perature of coking is attained. Carbonization temperatures above the "optimum" for each particular coal, invariably have resulted in severe deterioration in the macro-mechanical indices of the coke. In the laboratory studies, for most of the coals prepared under "standard" conditions, the particular "optimum" temperature of final carbonization lies between 1000°C and 1200°C, although in some cases further improvement in mechanical strength may be induced by even higher temperatures.

In the case of the Illinois coals, "optimum" final coking temperature proved to be 1850°F (1010°C); for the Australian and Japanese coals, 1200°C has emerged as the most nearly satisfactory temperature of final coking.

Duration of Coking

The majority of the coals studied appear to yield "optimum" cokes when "soaked" at the final coking temperature for a relatively short period. In the laboratory studies, periods of more than two hours at maximum temperature of carbonization were usually accompanied by definite deterioration in the coke strength, although this invariably improved again with further extension of time to approximately 10 hours. As such prolonged "soaking" was not considered practicable, the two-hour final soaking period was adopted as standard.

Under "standard soaking" conditions, the coke produced usually exhibited a "steely", bright lustre and a minimum of breeze.

Rate of Heating

In coking, rate of heating must be related to the initial temperature and heat capacity of the oven on charging, the oven temperature increment per unit of time, and the thermal conductivity of both the coal charge and the progressively developing zone of coke, quite apart from the thermal characteristics of any reactions involved.

The influence of oven charging temperature upon coke-strength characteristics is discussed later as the principal theme of this paper. It is sufficient to observe here that the higher the oven temperature upon charging, the more rapid is the initial rate of heating, a factor which appears to be of particular importance in relation to the plastic temperature range, plasticity and volatile evolution characteristics of the coal.

In the laboratory studies, the initial rate of heating of the charge was increased by introducing the coal into the oven at successively higher temperatures. Thereafter, dependent upon the characteristics of the equipment available, standard rates of temperature increase were maintained at 3.6°C/min. (American coals) and 3.4°C/min. (Australian and Japanese coals) to 1000°C, followed by slightly reduced rates of heating to the maximum "soaking" temperatures. These figures closely approximate mean rates of temperature increase established in pilot oven studies, and were accepted as "standard" but subject to later investigation.

Charging Temperature and Coke Quality

Representative analyses of the American, Australian and Japanese coals which formed the subject of this study are quoted in Table I. Illinois seams Nos. 5 and 6, the

TABLE I — ANALYSES OF COAL

Seam	Prox. An. (% a.d. coal)				Ult. An. (% d.a.f. coal)					B.S. Index
	Moist.	Ash.	Vol.	F.C.	C.	H.	N.	S.	O.	
No. 6 Coal, Illinois	7.8	8.6	34.8	48.8	80.8	5.5	1.9			4
No. 5 Coal, Illinios	5.2	10.9	34.4	49.5	82.3	5.5	1.9	1.6	8.7	3½
Liddel Coal, N.S.W.	3.0	8.0	36.8	52.2	82.4	5.8	2.3	0.4	9.1	2½
Borehole Coal, N.S.W.	2.5	9.9	32.6	55.0	82.4	5.4	1.7	0.5	10.0	5
Bulli Coal, N.S.W.	1.1	7.2	22.2	69.5	89.0	5.0	1.9	0.3	3.8	8
Akahira, Japan	2.8	5.5	41.8	49.9	82.3	6.2	2.3	0.6	8.6	5
Futase, Japan	3.0	8.4	38.2	50.4	82.3	6.0	1.5	0.3	9.9	1½
Takashima, Japan	2.2	5.9	43.6	48.3	83.8	6.3	1.4	0.6	7.9	7

Liddell and Borehole of New South Wales, are quite comparable in chemical constitution and similar in overall petrographic character; the Bulli coal of New South Wales and the three Japanese samples were respectively of somewhat higher and lower rank.

Standard charges of each of these eight coals (controlled bulk and size consist) were introduced into the coking oven, of which the *initial* temperature was increased by successive increments to the particular final coking temperature adopted as optimum for each coal. In all cases, after charging, the oven temperature increase was maintained at the standard, controlled rate until the soaking temperature was attained.

With the exception of the Bulli and Takashima coals, all those examined revealed generally similar trends in the relationship between coke strength and oven charging temperature. In general, the majority of the strength indices improved progressively, reaching maxima for various particular charging temperatures ranging between 400°C and 1000°C; the decline in the strength index beyond the maximum was frequently precipitate. In the case of the Bulli coal, increased charging temperatures produced an initial deterioration in the strength indices of the coke, which thereafter improved to their particular maxima before declining rapidly. The Takashima coal in general exhibited deterioration in macro-strength indices and improvement in micro-strength characteristics with increased charging temperature.

Though frequently having pronounced effects upon the other strength characteristics, the temperature of oven charging assumed

most critical significance in relation to shatter and stability indices—both measures of the coke macro-structure. Severe deterioration of one or both of these indices is not infrequently accompanied by slight improvements in the strength of the coke substance, as is made evident by increased micro-strength and resistance to abrasion.

The American Coals

The most significant feature of these study series, results of which are shown graphically in figures 1 and 2, was the critical effect of charging temperatures in excess of 450°C and 540°C respectively on the shatter and stability indices. Progressive increases in charging temperature from 25°C to these critical values were accompanied by modest though erratic general improvements in shatter and some reduction in stability for the No. 6 coal; a general, gentle, but varying deterioration in all macro-strength indices occurred in the case of the No. 5 coal.

When charging was carried out at temperatures progressively higher than those indicated, both shatter and stability indices of the cokes produced from each of these coals exhibited a general and rapid decline. In each case the deteriorations were accompanied by slight improvements in resistence to abrasion and micro-mechanical strength, the trends being more strongly marked in the higher ranges.

It appears significant that in each case the critical charging temperature (450°C for No. 6 coal and 540° C for No. 5 coal) is within or just adjacent to the plastic temperature range of the coals. It is considered that when charged at successively higher temperatures, these coals are subjected to an ever-increasing rate of temperature increase up to, through, and above the plastic range, and are thus afforded less and less time for volumetric and other adjustments before the "setting" temperature is reached. The consequent accumulation of stresses and the development of increased jointing and fracturing is indicated by the decrease in macro-mechanical strength.

The toughness or hardness of the coke substance (resistance to abrasion and micro-mechanical strength) does not appear to be related to the heating rate in any particular range, and increases slowly with the rise of charging temperature.

Apart from the effects upon strength, increases in charging temperature were accompanied by marked and progressive improvement in the colour and lustre of the resultant cokes, which were also of rather smaller size consist.

The Australian Coals

As in the case of the American coals, charging temperature again assumed particular and critical significance in relation to coke shatter and tumbler stability indices, but serious and progressively increasing impairment of these factors did not occur until it exceeded 800°C. Unlike the Illinois seams, there was no serious and continuing decline in macro-strength of the coke produced, with charging temperatures immediately above the coal plastic range. However, the Liddell coal (Fig. 3) did exhibit a slight depression of all three macro-mechanical strength indices associated with a charging temperature of 500°C

which is slightly above the setting point. Progressive increases in charging temperatures to 800°C were accompanied by definite improvements in the macro- and micro-strength indices of the coke produced. Higher charging temperatures induced serious deterioration in macro-strength.

The Bulli coal (Fig. 5) returned a severely weakened coke when charging was carried out at temperatures of 200°C (very low macro-tumbler indices) and 400°C (depressed shatter and micro-mechanical strength); charging at increasing temperatures between 400° C and 800°C produced general and progressive improvements in the coke strength with well defined deterioration thereafter. Optimum micro-strength was obtained from coke produced by charging at air temperature. The plastic range of Bulli coal is approximately 390°C to 480°C.

The Borehole coal showed continuous and progressive improvement in all macro-strength indices of coke produced with increase of charging temperature up to 800°C (Fig. 4); thereafter shatter index declined abruptly, although tumbler stability did not deteriorate until the charging temperature exceeded 1000°C. Charging temperatures above 800°C were accompanied by accelerated improvement in coke micro-strength.

In each of these coals, the higher charging temperatures were accompanied by considerable improvement in both colour and lustre of the coke produced.

The Japanese Coals

For the three Japanese coals, variations in charging temperature produced three generally quite different trends in overall and particular variation of coke strength. The Akahira coal behaved in a manner broadly comparable with the Illinois coals Nos. 5 and 6; the Futase revealed trends rather similar to those of the Borehole coal of New South Wales; the Takashima coal could not be readily compared with any other coal as yet studied.

The Akahira was the only one of the eight coals discussed here which did not show an essentially parallel trend of shatter and stability indices throughout the greater part of the charging temperature range. The results of the macro-mechanical tests of the Akahira cokes suggest that a progressive increase in charging temperature to 1000°C brings about the formation of a joint or fracture system in the coke which is progressively more susceptible to rupture from impact but progressively less susceptible to abrasion. Micro-strength indices improved slightly and erratically with increased oven temperature at charging.

In the case of the Futase coal (Fig. 7) all macro-strength indices improved with increased charging temperature up to 600°C; thereafter the shatter index declined rapidly, followed by tumbler stability for temperatures exceeding 800°C. Micro-strength variation was erratic and not evidently significant.

The Takashima coal yielded a coke of superior macro-mechanical strength if charged to a cold oven. Progressive increases in the initial oven temperature to 800°C brought about a very substantial and progressive decline in these characteristics, after which there was a slight improvement. A somewhat erratic

but definite improvement in micromechanical strength is evident in response to increased charging temperatures.

Variations in the appearance and size characteristics ok Akahira and Futase cokes correspond closely with those of the American and Australian groups. The Takashima, however, showed no significant variation throughout the range in either friability or the fragmentary character of the coke yield; only lustre improved as higher charging temperatures were employed.

Summary and Conclusions

From this present brief review of as yet incomplete studies, it is evident that the program of temperature increase during carbonization has a profound and possibly particular effect upon the mechanical properties of the coke produced from any "coking" coal. Optimum qualities of macro- and micro-strength are seldom developed together under any single coking regime. Consequently, both coke producer and consumer must accept a compromise on quality characteristics, according to their particular requirements and the inherent limitations to controlled coking. On the other hand, it is evident that much may be achieved in the control of coke quality through careful selection and preparation of the raw coal.

For certain high volatile bituminous coals (e.g., Illinois Nos. 5 and 6, and Futase), charging to the oven at temperatures even modestly in excess of their plastic range may well induce serious deterioration in the macro-strength characteristics of the coke. Other bituminous coals may, with minor exceptions, yield substantially improved cokes when charged to an oven of which the temperature is 300 or 400°C higher than the plastic range (e.g., Liddell, Borehole and Bulli). Some coals may yield cokes which apparently deteriorate progressively in macro-strength characteristics with any increase of charging temperature above that of an air-cold oven.

No significantly progressive deterioration in coke micro-strength characteristics has been observed as accompanying increased oven temperature on charging. On the contrary, in the majority of cases, the strength of the coke substance appears to improve with increased initial oven temperatures, particularly in the higher ranges.

It is suggested that variations in coke character may be significantly influenced by rates of heating as related to the plastic range, plasticity characteristics, and gas evolution characteristics of the coal concerned; these in turn reflect the petrographic constitution, type distribution and rank of the seam. Further work is proceeding in this field of investigation.

References

(1) Marshall, C. E., Harrison, J. A., Simon, J. A., *and* Parker, M. A., 1958, Petrographic and Coking Characteristics of Coal: Laboratory studies of Illinois coal seams Nos. 5 and 6: Illinois State Geological Survey Bulletin 84.

(2) Tompkins, D. K., 1959, Preliminary Studies of the Coking Characteristics of Liddell Seam Coal. Institute of Fuel (Australian Membership) Symposium on Australian Fuels and their Utilization: Symposium Preprint.

(3) Branagan, D. F., 1959, Some Aspects of a Coking Study of the Borehole Seam. Institute of Fuel (Australian Membership) Symposium on Australian Fuels and their Utilization: Symposium Preprint.

Reprinted from Coal Age, December, 1961

DIRECT FIRING OF COAL SLURRY

ABSTRACT

Extensive test run at New Jersey power plant demonstrates feasibility of burning coal-pipeline product directly. Cyclone furnaces in regular service are fed with coal slurry at 70-30 solids-to-water ratio.

Call it a breakthrough, a milestone or whatever, the recent commercial-scale test on burning coal slurry at the Werner plant of Jersey Central Power & Light Co., South Amboy, N. J., is big news for coal. Two cyclone furnaces at the Werner plant burned nothing but pipeline slurry for a period of several weeks in late October and early November. There is some reduction in burning efficiency, as expected, but this is more than compensated by the overall economy that direct firing of slurry can provide.

The Objectives

One of the principal incentives in the test program was the desire for lower costs in transporting coal from the mines to East Coast power plants. The ultimate objective is a pipeline from the coal fields in northern West Virginia and western Pennsylvania to the New York-Philadelphia areas. In addition to lower transportation costs, direct firing of slurry eliminates much expensive coal-handling equipment. In a plant designed for the use of slurry, there would be no need for railroad sidings, barges, docks, coal towers, pulverizers, conveyors and the like.

The successful demonstration at the Werner plant is the culmination of joint research among Consolidation Coal Co., Babcock & Wilcox Co., Texas Eastern Transmission Corp. and Jersey Central Power & Light Co. The slurry burned at South Amboy actually passed through Consol's 108-mi pipeline from Cadiz, Ohio, to Cleveland. It was carried by barge from Lake Erie to Newark, N. J., via inland canals and the Hudson River, and stored in tanks at Pitt-Consol Chemical Corp. The slurry was transported in barges to the power plant and pumped into a 1,000,000-gal storage tank. It was pumped, as received, from the storage tank to a surge tank, thence directly to the burner nozzles in the cyclone furnaces.

The coal consumed in the test amounted to 10,000 tons of minus 8-mesh, prepared at Georgetown preparation plant of the Hanna Coal Co., a division of Consol. It was pumped through the pipeline to Cleveland at a concentration of

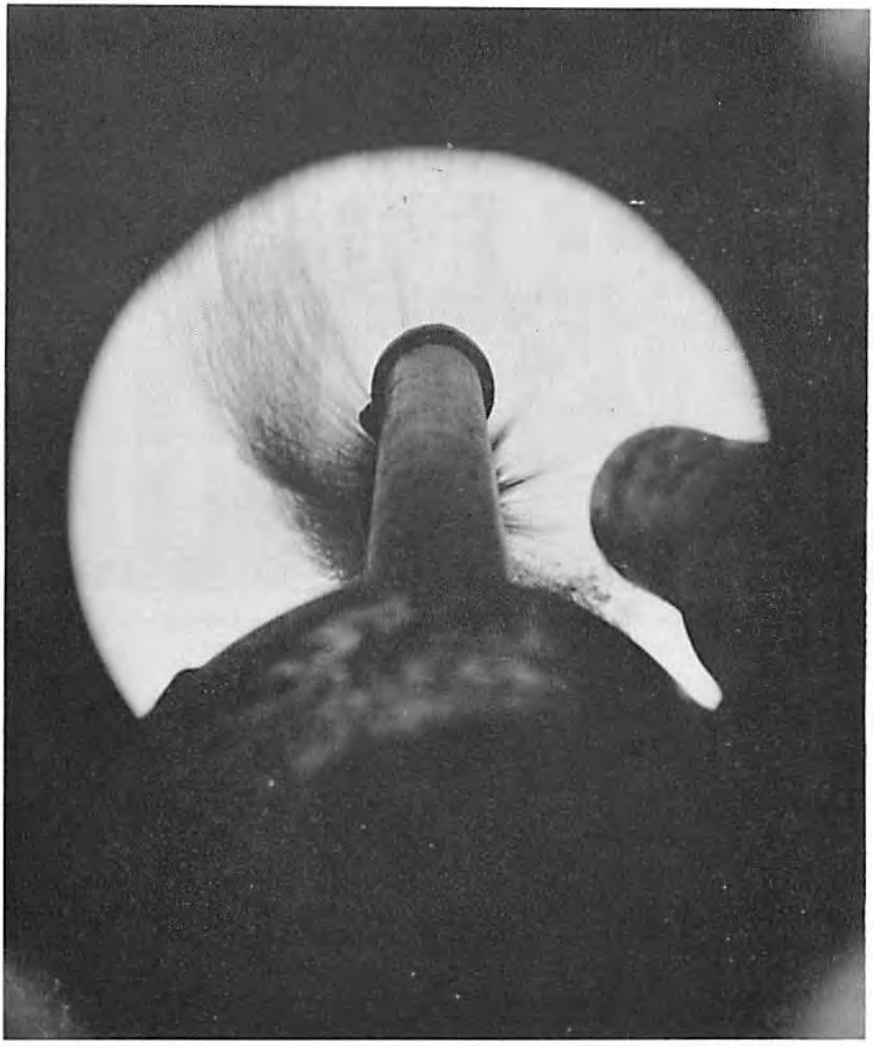


Fig. 1—This is coal slurry, containing 70% coal and 30% water, being introduced into the ignition zone of a cyclone furnace in on-line operation of a power plant at South Amboy, N. J. This may be the giant step leading to the construction of a coal pipeline to the East Coast from northern West Virginia and western Pennsylvania.

60% solids, by weight. Storage in Cleveland permitted decantation of some of the water, resulting in a slurry containing approximately 70% solids.

There has been no difficulty in maintaining the suspension since the slurry handles and stores much like oil. If settling is evident during a long period of storage, an air lance

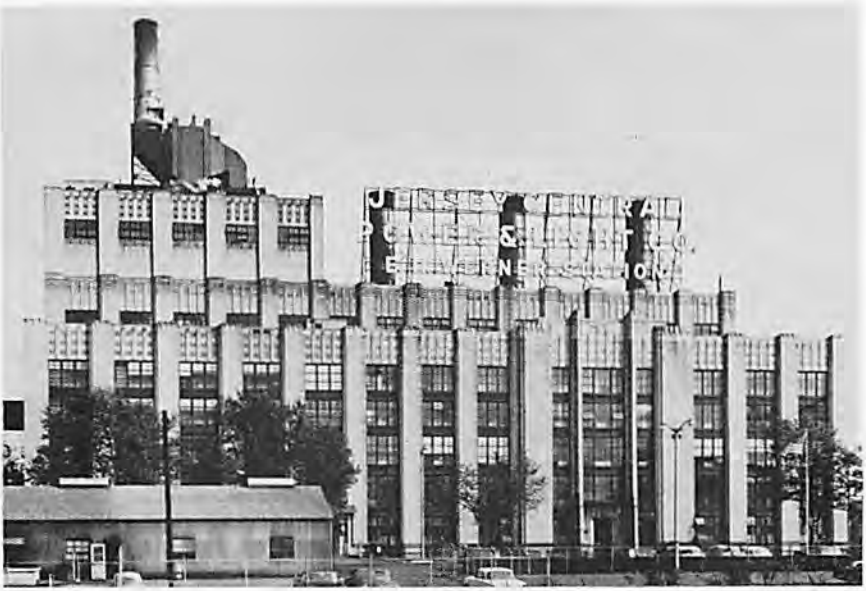


Fig. 2—The stack at the left in this view of the E. H. Werner Station discharges the products of combustion resulting from direct firing of coal slurry.

may be employed to reconstitute the mixture.

The Cyclone Furnace

The Babcock & Wilcox cyclone furnace firing coal slurry is the ultimate in simplicity and economy. It requires a minimum investment in equipment and a minimum of labor. The dry coal handling equipment, which is eliminated in the slurry-firing method represents from 5 to 7% of total investment, saving about $3,500,000 in a typical 500,000-Kw station.

As explained by Neil W. Eft, research engineer, Babcock & Wilcox, the slurry with no auxiliary fuel is introduced at low pressure (35 psi) into the front of the cyclone furnace through a simple pipe and spray nozzle. The fuel is distributed in the furnace in a hollow conical spray. Hot primary air at 700°F is introduced tangentially behind and around the coal nozzle. Spinning around the coal nozzle, the primary air vaporizes the water from the finer coal particles and accelerates them into a tangential path. Ignition of the finer particles takes place almost instantaneously.

Hot secondary air, five times the volume of the primary air, and spinning around the cyclone in the same direction, is introduced immediately after the ignition zone. Centrifugal force throws the coal particles to the outer wall of the furnace. Temperature in the furnace is 3,000°F —hot enough to liquefy the ash which then flows down the furnace walls into a slag pit. Studies show that an entering particle of coal is dried, burned and slagged in 1/100 sec. Water in the slurry goes up the

stack as vapor. There is less vapor than in a gas-fired boiler.

Although ignition of the coal-water mixture is more difficult and the maximum temperature reached is lower than with dry coal, these natural differences due to the character of the fuel are not overly detrimental to the combustion process. The B&W cyclone furnace is the only type of equipment available today to burn coal slurry directly.

Many generating stations are equipped with pulverized coal-fired boilers which cannot use coal slurry directly. Coal suitable for these stations should contain less than 20% moisture. This means that about 60% of the water in coal slurry must be removed before the coal can be pulverized and burned.

At the Alliance (Ohio) research center of B&W a cooperative program between Consol and B&W has already shown that the excess moisture in coal slurry can be removed in either a disc filter or a solid-bowl centrifuge. The reduction in moisture content not only increased the efficiency of the steam boiler but also permits the coal to be conveyed and pulverized using the equipment

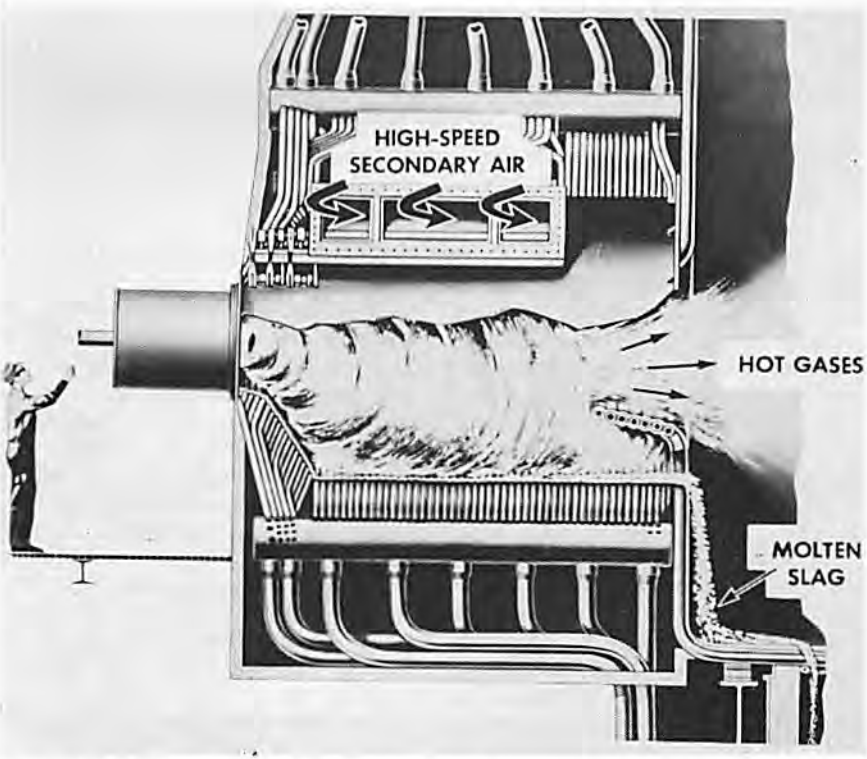


Fig. 3—Cyclone furnace is the ultimate in simplicity and economy. Slurry which requires minimum handling, is pumped directly into input line at left. Hot gases leaving the cyclone enter the boiler unit to generate steam.

Fig. 4—Source of the new fuel is the Georgetown preparation plant of Hanna Coal Co., near St. Clairsville, Ohio. Slurry for South Amboy test actually passed through Hanna's 108-mi pipeline to Cleveland.

currently available in many plants. The removal of this water does require additional capital investment.

However, an entire existing plant can easily convert to this new fuel and take advantage of the reduction in transportation costs. The effect of this on the nation's electric utility industry is of far-reaching economic significance.

Pipeline to the East

"Texas Eastern now considers its primary objective to be the pipeline transportation of energy in whatever form it is needed," declares T. W. Thagard, vice president, Texas Eastern Transmission Corp., in explaining that his company's interest in this project was stimulated by the fact that its operations had already been diversified to include handling energy in forms other than natural gas.

Two of the basic requirements for economic pipeline transportation are large reserves at the supply end and large volume requirements at the market end. Virtually unlimited coal reserves exist in many parts of the country, and certainly the electric generating stations have large volume requirements, not only today but expanding constantly with the increasing use of electricity. With these two essentials already in existence there is every reason to expect growth in coal pipelining.

Pipeline transportation provides unrivaled reliability. Furthermore, transportation rates on the movement of tonnages between points by all methods tend to become more

stable with increased competition. In the event of a national emergency, a high-capacity eastern coal-pipeline system already in operation would be of tremendous value to the security of the nation.

In pointing to the successful operation of the Cadiz-to-Cleveland pipeline, which to date has transported more than 5 million tons, Eric H. Reichl, director of research and development, Consolidation Coal Co., says continuing research has resulted in the ability to increase the percentage of solids in coal-pipeline streams from the original 50-50 to the present 60-40. Other advances in the art have been made that stabilize the slurry so that it handles much like fuel oil in conventional tankage and tank cars.

Joseph Pursglove, Jr., president, Pitt-Consol Chemical Co., foresees a pipeline to the East possibly as large as 30 in. in diameter.

With regard to the actual demonstration at the Werner plant, John E. Logan, vice president—operations, Jersey Central Power & Light, points out that in burning slurry the company expects to encounter some reduction in boiler efficiency, but that overall financial benefits can be realized from its use.

Fig. 5—Destination is the Werner plant to which the slurry was transshipped by barge. Pumps are lowered into barge to transfer slurry to 1,000,000-gal. oil storage tank for subsequent direct firing.

In making the plant available, Mr. Logan said, JCP&L acted in the interest of the entire utility industry. Electric companies the country over followed the test with great interest.

Reprinted from Mining Congress Journal, September, 1961

RECENT PROGRESS IN THERMAL DRYING ULTRA-FINE COAL

RAYMOND E. ZIMMERMAN
Vice President
Paul Weir Company
Chicago, Illinois

ABSTRACT

Over 150 tph of filter cake containing up to 30 percent surface moisture is being dried to 5 percent surface moisture at a coal preparation plant in Turkey. Heat consumption is 3,173,000 Btu per ton of water evaporated.

A great deal of information has already been published concerning the many devices used to dry coal with heat. Most of these dryers do a satisfactory job on particular size ranges of coal. The trend today appears to be in favor of the fluidized bed type for treating slack coal sizes, and, unquestionably, this type of dryer is doing an excellent job.

However, in addition to the requirements for drying slack sizes of coal, an increasing problem is presenting itself in this country in the need for drying ultra fine sizes—the minus 0.5-mm or 28-mesh range. This is a result of the rapid spread of froth filtration plants used to remove this material from cleaning plant slurry or recirculating water.

Either the economics of coal recovery or stream pollution laws, or a combination of both, has dictated the need to recover these fines. Whatever the reason, its recovery has intensified the problem of removing moisture from the recovered coal.

The best we can usually expect from either centrifuges or vacuum filters is to reduce the moisture of flotation coal down to 20-30 percent. Beyond that thermal drying is required—by no means an easy task. Handling 20 to 30 percent moisture ultra fines, usually in the form of filter cake, is difficult. Evaporating the large quantities of water involved and preventing high dust loss after it is dried are problems of the first magnitude.

There are a few dryers on the market today that can properly handle this difficult material. Perhaps one of the solutions is not to dry it in its present form, but to pelletize it first—pelletize and dry in one operation. Research is being conducted at the present time to develop a practical and economical way of doing this.

Another good way to handle froth

Fig. 1—The Zonguldak coal washing plant is in the heart of town, and efficient dust collection is essential. Primary and secondary dust collectors can be seen on the roof of the drying plant.

flotation concentrates, or ultra fines, is to concentrate it to pulp densities of from 60 to 65 percent solids and burn it directly in power plant boilers. Experimental work on this possibility is being carried on by one of the larger coal companies in this country in connection with long distance pipelining of coal.

However, as advantageous as these methods may be, the fact remains that in many situations it will still be desirable to thermally dry minus 0.5-mm filter cake.

Drying 150 tph of Filter Cake

This article describes a thermal dryer installation where this is being accomplished successfully. It involves drying the product from a froth flotation plant treating as much as 120 to 150 tph of minus 0.5-mm coal.

The drying is being accomplished in Buttner dryers, manufactured by Buttner-Werke AG., Germany. They were installed under the direction of the Paul Weir Co. at Zonguldak, Turkey, in connection with the operation of the washery at Zonguldak.

Zonguldak coals are extremely friable and, although of high volatile bituminous coal quality, are somewhat similar to Pocahontas coals in their friability. As a consequence, the washery itself, handling 800 tph (short tons) run-of-mine feed, was designed to handle as much as 65 to 70 percent minus ¼-in. Since the minus 0.5 mm, therefore, amounted to a very sub-

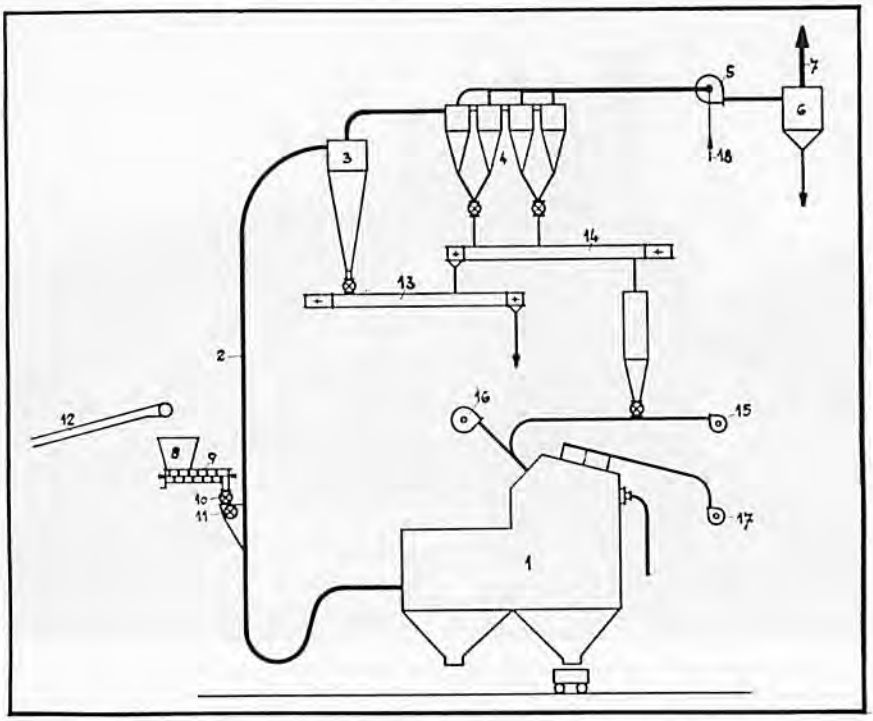


Fig. 2—Flow diagram of the heat drying circuit at the Zonguldak plant (see text for explanation).

stantial tonnage of raw coal, it was desirable and necessary to provide a froth flotation plant. Tonnage to this plant ran from 120 to 150 tph.

The flotation plant filter cake product contained from 20 to 30 percent surface moisture. The large percentage of the washery product represented by this high moisture product required that it be thermally dried, regardless of whether it was to be mixed with coarser sizes or shipped by itself.

This was accomplished in two parallel Buttner dryer systems of the Rema-Rosin type. This type of dryer is frequently called a "rapid recirculation" dryer and, in fact, is quite similar to what we in the United States call a "flash dryer."

Figure 1 is a general view of the washer. Primary and secondary dust collectors are on the roof of the drying plant. Since the plant is in the heart of the town of Zonguldak, it was essential that dust collection equipment be highly efficient.

Two Drying Circuits

There are two parallel heat drying circuits in the plant, as shown in figure 2. Each consists essentially of furnace (1), drying column (2), primary collectors (3), secondary collectors (4), exhaust fan and wet collector (5), entrainment trap (6), exhaust stack (7), wet coal feed hopper (8), paddle mixers (9), rotary air lock (10), rotary slinger (11), wet coal feed conveyor (12), dried coal

product conveyor (13), secondary dried coal (dust) conveyor (14), primary furnace air blower (15), secondary furnace blower (16), and tertiary furnace blower (17).

Details of the bottom of the drying column are shown in figure 3. The saxophone shape (a) takes the heated gases from the furnace outlet (b). These gases come from a furnace which burns dust from the secondary dust collectors. The furnace has a combustion section and an air tempering section where air is sucked in through louvres in automatically controlled proportions depending upon the temperature requirements. A refractory brick-constructed gate (c) permits the furnace to be sealed off during shutdown periods. The insulated 36-in. diameter stainless steel drying column (d) is approximately 50 ft high, and curves (e) into parallel primary cyclone collectors where the bulk of the product is collected. Electric heating elements (o) at this curved section prevent any possible build-up of damp coal.

Wet coal (filter cake) (f) is fed to the dryer column by a rotating slinger (g) which throws the coal into the column and gives a final chance to break up any lumps of cake still existing. A heating element (o) at this point prevents wet coal from sticking to the feed chute. A rotary air lock (h) prevents the escape of hot gases and excessive air leakage. A double paddle mixer (i) and a second paddle mixer (k) take wet coal feed from hopper (m). A dried product, to be mixed with the wet feed, can be fed through a section of pipe (l) if desired. This was seldom found to be necessary—generally only when filter cake moisture neared 30 percent.

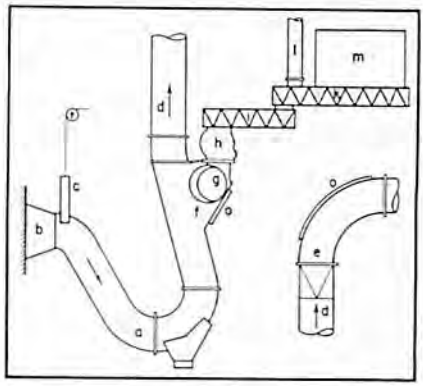


Fig. 3—Schematic view of the bottom of the drying column, including the feed arrangement.

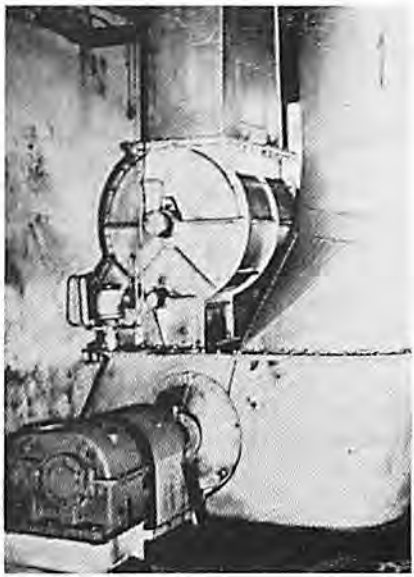


Fig. 4—Wet coal is fed through a rotary airlock (center) to a feed slinger (lower left) which passes it into the bottom of the drying column (right).

The rotary lock, slinger and section of the drying column are shown in figure 4.

TABLE I—GENERAL DATA

Location of dryer installation	Zonguldak, Turkey
Type of dryers	Two Buttner "Rema Rosin" Flash dryers
Kind of feed	Bituminous Coal Froth Flotation Filter Cake
Size of feed	28 mesh x 0
Feed moisture	25.2% (Surface)
Product moisture	5–6% (Surface)
Dry dust collectors	Two van Tongeren multiclones per dryer
Exhaust fan and wet scrubber	Eck, dual inlet, water injection type, capacity 33,000 cfm @ standard conditions.
Furnace	Refractory lined, air cooled, suspended arch, with a combustion chamber and an air mixing chamber, and automatic ash removal. Capacity, 62,000 Btu
Burner	Twin pulverizer fuel burners using dust product from multiclones. Fuel oil burner used for initial start up.

Table I summarizes general basic data concerning the Zonguldak dryer installation. Figure 5 is a schematic arrangement of the secondary dust collectors. They are multiclones of the van Tongeren design. They consist of two sets of four each of approximately five ft diameter cyclones. Intake gases and dust pass into a manifold (a) from the primary cyclone collectors. Dust drops (b) into hoppers (e) through rotary locks (g) and thence onto a conveyor (h) where fuel for the furnace passes into a hopper ( ). Any excess dust combines with the dried coal. Exhaust gases (c) pass through a collector duct (c) and thence down (k) into the exhaust fan. Special plates (d) will rupture in the event of an accidental explosion. There is very little chance of this taking place and, in the course of our operations it did not happen at any time.

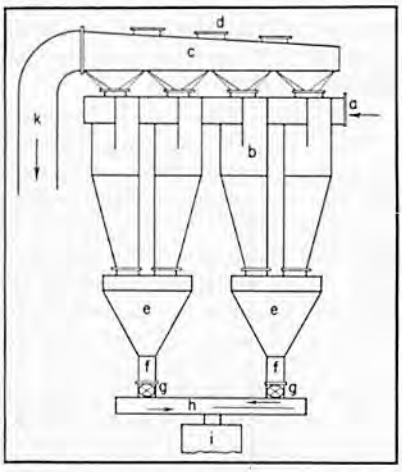


Fig. 5—Schematic arrangement of secondary dust collectors.

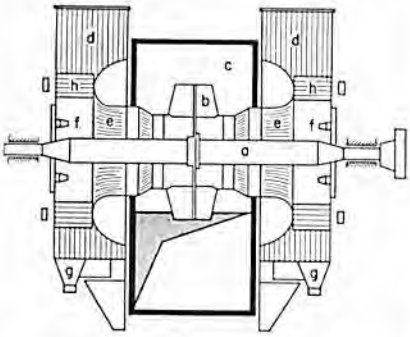


Fig. 6—Cross section of the combined exhaust fan and wet dust collector.

Fig. 7—One common stack serves both dryers.

Dust Collection

Figure 6 is a cross section of the combined exhaust fan and wet dust collector. The drive shaft (a) from a direct-connected motor operates impeller blades (b) of the Dr. Eck design. The blades are made of Thermax. The casing (c) is lined with acid-resistant tiles. There are two suction inlets (d), air inlets (e), water injection spray nozzles (f) and water and slurry outlets (g). Air volume is regulated by a spinning device (h) which can be adjusted by remote control from the plant control station. At 115°C, it was exhausting 82,500 cfm of gases and vapor and pulling 22 in. of water gauge.

Gases and vapor from this fan are discharged into an entrainment trap at the bottom of the exhaust stack. This and the stack is shown in figure 7, a photograph of one end of the heat drying plant. The entrainment trap is simply a cyclone in which the wet vapors, entering tangentially, cling to the sides of the cyclone and water containing slurry discharges at the bottom, the gases and purer water vapor dis-

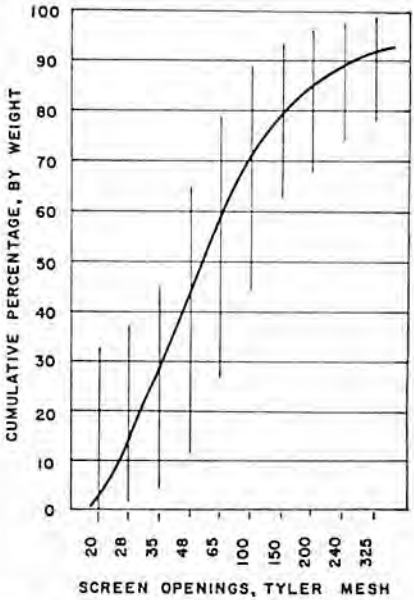


Fig. 8—Size distribution curve of feed to the dryers. Fifty six percent is minus mesh and 15 percent is minus 800 mesh.

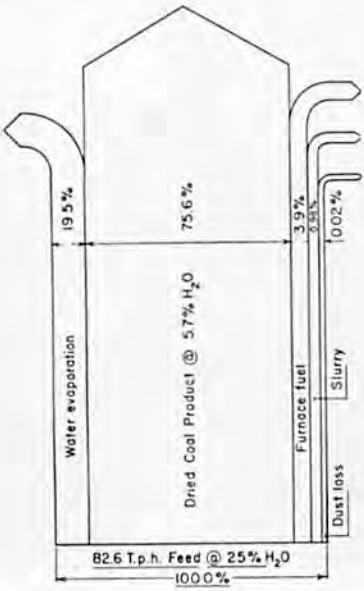


Fig. 9—Material balance chart.

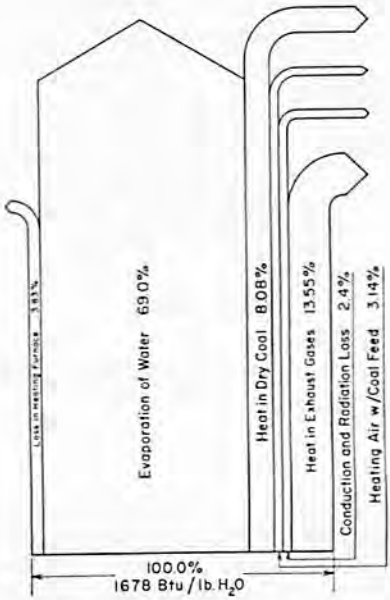


Fig. 10—Heat balance chart.

charging up the stack. One common stack serves both dryers.

Figure 8 is a curve showing the size distribution of the heat dryer feed, or the froth filtration plant product. It is practically all minus 20-mesh material, 56 percent under 48-mesh and 15 percent through 200 mesh. This is a typical analysis under normal conditions, although in actual practice the feed frequently varied in the direction of much greater percentages of minus 200 mesh.

Material and Heat Balance

Figure 9 is a material balance in diagrammatic form of the feed input distribution during the plant acceptance tests. Of 82.6 tph feed input at 25.2 percent surface moisture, the dried coal product at 5.7 percent moisture amounted to 75.6 percent of the feed. Nineteen and a half percent was evaporated as water vapor. The furnace consumed 3.9 percent, dust loss amounted to 0.02 percent, and slurry from the wet collector accounted for 0.98 percent of the feed.

The heat balance is shown in diagrammatic form in figure 10. Total heat consumption is 1678 Btu per lb of water evaporated, distributed as follows: 69 percent to evaporate the water; 8.08 percent to heat the coal, 13.55 percent is heat loss in the exhaust gases; conduction and radiation losses are 2.4 percent; 3.14 percent is used in heating the air coming in with the coal feed, and 3.83 percent is lost in heating the furnace.

A summary of pertinent data obtained during the plant's acceptance tests are shown in Table II. Here it

TABLE II—OPERATING RESULTS (PER DRYER)

1. Wet feed	82.6 Short tons/hr
2. Water content feed (Surface moisture)	25.2%
3. Water content product (Surface moisture)	5–6%
4. Dried product	66.5 Short tons/hr
5. Water evaporated	16.1 Short tons/hr
6. Heating gas temperature (inlet)	1027° F
7. Vapor temperature (dryer exit)	239° F
8. Dried coal temperature	149° F
9. Heat consumption (Btu/ton water evaporated)	3,173,000
10. Dust content exhaust gases	0.073 grains/cu ft
11. Drying column gas velocity (top of column)	60 ft/sec
12. Power consumption	395 kwh
13. Gases and vapor through exhaust @ 115° C	82,500 cfm
14. Wet scrubber (Slurry, dry basis)	860 lb/hr

is indicated that 3,173,000 Btu were required to evaporate a ton of water. The final dust loss up the stack amounted to only 0.073 grains per cu. ft. The wet scrubber slurry contained 860 lb. per hour of the feed (dry basis) which was sent back to the washery for recirculation. Power consumed was 395 kwh. Moisture in the dried coal product was 5-6 percent.

Actually it was entirely possible to produce a bone dry product, however it was determined that when the product moisture was reduced below five percent it became too dusty to handle at the loading point into bunkers or railroad cars. It is also believed that some hazard would result from possible spontaneous combustion if the moisture content was made less than five percent.

The above description of the Buttner dryer installation at Zonguldak attempts to describe the basic design of the plant, the processing involved and the results achieved. The plant did a remarkably good job on an extremely difficult feed and unquestionably proved to be a successful way of drying ultra fine coal.

Greater efficiency could be achieved in dust collection by more sophisticated equipment. Electrostatic precipitators are successfully being used in Europe in similar installations, but for the particular job at Zonguldak the equipment described was found satisfactory.

Reprinted from Mechanization, November, 1961

UNDERGROUND SPOTLIGHT . . . 1961

ABSTRACT

Highlights of the 1960 production year, with a record of steady advances in continuous mining, substantial gains in several states during the year, and some interesting exceptions to current trends—and a look at developments in underground mining in 1961, with an eye to the future.

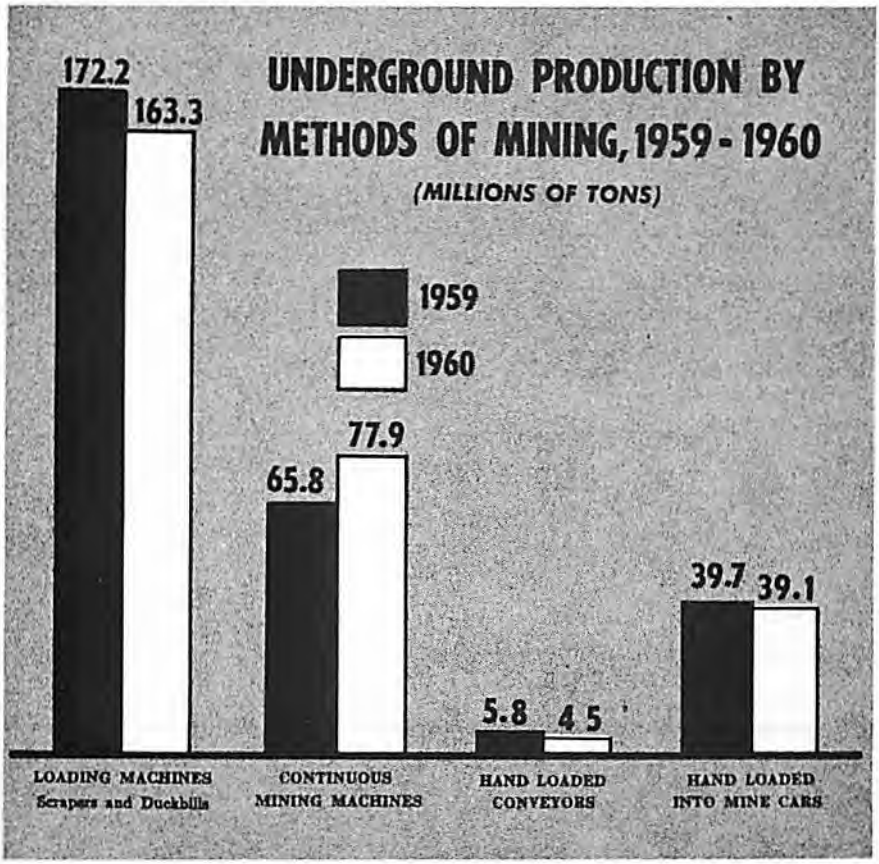
The small increase in bituminous coal production in 1960 was reflected in a gain of 1.5 million tons of underground output during the year. With total production at 415.5 million tons of bituminous coal and lignite for 1960, underground mining contributed 284.9 million tons toward that total. This was equal to 69 percent, the same as in 1959, and of this total, 86.7 percent was mechanically loaded—a new all-time record for the second straight year.

In terms of tons, production for the year from underground bituminous hand-loading operations was 39.1 million tons, 1.5 percent lower than in 1959; the total output mechanically loaded was 245.8 million tons, up to 0.9 percent over the previous year.

Again, productivity rose over the 10-tons-per-manshift mark, exceeded for the first time in 1959 for underground mines. In 1960, the productivity rate for underground mines was 10.64 tons per manshift, an increase of 5.6 percent.

Six states showed an underground productivity rate of better than 10 —Illinois, Indiana, West Virginia, Ohio, Utah, and Kentucky. Illinois again had the highest rate in the Nation, with an all-time record output of 17.3 tons per manshift, followed by Indiana with 11.96, West Virginia with 11.78, Ohio with 10.95, Utah with 10.71, and Kentucky with 10.61.

West Virginia was the National leader again in terms of underground tonnage of bituminous coal produced, mining a total of 109.2 million tons, just a shade under the 1959 output of 109.4 million tons by this method. Kentucky passed the state of Pennsylvania for the first time, producing 44.5 million tons to the Keystone State's 44.1 million tons. For Kentucky, this was an increase of 6.9 percent; for Pennsylvania it represented a slight decrease of 1.3 percent below the previous year. Greatest percentage gain, however, occurred in Alabama, where production of 10.4 million tons of bituminous coal repre-



sented a 13 percent rise over 1959 production.

A Look At 1961

To date, overall bituminous coal production in 1961 has gone about as predicted at the first of the year. The first two quarters were quite slow, reflecting the general state of the Nation's economy, and the question is whether the pick-up in the second two quarters will be enough to compensate for the lower production level of the first six months.

At the end of the first six months, production was down 13.4 percent below 1960; at the end of July, this had been cut to a 12 percent drop; at the end of August, the industry had a record showing only a 10.5 percent fall from the comparable 1960 period. By the end of September, it was down to 9 percent; and as October ended, the deficit was less than 8 percent. Projecting this upward climb to the end of 1961, it appears that the bituminous coal industry will just slip over the 400-million-ton mark again, with pretty good 1962 prospects for a rather

TABLE I—DATA ON MAJOR STATES PRODUCING COAL BY UNDERGROUND METHODS, 1960

State	Production Millions of Tons	Tons Per Manday	Avg. Value Per Ton-Dollars
Alabama	10.4	7.8	$7.61
Illinois	23.3	17.4	4.00
Indiana	4.8	12.0	4.29
Kentucky	44.5	10.6	4.69
Ohio	9.2	11.0	4.49
Pennsylvania	44.1	9.0	6.07
Tennessee	3.9	6.7	3.68
Utah	5.0	10.7	6.35
Virginia	25.8	9.4	4.50
W. Virginia	109.2	11.8	5.14

Source: Bureau of Mines, U.S. Department of the Interior

substantial gain—in the neighborhood of 20 million tons.

States which show an increase in bituminous coal production so far in 1961 over 1960 are Maryland, Montana, New Mexico, Tennessee, and Wyoming. Since these are all, for the most part low production states and all but two are primarily strip-mining areas, it appears likely that at the end of 1961, the industry will again see a gain in the percentage of total output mined by stripping, and a corresponding percentage decline in coal originated by underground mines. If this proves to be the fact, it would be well to remember that by far the major portion of the production still must be mined underground, and there is no likelihood of any change in the near, remote, or distant future.

Continuous Mining Still Climbing

As has been reported earlier, overall bituminous coal output in 1960 was only 0.8 percent over the previous year, and underground production was up 0.5 percent—but output by continuous mining machines showed an increase of *18.4 percent* in 1960 over 1959. Expressed in production tonnage, this increase was over 12 million tons. Final Bureau of Mines statistics for 1960 show that bituminous production by continuous miners reached 77.9 million tons, compared with 65.8 million tons in the previous year. In addition, the Bureau re-

TABLE II—TRENDS IN UNDERGROUND METHODS OF BITUMINOUS COAL AND LIGNITE PRODUCTION, 1958-1960

Underground Mines	Thousand Net Tons		
	1958	1959	1960*
Continuous mining only	12,151	16,287	21,000
Mixed (continuous and conventional mining)	109,577	108,973	106,000
Conventional mining only:			
With mechanical loading	124,105	119,879	119,000
With hand loading only	41,051	38,295	39,000
TOTAL UNDERGROUND	286,884	283,434	285,000

**Estimated.*

ports that during 1960, manufacturers of continuous mining machines sold 128 units, foreshadowing another increase when 1961 production figures are analyzed.

Gains were registered in output from continuous mining machines in all six leading states in terms of production of bituminous coal by this method. The leading state, West Virginia, showed a 21 percent increase in output in 1960, rising to 31.6 million tons by this method in 1960 and 26.0 million tons in 1959. The increase was almost as substantial in the second state, Pennsylvania, where total output from continuous mining machines in 1960 was 27 million tons and 1959 production was 22.7 million tons of bituminous coal, for an increase of 19.2 percent. Other leading states showed these increases in 1960 over 1959: Illinois, up 16.3 percent to almost 7 million tons; Kentucky, up 29.1 percent to 3.9 million tons; Ohio, up 6.1 percent to 3 million tons; and Utah, up 26.6 percent to 1.5 million tons. These six states accounted for 95 percent of all bituminous coal output from continuous mining machines. It is interesting to note, however, that in New Mexico, where continuous mining machines were not used until 1959, the end of 1960 found that 81.2 percent of all underground production was from continuous miners, and the percentage is sure to have grown during 1961, since this was one of the five states showing a production increase at the end of October, 1961.

All in all, production from continuous mining machines in 1960

accounted for 27.4 percent of all underground production, and 18.8 percent of production by all methods combined—both new records.

Conventional Mining Methods in 1960

Total mechanically loaded underground output, all methods, was primarily accomplished in nine states in 1960. These nine, West Virginia, Pennsylvania, Kentucky, Illinois, Virginia, Alabama, Ohio, Utah, and Indiana, contributed 239.7 million tons of the 245.8 million mechanically loaded in 1960, or 97.5 percent of the total. Gains were registered in Kentucky, Virginia, Alabama, Utah, and Indiana, with the largest percentage gain registered in Alabama—12.3 percent —and the largest tonnage increase made in Kentucky, with 1.5 million tons over the previous year.

Excluding continuous mining machines from underground mechanical loading, however, shows a different picture. Here, measuring output loaded by mobile loading machines, scrapers, and conveyors equipped with duckbills or other self-loading heads, there was a decline of 5.1 percent below 1959 production. Total 1960 production by these machines was 163.3 million tons, compared with 172 million in 1959. Kentucky, Alabama, Virginia, and Utah showed increases over the previous year, while the greatest decline came from Pennsylvania with a drop of 24.1 percent below 1959 output. Alabama showed the greatest gain, with 8.5 million tons loaded in 1960 and 6.9 million tons loaded by machines in 1959, for an increase of 22.6 percent.

Examining final statistics for output hand loaded in 1960, some increases were still made in spite of the general decline in favor of mechanization. Kentucky and Colorado gained considerably in output hand-loaded into conveyors, although their gains are only relative, since total output loaded by this method in the country in 1960 was only 4.5 million tons, and six states accounted for 84 percent of that total. Considerably larger in terms of tons is hand loading into mine cars, still a significant portion of underground production. In 1960, output by this method was just over 39 million tons, about the same as in the previous year. Kentucky, West

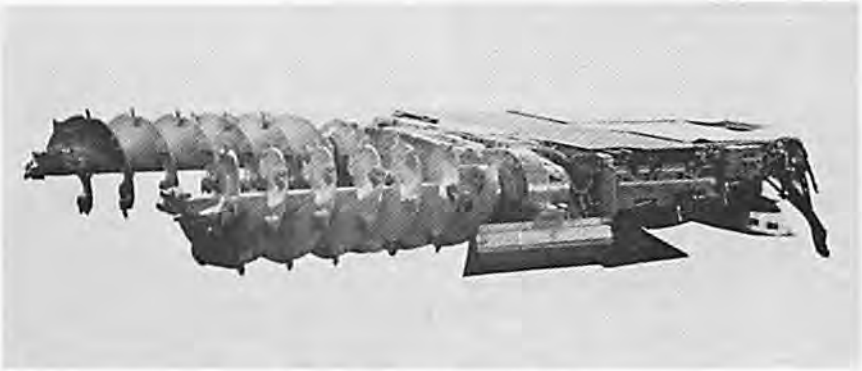


Fig. 1—Continuous mining machine.

Virginia, and Alabama showed increases over 1959 totals, with the biggest increase coming in Kentucky. Already the leading state in output by this method, in 1960 Kentucky production loaded by hand into mine cars was 11.9 million tons, up 13.9 percent over the 10.5 million tons loaded in 1959. In West Virginia, an 8-percent increase was registered, and Alabama had a 23.5-percent increase in output loaded into mine cars by hand.

Fig. 2—Shuttle car.

Equipment Developments In Underground Mining

Since 1961 was the year of another American Mining Congress "Coal Show," there was considerable activity among the manufacturers of underground mining equipment. Some of these activities are reflected in the summary of equipment displayed at Cleveland this year:

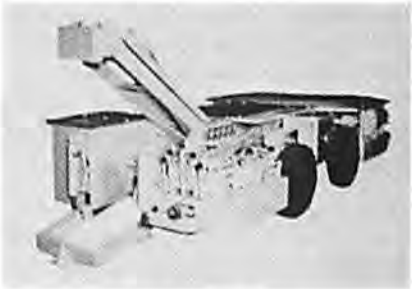


Fig. 3—Roof bolter.

Permissible Mine Tractor.—A 10,000-lb. permissible mine tractor was shown, on which all four wheels drive and carry an equal load, regardless of uneven ground, through use of a unique wheel suspension.

Fig. 4—Face drill.

Continuous Mining Machines.—Several continuous miners were displayed during the year, with improvements and innovations claimed for all. Particular emphasis was placed on machines for low-seam coal. One such machine, designed for use in coal from 36- to 54-inches thick, is only 30 inches high, and another is only 20 inches high.

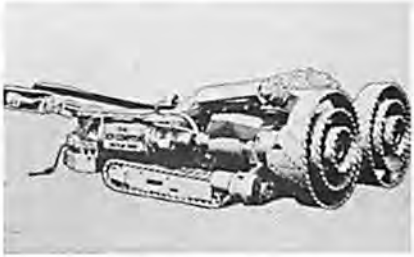


Fig. 5—Circular miner.

Bug Duster.—A bug duster, designed for use on cutting machines, was presented during the year and was said to contain many improvements. It is mechanically operated,

being driven from the main bevel gear, which in turn is powered by the main motor of the cutting machine. This relieves strain on the hydraulic system, and is said to provide greater reliability in conveying dust away from the cutting chain.

Coal Drilling Machine.—One machine can drill holes 11 feet deep in a height range from about 22 inches to 9 feet and horizontally 8 feet to each side of the machine's centerline; another utilizes a new type of drill head which is said to apply thrust within one foot of the face, with one man operating both drilling and shooting due to the speed of the drill.

Fire Fighting Machine.—Utilizing the foam-plug principle which has been developed in recent years, this portable system for controlling Class A and B mine fires produces a wall of moist, quenching foam through a roll of plastic tubing that can be unrolled up to distances of 250 feet.

Other Developments

Warning for Suspicious Roof Condition.—A process using sound waves to detect defects in roof and to give preventive warnings has been presented in a paper by two Bureau of Mines scientists. The process, similar to radar or sonar sounding devices, induces sound waves into the roof, and the waves are then reflected by inner nonconformities and inconsistencies of the roof structure.

Design and construction of a pilot portable transmitter is now underway, which can be used in gaseous or dusty mine atmospheres, with the results read and interpreted by regular mine personnel. According to the inventors of the device, its sound waves can pass easily through material as much as 5 feet thick.

Hydraulic Mining Developments.—The Department of the Interior has announced a joint venture of the Bureau of Mines and the Northern Pacific Railway Company to survey the possibilities of mining State of Washington bituminous coal by hydraulic methods. The large-scale research program will be carried out at Roslyn, Washington, at a mine owned by Northern Pacific. Bureau and railroad officials hope that hydraulic mining will prove to be the answer to the difficult problems of mining coal from the steeply pitching seams found in the Roslyn area.

Experimental work with hydraulic mining has also been done on a large scale at a drift mine owned by Rochester & Pittsburgh Coal Company under lease to the Bureau. Here, the coal is Pittsburgh seam bituminous, in a relatively flat seam about 65 inches thick, and overlain by about a foot of slate. Using maximum pressure of 4,000 psi and 300 gallons per minute, one test showed a production rate of about 12 tons mined in approximately 15 minutes.

Work is also being done in the anthracite fields of eastern Pennsylvania on hydraulic mining, but it is too early for an adequate analysis of test results.

Looking At 1962

Each year expert opinion writes that "tomorrow will be better," and frequently the same experts at the end of the year are busy explaining just what happened to cause their

predictions to go astray. Cyclical conditions, incipient recessions, altered consumer marketing patterns, Government controls, lack of Government controls—all are cited as explanation of "just what went wrong."

At this early date, it could be that 1962 will be the year to please all these experts. For it seems logical that the year just ahead will enjoy a continuation of the rise in the economic activity which started at midyear 1961. Most experts again are calling for a prosperous year for business and the country.

If they are right, it will be a good year for coal. And since underground mining accounts for over two of every three tons mined, that means a good year for the underground mines of the country. Conditions seem to favor this view.

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 Presi-

ident 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, with the executive board, 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, sign all orders for money, and shall purchase necessary supplies.

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 himself, and shall retain these orders as vouchers. He shall give bond in such sum as the Institute may provide, the premium on said bond being paid by the Institute.

He shall act as editor-in-chief for the Institute and may furnish the newspapers and other periodicals such accounts of our transactions and discussions as are proper to be published. His own judgment is to prevail in such matters unless objection is lodged at a regular meeting or by the executive board.

The retiring president shall act ex-officio in any capacity for the ensuing year.

Section 4. The president shall appoint an auditing committee annually to audit the accounts of the secretary-treasurer, and said audit shall be submitted to the November meeting of the Institute.

Section 5. The Executive Board shall perform the duties specifically prescribed by this constitution; it shall supervise the expenditures

and disbursements of all money of the Institute, and no expenditure other than current expenses shall be authorized without first having the approval of the Executive Committee; it shall act as program committee for each meeting to determine what is to be published in the proceedings and shall perform such other duties as may be referred to them by regular or special meeting of the Institute.

ARTICLE V.

Meetings.

Section 1. Regular meetings shall be held in June and November of each year and on such days and in such places as may be determined by the executive board of the Institute. Notice of all meetings shall be given at least thirty days in advance of such meetings.

Section 2. Meetings of the executive board shall be held on the call of the president, or at the request of three members of the executive board, the president shall call a meeting of the board.

ARTICLE VI.

Amendments.

Section 1. This Constitution may be altered or amended at any regularly called meeting by a majority vote of the members present, provided notice in writing has been given at a previous semi-annual meeting of said proposed change of amendment.

ARTICLE VII.

Order of Business.

At all meetings, the following shall be the order of business:

(1) Reading of minutes.
(2) Report of executive board.
(3) Report of officers.
(4) Report of committees.
(5) Election of new members.
(6) Unfinished business.
(7) New business.
(8) Election of officers.
(9) Program.
(10) Adjournment.

ILLINOIS MINING INSTITUTE

LIFE MEMBERS

ADAMS, R. L., Consultant.....Old Ben Coal Corp., 702 S. Russell, Marion, Ill.

BALDWIN, RICHARD, Pres.....
Midwest-Radiant Corp., 220 N. Fourth St., St. Louis 2, Mo.

BALL, CLAYTON G.....Paul Weir Company, 20 North Wacker Dr., Chicago 6, Ill.

BELL, J. H., Pres.....Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.

BOWMAN, F. T., Pres.....The Bowdil Co., Box 470, Canton, Ohio

BROADWAY, J. W.....Bell & Zoller Coal Co., 208 S. LaSalle St., Chicago, Ill.

BROWNING, J. ROY.....208 S. LaSalle St., Chicago 4, Ill.

BUCHANAN, D. W., Chrmn. of the Bd. .....
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago 6, Ill.

BUCHANAN, D. W., JR., Pres.....
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago 6, Ill.

BUTCHER, FRED E. .....505 Baum Bldg., Danville, Ill.

CAMPBELL, WM. C., Assistant to President.....
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago, Ill.

CARNEY, WILLIAM ROY.....33 S. Clark St., Chicago 3, Ill.

COLNON, STUART.....Bell & Zoller Coal Co., 208 S. La Salle St., Chicago 4, Ill.

CROWDER, GORDON G.....4545 Connecticut Ave., N.W., Washington 8, D.C.

CUNNINGHAM, M. F., Vice Pres.....
Goodman Mfg. Co., 4834 S. Halsted, Chicago, Ill.

EMMONS, W. STUART, Vice Pres.....
Hulburt Oil & Grease Co., Philadelphia 34, Pa.

FITZGERALD, P. H. ....Allen & Garcia Co., 816 Chappell Rd., Charleston 4, W. Va.

FLETCHER, ROBERT, Vice Pres. .....
J. H. Fletcher & Co., P. O. Box 353, Huntington, W. Va.

FLETCHER, WILLIAM.....
J. H. Fletcher & Co., P. O. Box 353, Huntington, W. Va.

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., Consulant.....1705 Morgan Ave. So., Minneapolis 5, Minn.

GIVEN, IVAN A., Editor.....Coal Age, 330 W. 42nd St., New York 18, N. Y.

GOSSARD, A. G., V. P. & G. M. .....
Snow Hill Coal Corp., Mchts. Nat. Bk. Bldg., Terre Haute, Ind.

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 Coal Co., Harrisburg, Ill.

HARRIS, ALLYN .....500 W. Union, Wheaton, Ill.

HARRIS, JOSEPH, Pres. .....
Russell Fork Coal Co., Inc., P.O. Box 174, Elkhorn City, Ky.

HAYDEN, CARL T., Vice Pres. .....
Sahara Coal Co., 59 E. Van Buren St., Chicago 5, Ill.

JENKINS, G. S., Pres. .....
Clarkson Div. Nat'l Mines Service, 2060 Railway Exch. Bldg., St. Louis 1, Mo.

JENKINS, WM. J., II.....Westinghouse Elec. Corp., Blairsville, Pa.

JOHNSTON, W. A., Pres. .....
Illinois Central System, 135 E. Eleventh Pl., Chicago 5, Ill.

KEELER, E. R. .....Rockford Lumber & Fuel Co., Rockford, Ill.

KOLBE, FRANK F., Pres.....
The United Electric Coal Co's., 307 N. Michigan Ave., Chicago 1, Ill.

LEACH, B. K., Pres.....Egyptian Tie & Timber Co., 1263 Purdue Ave., St. Louis, Mo.

LINDSAY, GEORGE C., Editorial Dir.....Rock Products, 79 W. Monroe, Chicago, Ill.

LIVINGSTON, H. C., Pres.....
Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 2, Ill.

McCOLLUM, H. C.....
Peabody Coal Co., Peabody Plaza, 301 Olive St., St. Louis 8, Mo.

McMASTER, D. H. .....Box 562, Madisonville, Ky.

MORROW, J. D. A., Board Chmn.....Joy Manufacturing Co., Franklin, Pa.

MURPHY, FRANCIS B.....1335 Chestnut Ave., Wilmette, Ill.

MURPHY, H. C., President.....
Burlington Lines, 547 W. Jackson Blvd., Chicago 6, Ill.

NUGENT, FRANK, Pres.....
Freeman Coal Mining Corp., 300 West Washington, Chicago 6, Ill.

PEABODY, STUYVESANT, JR. .....
Peabody Coal Co., 209 S. La Salle St., Chicago 4, Ill.

PLATTS, E. M.....2035 E. Montebello, Phoenix, Ariz.

POLING, GILBERT.....
Evansville Elec. & Mfg. Co., 600 W. Eichel Ave., Evansville, Ind.

RICHARDS, L. O.....Box 1334, Clearwater, Fla.

ROMAN, F. W.....4820 Remington Dr., Sarasota, Fla.

ROSING, BORGE, Mgr. Sales.....
West Va. Works, Connors Steel Div., Box 118, Huntington 6, W. Va.

RYAN, J. T., JR., Pres. .....
Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

SCHONTHAL, D. C. .....West Va. Steel & Mfg. Co., Huntington 6, W. Va.

SCHONTHAL, JOSEPH.....
J. Schonthal & Associates, Inc., 224 S. Michigan, Chicago 4, Ill.

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

SCHUBERT, R. R., V. P. and Gen. Mgr.
Greensburg Machine Co., Greensburg, Pa.

SCHULL, B. H., Director.....Dept. of Mines & Minerals, Springfield, Ill.

SEE, FRED O., Vice Pres., Mining Div.
Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.

STEVENS, E. F.
Binkley Mining Co., 4th Floor, 1006 Olive St., St. Louis, Mo.

STOVER, HOLLY, Exec. Asst. Pres.....C.B.&Q.R.R., 547 W. Jackson, Chicago 6, Ill.

SULLIVAN, J. L.....P. O. Box 62, Tappahannoc, Va.

TAYLOR, H. H.....2042 Stella St., Fort Myers, Fla.

TRUAX, A. H., Pres.....Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 1, Ill.

VON MEDING, WILLIAM, Pres.
Allen & Garcia Co., 332 S. Michigan Ave., Chicago 4, Ill.

VON PERBANDT, L. K.....7955 S. Albany, Chicago 29, Ill.

WALKER, HAROLD L., Dir. Research
University of New Mexico, 5101 Royene, N.E., Albuquerque, N. Mex.

WANNER, E. W.....Kenilworth Apartments, Philadelphia 44, Pa.

WARE, LOUIS, Pres.
International Minerals & Chem. Corp., 20 N. Wacker Dr., Chicago 6, Ill.

WEARLY, WM. L., Pres.
Joy Manufacturing Co., 333 Oliver Bldg., Pittsburgh 22, Pa.

WEIR, CHARLES R., Salesman
Johns-Mansville Sales Corp., Merchandise Mart Plaza, Chicago 54, Ill.

WEIR, J. P. .....Paul Weir Company, 20 N. Wacker Dr., Chicago 6, Ill.

WHITE, FRANK L.....Cadillac Motel, Daytona Beach, Fla.

WHITE, HUGH, Pres., Dist. 12
United Mine Workers of America, United Mine Workers Bldg., Springfield, Ill.

WOMMACK, A. J.
Bearings-Belting & Supplies Co., 3144 Olive St., St. Louis 3, Mo.

WOODS, HENRY C., Chmn. of the Board
Sahara Coal Co., 59 E. Van Buren St., Chicago 5, Ill.

HONORARY MEMBERS

BUCHANAN, D. W., Chairman of the Bd.
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago 6, Ill.

CADY, GILBERT H. .....504 W. Oregon St., Urbana, Ill.

PFAHLER, F. S.....Route 2, Bourbonnais, Ill.

WEIR, PAUL, Board Chairman
Paul Weir Company, 20 N. Wacker Dr., Chicago 6, Ill.

WILKEY, FRED S., Secy.
Illinois Coal Operators Assn., 307 N. Michigan Ave., Chicago 1, Ill.

Buyer meets Seller in the back of this book.

ILLINOIS MINING INSTITUTE

ACTIVE MEMBERS

ABERNATHY, NORMAN R., Ind. Sales Rep.....
Shell Oil Co., 114 N. Sterling Ave., West Peoria, Ill.

*ADAMS, R. L., Consultant.....Old Ben Coal Corp., 702 S. Russell, Marion, Ill.

ADAMS, WM. G.....Chicago Pneumatic Tool Co., P.O. Box 144, Peoria, Ill.

AHLEN, L. S.....Goodman Mfg. Co., 137 The Lane, Hinsdale, Ill.

AITKEN, W. I., Manufacturers Agent.....201 Archer Avenue, Peoria, Ill.

AITKEN, WM. P.....Dooley Bros., 1129 Bellaire Dr., Mt. Vernon, Ill.

ALLEN, GEORGE W., Mining Prod. Eng.....
Bolt & Nut Div., Republic Steel Corp., 1907 Carter Rd., Cleveland 13, Ohio

ANDERSON, ERNEST, Sales.....
Allegheny Ludlum Steel Corp., P.O. Box 57, Herrin, Ill.

ANDERSON, MAT .....
Bituminous Casualty Corp., 606 Grandview Dr., Edwardsville, Ill.

ANDERSON, W. H.....
Mechanization Magazine, 4311 Board of Trade Bldg., Chicago 4, Ill.

ARMITAGE, A. H., Gen. Mgr.....Dooley Bros., 1201 S. Washington St., Peoria, Ill.

AUSTIN, VAN E., Asst. Gen. Supt. .....
Freeman Coal Co., 825 N. 13th St., Herrin, Ill.

BAILIE, C. C., Asst. Chief Engr.....Old Ben Coal Corp., 305 W. Reed, Benton, Ill.

BALCAR, FRANK A., Owner.....B B R Drilling Co., St. Clairsville, Ohio

*BALDWIN, RICHARD, Pres.....
Midwest-Radiant Corp., 220 N. Fourth St., St. Louis 2, Mo.

*BALL, CLAYTON G. .....Paul Weir Company, 20 N. Wacker Dr., Chicago 6, Ill.

BARBER, MARTIN O., Prod. Engr.....
Bell and Zoller Coal Co., 713 Fifth West St., Johnson City, Ill.

BARCO, L. W., Supt.....United Electric Coal Co., Box 509, Canton, Ill.

BAREFOOT, C. S., Reg. Mgr.....
Gould National Batteries, Inc., 2311 Hampton Ave., St. Louis 10, Mo.

BARMINSKI, ROMIE, Safety Insp.....Old Ben Coal Co., 206 College St., Benton, Ill.

BARNES, F. A., Industrial Lubrication Engineer.....
Standard Oil Co., 1524 W. Wood St., Decatur, Ill.

BASELEY, DEAN W., Industrial Engr.....Old Ben Coal Corp., Box 37, Sesser, Ill.

BASTIAN, HUGH, Asst. Mgr. .....
Vascoloy-Ramet Corp., 800 S. Market St., Waukegan, Ill.

BAYER, JAMES L., Res. Engr., Coal Petrographer.....
The Youngstown Sheet and Tube Co., Youngstown 1, Ohio

BECK, CLARENCE V., Pres. .....
Clarence V. Beck & Co., Inc., 1103 Fullerton Bldg., St. Louis 1, Mo.

BECK, CLARENCE V., JR., Mng. Engr. .....
Little Dog Coal Co., 1103 Fullerton Bldg., St Louis 1, Mo.

BECKER, J. C.....
Hewitt-Robins, Inc., Robins Conveyors Div., 17th & Bloomingdale, Melrose Park, Ill.

BEDA, PAUL W.....1807 Glenview Rd., Glenview, Ill.

*BELL, J. H., Pres.....Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.

BENOWICZ, CASMER A., Vice Pres. .....
Zeigler Coal & Coke Co., 231 S. La Salle St., Chicago 4, Ill.

BENSON, FRED O., Field Engr. .....
Flexible Steel Lacing Co., 4607 Lexington St., Chicago 44, Ill.

BERRY, LES, Pres.....Berry Bearing Co., Michigan Ave. at 26th St., Chicago 16, Ill.

BERRY, WILLIAM F., Proj. Scientist.....
Bituminous Coal Research, Inc., 350 Hochberg Rd., Monroeville, Pa.

BIGLEY, P. W.....C.M.I., 146 President St., St. Louis 18, Mo.

BILDERBACK, JAMES E.....C. M. I., 146 President St., St. Louis 18, Mo.

BIPPEN, BUD, Sales Engr. .....
United States Rubber Co., 1513 Grant Road, Webster Groves, Mo.

BIXBY, K. R., Gen'l Mgr.....Bixby-Zimmer Engineering Co., Galesburg, Ill.

BLAKE, CHARLES W., Sales & Engr.....
Hulburt Oil & Grease Co., Box 59, West Frankfort, Ill.

BLAKENEY, CHARLES, State Mine Insp.....
Dept. Mines and Minerals, RR 4, Danville, Ill.

BLANKINSHIP, G. F., Sales Engr.....Egyptian Sales Agency, Murphysboro, Ill.

BLYTHE, P. M., Sales Repr.....
Raybestos-Manhattan, Inc., 6010 Northwest Highway, Chicago 31, Ill.

BOIKE, E. J., Engr.....
Cincinnati Mine Machinery Co., 2980 Spring Grove Ave., Cincinnati 25, Ohio

BOLT, WILLIAM W.....Ill. Div. Highways, P. O. Box 356, Pawnee, Ill.

BOOK, C. L., Dist. Mgr.....W. M. Hales Co., 501 N. Douglas St., West Frankfort, Ill.

BORGOGNONI, JAMES G., First Aid....Peabody Coal Co., P.O. Box 128, Bulpitt, Ill.

BOTTOMLEY, E. J. .....Centralia Petroleum Co., Booneville, Ind.

BOTTOMLEY, J. A., Supt. .....Mine No. 6, Sahara Coal Co., Harrisburg, Ill.

BOULTER, GEORGE W., Asst. Mgr. Mining Div.....
Marion Power Shovel Co., 617 W. Center St., Marion, Ohio

BOWERS, GEORGE F., Mgr. Nat. Accts.....
Standard Oil Co., 910 S. Michigan Ave., Chicago 5, Ill.

BOWLIN, CARL, Supt.....Truax-Traer Coal Co., 115 Middle Park Dr., Canton, Ill.

*BOWMAN, F. T., Pres.....The Bowdil Co., Box 470, Canton, Ohio

BOYD, Charles, Mine Supt.....Sahara Coal Co., 209 W. College St., Harrisburg, Ill.

BOYETT, KENNETH, Supt.....Ayrshire Collieries, R.R. 1, Harrisburg, Ill.

BRADY, EARL.....Long-Airdox Corp., Morrisonville, Ill.

BREIDENBACH, GEORGE C., V. P. Charge of Sales.....
T. J. Gundlach Machine Co., 1 Freedom Dr., Belleville, Ill.

BRENTZ, H. W., JR., Sales & Serv. Engr.....
Kensington Steel, 298 N. First, Farmington, Ill.

*BROADWAY, J. W.....Bell & Zoller Coal Co., 208 S. LaSalle St., Chicago, Ill.

BRODERICK, JOHN K., JR.....
Broderick & Bascom Rope Co., 4203 N. Union, St. Louis 15, Mo.

BROWN, CHARLIE L., Salesman.....American Oil Co., 131 Bond St., Morton, Ill.

BROWN, HAROLD C.....
Peabody Coal Co., 1301 Purdue Ave., University City 14, Mo.

*BROWNING, J. ROY.....208 S. LaSalle St., Chicago 4, Ill.

BRUZEWSKI, R. F., Assoc. Prof.....Missouri School of Mines, Rolla, Mo.

BUCELLUNI, GUIDO, Operating Dept.....
Manson Mach. Co., 319 N. Simpson, Taylorville, Ill.

*†BUCHANAN, D. W., Chmn. of the Bd.....
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago 6, Ill.

*BUCHANAN, D. W., JR., Pres.....
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago 6, Ill.

BUCHANAN, DON P., Mgr. Ind. Sales.....
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago 6, Ill.

BUEL, R. W., Sales Engr.....American Oil Co., 910 S. Michigan Ave., Chicago, Ill.

BUENAGA, HENRY F.....U. S. Rubber Co., 4819 Knoxville Ave., Peoria, Ill.

BUNISH, STEVE, Mining Cable Engr. .....
Anaconda Wire & Cable Co., 1411 Wabash, Marion, Ind.

BURKHALTER, DALE H., Prep. Mgr.....
United Elec. Coal Co., 928 S. 2nd, Canton, Ill.

BURKLOW, CLIFFORD, Storekeeper.....Sahara Coal Co., Inc., Harrisburg, Ill.

*BUTCHER, FRED E.....505 Baum Bldg., Danville, Ill.

BUTTS, W. D., Pur. Agent .....
Material Service Corp. and Freeman Coal Co., 4226 S. Lawndale, Lyons, Ill.

BYRON, DON E., Sales Repr.....
The W. S. Tyler Co., 200 S. Michigan Ave., Chicago 4, Ill.

BUYS, V. W., Dist. Mgr.....
Mine Safety Appliances Co., 1915 Washington Ave., St. Louis 3, Mo.

CADY, GEORGE HILL, Cust. Serv. Mgr.....
Columbus McKinnon Corp., Fremont St., Tonawanda, N. Y.

†CADY, GILBERT H. .....504 W. Oregon St., Urbana, Ill.

CAMERON, CAMPBELL R., Gen. Supt.
Lone Star Steel Co., Box 690, McAlester, Okla.

CAMPBELL, DON C., Sales
Gooding Rubber Co., 806 E. 31st St., La Grange Park, Ill.

*CAMPBELL, WM. C., Assistant to President
Old Ben Coal Corp., 360 W. Jackson Blvd., Chicago, Ill.

CARNEGIE, WM. G., Asst. Chief Engr.
Roberts & Schaefer Co., 201 N. Wells St., Chicago 6, Ill.

*CARNEY, WILLIAM ROY.....33 S. Clark St., Chicago 3, Ill.

CARSON, W. H., Asst. Sales Mgr.
Goodman Mfg. Co., 4834 S. Halsted St., Chicago 9, Ill.

CHAPMAN, GEORGE H., Proj. Engr.
Paul Weir Co., 20 N. Wacker Dr., Chicago 6, Ill.

CLARK, GEORGE B., Chmn.
Dept. of Min. Eng., Missouri School of Mines, Rolla, Mo.

CLARK, HOWARD M., Supt.....Truax-Traer Coal Co., DuQuoin, Ill.

CLAYTON, R. R.....Hercules Powder Co., 332 S. Michigan Ave., Chicago 4, Ill.

CLEGG, KENNETH E., Asst. Geologist
Ill. Geological Survey, Natural Resources Bldg., Urbana, Ill.

COCHRAN, R. B.....Blue Bird Coal Co., Harrisburg, Ill.

COLESWORTHY, CHARLES S., Dist. Mgr.
Automotive Tire Sales, U.S. Rubber Co., 305 S. Broadway, St. Louis, Mo.

*COLNON, STUART.....Bell & Zoller Coal Co., 208 S. La Salle St., Chicago 4, Ill.

CONRAD, H. A., Outside Supt. .....Enoco Collieries, Inc., Bruceville, Ind.

CONWAY, C. C., Asst. to Pres.....National Mines Service, Nashville, Ill.

COOMBES, D. R., Pres.
Mechanization, Inc., 1120 Munsey Bldg., Washington 4, D. C.

COOMBES, RAYMOND, Exec. Vice Pres.
Mechanization, Inc., 1120 Munsey Bldg., Washington 4, D. C

CRAGGS, JOE.....Peabody Coal Co., Taylorville, Ill.

*CROWDER, GORDON G.....4545 Connecticut Ave., N.W., Washington 8, D.C.

*CUNNINGHAM, M. F., Vice Pres.
Goodman Mfg. Co., 4834 S. Halsted, Chicago, Ill.

CURL, JOHN R., Industrial Engr.
Central Ill. Public Service Co., 104 E. 3rd St., Beardstown, Ill.

CURRY, B. L., Safety Engr.
Lone Star Steel Co., 1501 E. Comanche, McAlester, Okla.

DALLAS, CLYDE, Supt.....Fairview Collieries Corp., 360 Sycamore Ter., Canton, Ill.

DANKO, JOHN, Chief Elect.....Peabody Coal Co., 417 Taft Ave., Taylorville, Ill.

DAUB, CHARLES L., Lubr. Engr.
Standard Oil Co., 20 N. Wacker Dr., Chicago 80, Ill.

DAVIS, HAROLD, Managing Ed.....
Coal Age Magazine, 330 W. 42nd St., New York 36, N. Y.

DAVIS, JAMES C., Pur. Dept. .....
Bell & Zoller Coal Co., P.O. Box 97, Johnston City, Ill.

DAVIS, NELSON L.....Nelson L. Davis Co., 517 Main St., McHenry, Ill.

DAVIS, T. E.....The Jeffrey Mfg. Co., 1066 Diamond St., Evansville 11, Ind.

DAVISON, ROBERT H., Salesman.....
W. M. Hales Company, P.O. Box 91, Madisonville, Ky.

DAWSON, HUGH, Sales .....Bethlehem Steel Co., 500 W. Monroe, Herrin, Ill.

DILLINGHAM, HERVIE, Ind'l Sales.....
American Oil Co., 1108 E. Lindell, West Frankfort, Ill.

DINN, TOM., JR.....Dinn Oil Co., 502 E. Oak St., West Frankfort, Ill.

DOERNER, NORMAN P., Sales Rep.....Sligo, Inc., P.O. Box 171, St. Louis 66, Mo.

DONALDSON, ROBERT F., Supt.....United Electric Coal Co., Glasford, Ill.

DONIE, CARL, Supt.....Fairview Collieries Corp., 359 E. Vincennes St., Linton, Ind.

DONNER, ROBERT L., Salesman.....
John A. Roebling's Sons Div., 632 S. Englewood Ave., Evansville 14, Ind.

DONOVAN, JOHN P.....
Power Transmission Equipment Co., 1245 W. Fulton St., Chicago, Ill.

DOOLEY, E. F.....Dooley Bros., 1201 S. Washington, Peoria, Ill.

DOOLEY, R. A., Pres.....Dooley Bros., 1201 S. Washington St., Peoria, Ill.

DRYDEN, JOSEPH L., Chief Engr.....
Bixby-Zimmer Engr. Co., 961 Abingdon St., Galesburg, Ill.

DUANE, JIM, Sales Mgr.....Pollock Bros., 7 N. Jackson St., Harrisburg, Ill.

EADIE, GEORGE R.....308 Ceramics Bldg., Urbana, Ill.

EASH, C. D., Field Engr.....Anaconda Wire & Cable Co., Marion, Inr.

EDDY, BRYAN, Owner.....Eddy Coal Co., Cantrall, Ill.

EDGAR, R. L., Sales Mgr. ..... c/o Watt Car & Wheel Co., Barnesville, Ohio

EMLING, DALE H., Engr.....
United Electric Coal Companies, 307 N. Michigan Ave., Chicago, Ill.

*EMMONS, W. STUART, Vice Pres. .....
Hulburt Oil & Grease Co., Philadelphia 34, Pa.

ENDICOTT, W. A.....Fairview Collieries Corp., Big Four Bldg., Indianapolis, Ind.

FAERBER, G. A., Dist. Sales Mgr.....
American Chain & Cable Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

FARRIS, WM. DALE, Research Assoc.....Ill. State Geological Survey, Urbana, Ill.

FAVA, JOHN, County Mine Inspector.....
Vermilion Cty., 1313 English St., Westville, Ill.

FERGUSON, CHARLES R., Director .....
United Mine Workers of America, 1435 K St., N.W., Washington 5, D. C.

FERGUSON, W. T. .....Goodman Mfg. Co., 4834 S. Halsted St., Chicago 9, Ill.

FIEDLER, RAY L., Purch. Agt. & Traffic Mgr.....
Sahara Coal Co., Inc., 59 E. Van Buren St., Chicago 5, Ill.

FIEHLER, RAYMOND H., Field Repr.....
Central Mine Equipment Co., 6200 N. Broadway, St. Louis 15, Mo.

FINAZZO, LAWRENCE.....Industrial Lumber, P.O. Box 145, West Frankfort, Ill.

FITZGERALD, JOHN E., Sales.....
Dodge Chicago Ind. Equip. Co., 330 E. 24th St., Chicago 16, Ill.

*FITZGERALD, P. H. ....Allen & Garcia Co., 816 Chappell Rd., Charleston 4, W. Va.

*FLETCHER, ROBERT, Vice Pres. .....
J. H. Fletcher & Co., P.O. Box 353, Huntington 1, W. Va.

*FLETCHER, WILLIAM .....
J. H. Fletcher & Co., 709 W. Seventh St., Huntington, W. Va.

FLOTA, DAVID, Elec. Engr.....Sahara Coal Co., 412 N. Granger, Harrisburg, Ill.

FOLLY, C. L., Ind. Engr.....Central Ill. Public Service Co., Mattoon, Ill.

FORBES, CHARLES J. .....Frank Prox Co., 1201 S. First St., Terre Haute, Ind.

FORMAN, J. S.....Mt. Olive & Staunton Coal Co., 1776 Arcade Bldg., St. Louis, Mo.

FORRESTER, E. W.....
Duquesne Mine Supply Co., Inc., 757 E. Columbia St., Evansville 11, Ind.

FORSYTH, JAMES G., Pres.....
Forsyth-Carterville Coal Co., 20 S. Central, Clayton 5, Mo.

FOSTER, I. O., Dist. Mgr.....
Commercial Testing & Engr. Co., 228 N. LaSalle St., Chicago 1, Ill.

FOX, JAMES M., Engr.....Freeman Coal Mining Corp., West Frankfort, Ill.

FRALA, JAMES D., Sales Repr.....
American Chain & Cable Co., Inc., Box 436, Salem, Ill.

FREEBOURN, N. E., Prod. Engr.....
Broderick & Bascom Rope Co., 14844 Phelps Dr., Bridgeton, Mo.

FRYE, JOHN C., Chief.....
State Geological Survey, 121 Natural Resources Bldg., Urbana, Ill.

FUCHS, A. J., Coml Mgr. .....Standard Oil Co., 8400 Maryland Ave., St. Louis, Mo.

*FULFORD, J. H., Pres.....The Jeffrey Mfg. Co., Columbus 16, Ohio

GABER, ANDREW J.....United Electric Coal Co., 64 S. First St., Canton, Ill.

GALLAGHER, JOHN B., Gen. Mgr.....Antipol Corp., 407 Hill Arcade, Galesburg, Ill.

GAMMETER, E. .....Paul Weir Co., 20 N. Wacker Dr., Chicago 6, Ill.

*GARCIA, JOHN A.....Allen & Garcia Co., 332 S. Michigan Ave., Chicago 4, Ill.

GARDINA, JACK, Branch Mgr.....
Cummins Peoria, Inc., 1800 S.W. Washington St., Peoria 2, Ill.

GARWOOD, THOMAS L. ....Freeman Coal Co., P.O. Box 120, West Frankfort, Ill.

GAVENDA, B.....Gavenda Bros., 352 S. Second St., Canton, Ill.

GERLER, WARREN C. .....Link-Belt Co., 300 W. Pershing Rd., Chicago 9, Ill.

*GEROW, T. G., Consultant.....1705 Morgan Ave. So., Minneapolis 5, Minn.

GHARST, C. F., Mgr.....C. F. Gharst Supply Co., P. O. Box 62, Terre Haute, Ind.

GILES, WM. S., Pres. .....
Giles Armature & Electric Works, Inc., 703 W. Stockton, Marion, Ill.

GILMARTIN, LEO, Supt.....
Peabody Coal Co., Mine No. 10, 700 W. Adams St., Taylorville, Ill.

*GIVEN, IVAN A., Editor.....Coal Age, 330 W. 42nd St., New York 36, N. Y.

GLENN, R. A., Mgr., Chem. Div.....
Bituminous Coal Research, Inc., 350 Hochberg Road, Monroeville, Pa.

GOLDMAN, TOM, Supt. .....Sahara Coal Co., 813 Madison, Eldorado, Ill.

GOODING, ROBERT E, Pres. .....
Gooding Rubber Co., 806 E. 31st St., La Grange Park, Ill.

GOODWIN, C. L., Foreman.....Sahara Coal Co., Harrisburg, Ill.

*GOSSARD, A. G., V. P. & G. M. .....
Snow Hill Coal Corp., Merchants Nat. Bank Bldg., Terre Haute, Ind.

GOTHARD, STERLING, Salesman.....
J. Schonthal & Assoc., 604 S. 18th St., Herrin, Ill.

*GRADY, EDWARD L., President.....
E. L. Grady Coals, Inc., 307 N. Michigan Ave., Chicago 1, Ill.

GRAF, JOSEPH W., Domestic Sales Mgr.....
Athey Products Corp., 5631 W. 65th St., Chicago 38, Ill.

GRAHAM, JAMES A., Mgr. Mining Tool Sales.....
Allegheny Ludlum Steel Corp., 1500 Jarvis Ave., Ferndale, Detroit, Mich.

GRAHAM, K. W.....Freeman Coal Mng. Corp., Box 187, Farmersville, Ill.

GRASSINGER, JOE, Salesman.....Giles Armature & Electric Works, Marion, Ill.

GRAY, RALPH J., Senior Technologist.....
U. S. Steel Corp., Applied Research Lab., Monroeville, Pa.

GREEN, E. E., Supt.....Zeigler Coal & Coke Co., 712 S. Thomas St., Christopher, Ill.

*GREEN, J. G.....Hooper-Green Co., 407 S. Dearborn St., Chicago 5, Ill.

GREER, R. D.....The Jeffrey Manufacturing Co., Columbus 16, Ohio

GREZLAK, ED.....207 S. Main St., Zeigler, Ill.

GRIDER, LAWRENCE, Supply Clerk.....
Peabody Coal Co., 513 Williams St., Springfield, Ill.

GRIESEDIECK, HENRY, Gen. Mgr.....
American Pulverizer Co., 1249 Macklind Ave., St. Louis 10, Mo.

GRIFFIN, DONALD N., Vice Pres.....
The Deister Concentrator Co., P. O. Box 28, Fort Wayne 1, Ind.

GRIGGS, E. C., Dist. Mgr.....
Nortons-Tividale, Ltd., 307 N. Michigan Ave., Chicago 1, Ill.

GRONBECK, M. P., Dir. of Safety.....
Wisconsin State College & Inst. of Technology, Platteville, Wis.

GROSSE, ROBERT A., Sales Engr.....Hewitt Robins, 4030 Chouteau, St. Louis, Mo.

GRUBB, HERBERT E., JR., Sales Rep.
Hulburt Oil & Grease, 1221 Poole St., Springfield, Ill.

GUINEY, GEORGE, Inspector at Large.....State of Illinois, Sesser, Ill.

GUINEY, JAMES G., State Mine Insp.
Dept. Mines & Minerals, 1112 Broadway, Lincoln, Ill.

GUTHRIE, ROBERT W., Ind. Sales Repr.
Socony Mobil Oil Co., 600 N. Maple St., Benton, Ill.

HAIR, R. T., Vice Pres. Tech. Serv.
Coal Machinery Div., Joy Mfg. Co., 333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.

*HALBERSLEBEN, PAUL, G. S. .....Sahara Coal Co., Harrisburg, Ill.

HALES, HERBERT F., Exec. Vice Pres.
W. M. Hales Co., P.O. Box 65, Danville, Ill.

HALES, W. M., Pres. .....W. M. Hales Co., 605 W. 116th St., Chicago 28, Ill.

HARDY, JOHN W., Asst. Comm'r.
Illinois Coal Operators Assn., 1220 West Main St., Taylorville, Illinois

HARNEY, A. A., Asst. Sales Mgr. .....Mississippi Lime Co., 7 Alby St., Alton, Ill.

HARRELL, M. V., Engr.....Truax-Traer Coal Co., RFD 2, Du Quoin, Ill.

*HARRIS, ALLYN .....500 W. Union, Wheaton, Ill.

*HARRIS, JOSEPH, Pres.
Russell Fork Coal Co., Inc., P.O. Box 174, Elkhorn City, Ky.

HARRISON, JOHN ALBERT, Assoc. Geologist.
Illinois Geological Survey, Urbana, Ill.

HARRISON, WILLIAM B., JR., Vice Pres.
Brad Harrison Co., 4222 Warren Ave., Hillside, Ill.

HARROLLE, G. W. "JAKE"
Jake's Tire & Recap Service, 1001 N. Court St., Marion, Ill.

HARVEY, HADLEY.....Ohio Brass Co., 1414 S. E. First St., Evansville, Ind.

HAWKINS, WARREN, Sales & Serv.
Frank Prox Co., Inc., 1201 S. 1st, Terre Haute, Ind.

*HAYDEN, CARL T., Vice Pres.
Sahara Coal Co., 59 E. Van Buren St., Chicago 5, Ill.

HAZEN, L. G., Eng. Sales.....Mobil Oil Co., 408 E. Water St., Pinckneyville, Ill.

HELFINSTINE, R. J.
Ill. Geological Survey, 100 Natural Resources Bldg., Urbana, Ill.

HELWIG, W. O.....Helwig Co., 2550 N. 30th St., Milwaukee 10, Wis.

HENDERSON, MARVIN D., Ind. Sales Engr.
Illinois Power Co., 500 S. 27th St., Decatur, Ill.

HENDERSON, R. E., Gen. Supt.....Truax-Traer Coal Co., Du Quoin, Ill.

HENNESSEY, WM. R.....Long-Airdox Corp., 307 N. Michigan Ave., Chicago 1, Ill.

HEPBURN, R. J. 1st Vice Pres.
United Electric Coal Co., 307 N. Michigan Ave., Chicago 1, Ill.

HERRING, HARRY A., Pres.....Witt-Armstrong, 505 N. MacArthur, Springfield, Ill.

HIMEBAUGH, GRANT S., Mgr. Dist. Sales.....
Raybestos-Manhattan, Inc., Manhattan Rubber Div.
6010 Northwest Hwy., Chicago 31, Ill.

HODGSON, C. H., Sales.....Mine Safety Appliances, 110 Hudelson, Benton, Ill.

HOFFMEISTER, ROBERT F.....C.I.P.S. Co., 1514 Illinois Bldg., Springfield, Ill.

HOLLIS, R. FRANK, Gen. Supt.....Alton Box Board Co., Box 276, Alton, Ill.

HOLT, HUGH L.....Dowty Mining Equipment, Cheltenham, England

HOPPER, W. HOLLIE, Supt.....
Fairview Collieries Corp., 1412 Southfield Rd., Evansville, Ind.

HUBBERT, PHILIP L., Sales Repr.....
National Mine Service, 131 Boggess Blvd., Madisonville, Ky.

HUEY, JOHN J., Dir. Research.....
The United Electric Coal Co's, 307 N. Michigan Ave., Chicago 1, Ill.

HUGILL, E. P., Field Engr. .....Gates Rubber Co., P.O. Box 499, Mt. Vernon, Ill.

HUNT, SEWELL L., Supt.....Lumaghi Coal Co., 231 N. Seminary, Collinsville, Ill.

HURTTE, RAYFORD, Clerk.....Peabody Coal Co., 1100 Poplar St., Taylorville, Ill.

HYETT, L. B., Purch. Agt...Freeman Coal Mining Corp., 4226 S. Lawndale, Lyons, Ill.

HYLAND, D. D., Midwest Area Mgr.....
Jones & Laughlin Steel Corp., 3434 S. 53rd Ave., Chicago 50, Ill.

INMAN, ROBERT H., Mining Engr.....
United Electric Coal Co., 307 N. Michigan, Chicago 1, Ill.

IRWIN, FRANK, Sales Repr.....
National Mines Service Co., P.O. Box 538, Mt. Vernon, Ill.

JACKMAN, H. W., ...Ill. State Geological Survey, Urbana, Ill.

JACKSON, GLENN F., Asst. Editor.....
American Mining Congress, 1102 Ring Bldg., Washington 6, D.C.

JANES, JOHN R., Prod. Engr.....Old Ben Coal Co., 202 E. Capitol, Benton, Ill.

JANKOWSKY, CHARLES, Resident Engr.....
Orient Mine No. 3, Freeman Coal Mining Corp., 702 Sheridan Dr., Benton, Ill.

JAYNE, JAMES J., St. Mine Inspr. .....State of Illinois, Box 195, Cuba, Ill.

*JENKINS, G. S., Pres. .....
Clarkson Div. Nat'l Mines Service, 2060 Railway Exch. Bldg., St. Louis 1, Mo.

JENKINS, JAMES M., Mgr. Repair Dept.....
Reliance Elec. & Engineering Co., 24701 Euclid Ave., Cleveland 10, Ohio

JENKINS, RICHARD H., Gen. Mgr.....
Vibration Measurement Engs., 725 Oakton St., Evanston, Ill.

JENKINS, W. D., Branch Mgr. .....
Underwriters Safety & Claims, Bank of Marion Bldg., Marion, Ill.

*JENKINS, WM. J., II.....Westinghouse Elec. Corp., Blairsville, Pa.

JOHNS, H. M., Vice Pres. .....Centralia Petroleum Co., Box 506, Centralia, Ill.

JOHNSON, CHARLES W., Salesman .....
Kensington Steel Co., 505 Kensington Ave., Chicago 28, Ill.

JOHNSON, FRANK K., Engr. .....
Nelson L. Davis Co., 3922 W. Main St., McHenry, Ill.

JOHNSON, L. H. .....U.S. Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa.

JOHNSON, V. E., Combustion Engr. .....
Freeman Coal Mining Corp., 129 Prospect, Elmhurst, Ill.

*JOHNSTON, W. A., Pres. .....
Illinois Central System, 135 E. Eleventh Pl., Chicago 5, Ill.

JONES, EVERETT, Lubrication Engr. .....
Standard Oil Co., Decatur Div., 4160 Park Lane, Decatur, Ill.

JONES, ISHAM, Mine Mgr. .....Old Ben Coal Corp., Mine No. 2, Sesser, Ill.

JONES, LOY D., Sales Mgr. .....
Cummins Diesel of Indiana, Inc., 3301 English Ave., Indianapolis, Ind.

JORE, OLAV E., Sales Engr. .....
Anaconda Wire & Cable Co., 802 Guinevere Dr., Marion, Ind.

JUNGWIRTH, MILTON L., Engr. .....
Allis-Chalmers Mfg. Co., Box 512, Milwaukee, Wis.

JUSTICE, CLYDE H., Pres. .....
Du Quoin Iron & Supply Co., Inc., P.O. Box 181, Du Quoin, Ill.

JUSTICE, HENRY B., Sales Rep. .....
Du Quoin Iron & Supply Co., Inc., P.O. Box 181, Du Quoin, Ill.

KACHIK, D. J. .....Paul Weir Co., 20 N. Wacker Dr., Chicago 6, Ill.

KAGA, RAY L. .....Bixby-Zimmer Engr. Co., Lock Box 176, Arcola, Ill.

*KEELER, E. R. .....Rockford Lumber & Fuel Co., Rockford, Ill.

KELLER, FRANK, Sls. Mgr. .....Freeman Coal Mining Corp., Springfield, Ill.

KENNEDY, D. D., Pres. .....D. D. Kennedy Co., Inc., P.O. Box 177, Bellwood, Ill.

KESSLER, WALTER W., Coal Mine Inspr. .....
U. S. Bureau of Mines, 206 A West Main, Staunton, Ill.

KIMBALL, P. G. .....P. O. Box 416, Beckley, W. Va.

KLEIN ARMATURE WORKS .....Centralia, Ill.

KNODE, R. W., Gen. Mgr. of Sales .....
The Jeffrey Mfg. Co., 4th St., Columbus, Ohio

*KOLBE, FRANK F., Pres. .....
The United Electric Coal Co's., 307 N. Michigan Ave., Chicago 1, Ill.

KOLISEK, FRANK, Safety Engr. .....
Freeman Coal Mining Corp., 214 W. 5th St., Benton, Ill.

KOPP, ANDREW J. .....U. S. Bureau of Mines, 1012 W. Main, Benton, Ill.

KOPUSTER, JOHN .....Lafayette Coal Co., Livingston, Ill.

KOSANKE, ROBERT M., Geologist .....Illinois Geological Survey, Urbana, Ill.

KOSTBADE, GEORGE, Mgr. .....
Bearing Service Co., 1607 S. Kentucky, Evansville, Ind.

KOSTBADE, HOWARD W.....
Power Trans. Equipt. Co., 1245 W. Fulton, Chicago, Ill.

KOTZMAN, JOHN, Inspr.....
Dept. Mines & Minerals, 723 W. Elm, Taylorville, Ill.

KOVALESKI, NICK, Chief Electn.....
Old Ben Coal Corp., 410 E. Seventh St., Johnston City, Ill

KRAZER, RALPH G., Supt.....The United Electric Coal Cos., Box 691, Danville, Ill.

KRECHEL, DONALD C., Salesman .....
Cummins Diesel Co., 3229 Washington Ave., St. Louis, Mo.

LARSON, ROBERT L., V. Pres.....Regis Belt Maintenance, 7319 Hamlin, Skokie, Ill.

*LEACH, B. K., Pres.....Egyptian Tie & Timber Co., 1263 Purdue Ave., St. Louis, Mo.

LEET, C. M., Staff Engr.....American Oil Co., 8400 Maryland, Clayton, Mo.

LEIGHTON, M. M. .....State Geological Survey, Urbana, Ill.

LESENEY, R. M., Maintenance Engr.....Truax-Traer Coal Co., Fiatt, Ill.

LIGHTBURN, BILL, Sales.....Esco Corp., 1017 Grigg's, Danville, Ill.

LIND, D. C., Engr.....Morris Machine Works, 205 W. Wacker Dr., Chicago 6, Ill.

*LINDSAY, GEORGE C., Editorial Dir.....Rock Products, 79 W. Monroe, Chicago, Ill.

LINDSAY, W. L.....
Mobil Oil Co., Inc., 10275 Page Industrial Blvd., St. Louis 32, Mo.

LINTON, THOMAS, Engr., Mining Div.....
Link-Belt Co., 300 W. Pershing Road, Chicago 9, Ill.

LITTLEHALE, BEN F., Supt.....Bell and Zoller Coal Co., P.O. Box 65, Zeigler, Ill.

*LIVINGSTON, H. C., Pres.....
Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 2, Ill.

LOFQUIST, RALPH J.....Lofquist Co., 10228 Prairie Ave., Chicago 28, Ill.

LONG, GENE .....Truax-Traer Coal Co., Fiatt, Ill.

LONG, RALPH J. .....Westinghouse Electric Corp., 411 N. 7th St., St. Louis, Mo.

LUCAS, WALTER S., Chief Engr.....
Sahara Coal Co., 209½ W. South St., Harrisburg, Ill.

LUMAGHI, L. F., JR., Pres.....
Lumaghi Coal Co., 111 N. Fourth St., St Louis 2, Mo.

MAC DONALD, J. W., V. P. Chge. Engrg. .....
Old Ben Coal Corp., 601 N. Du Quoin, Benton, Ill.

MACKE, ARTHUR S., Vice Pres. & Gen. Mgr.....
Mid Continent Coal Corp., Box 128, Marissa, Ill.

MACKIE, HAROLD R., Foreman.....Stonefort Corp., Williamsfield, Ill.

MAHOOD, G. PHILLIPS.....
Bethlehem Steel Co., Rail & Track Access. Sales Div., Bethlehem, Pa.

MAKARAUSKAS, FRANK I., Div. Ind. Engr. .....C. I. P. S., Marion, Ill.

MALONE, JAMES "PAT", Mgr.....Jake's Tire & Recap, 1001 N. Court, Marion, Ill.

MANDRELL, CLYDE, Supt.
Bell and Zoller Coal Co., 609 Washington Blvd., West Frankfort, Ill.

MANLEY, PAUL.....Long-Airdox Corp., 307 N. Michigan Ave., Chicago 1, Ill.

MARKS, DEWEY.....Sahara Coal Co., Eldorado, Ill.

MARSH, JAMES B., Agent.....225 Webster Ave., Jacksonville, Ill.

MARTIN, J. A., Supt.....Traux-Traer, 26 Laurel Ave., Du Quoin, Ill.

MATTHEWS, JAMES B., Engr.
Templeton-Matthews Corp., 905 Sycamore Bldg., Terre Haute, Ind.

MATTHEWS, M. A.
Templeton-Matthews Corp., 905 Sycamore Bldg., Terre Haute, Ind.

MAUCK, H. E., Vice Pres.
Freeman Coal Mining Corp., 300 Washington St., Chicago 6, Ill.

McCALL, C. O.....B. F. Goodrich Co., 850 W. Washington St., Chicago 6, Ill.

*McCOLLUM, H. C.
Peabody Coal Co., Peabody Plaza, 301 Olive St., St. Louis 8, Mo.

McCULLOCH, WM. C., Pres.
Roberts & Schaefer Co., 201 N. Wells St., Chicago 6, Ill.

McDANIEL, O. KENNETH, Sales.
Standard Oil Co., 3903 N. Millbrook Rd., Peoria, Ill.

McDANIEL, OSCAR D., JR., Mgr. Ind. Eng.
Old Ben Coal Corp., 500 W. Main, Benton, Ill.

McDOWELL, JAMES E., Sales Engr.
American Oil Co., P.O. Box 422, Mt. Vernon, Ill.

McELWEE, R. M., Sales Engr.
General Electric Co., 818 Olive St., St. Louis, Mo.

McFADDEN, DAMON H., Asst. Chief Engr.
Ayrshire Collieries Corp., 105 S. Meridian St., Indianapolis, Ind.

McGOWAN, JOSEPH J., Pres.
McGowan's, Inc., 936 Chicago Ave., Evanston, Ill.

*McMASTER, D. H.....1738 Guardian Bldg., Detroit, Mich.

McNAIL, WILLIAM, Washer Supt. .....Bell & Zoller Coal Co., Zeigler, Ill.

McSPADDEN, PERCY G., Supt. & Co-owner.
Lincoln Coal Mine-McSpadden Bros., 337 Nugent Drive, Lincoln, Ill.

McVICKAR, ED, Product Sales Mgr.
H. K. Porter Co., Inc., 601 Grant St., Pittsburgh 19, Penn.

MEISSNER, JOHN F.
John F. Meissner Engineers, Inc., 308 W. Washington St., Chicago 6, Ill.

MENZIE, W. D., Sales Mgr.
National Mine Service, 2530 Koppers Bldg., Pittsburgh, Pa.

MERIDETH, ELMO.....Olin-Mathieson, 508 E. St. Louis St., West Frankfort, Ill.

MESSERSMITH, MAURICE R., Coal Mine Insp.
U. S. Bureau of Mines, 209 N. Du Quoin St., Benton, Ill.

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

MIKA, M. S., Commercial Sales Mgr.....U.S. Rubber Co., 8530 Page, St. Louis 14, Mo.

MIKESELL, D. B., President.....American Brattice Cloth Corp., Warsaw, Ind.

MILLER, A. R., Salesman .....
Warren Refining & Chem. Co., 164 E. Hickory St., Canton, Ill.

MILLER, J. W.....National Electric Coil Co., 224 S. Michigan Ave., Chicago 4, Ill.

MILLER, R. G., JR., V. Pres.....
Robert & Schaefer Co., 1338 Sunnyside Ave., Highland Park, Ill.

MITCHELL, DAVID R., Dean.....
Coll. of Mineral Industries, Penn. State University, University Park, Pa.

MITCHELL, ROBERT W., Eng. .....
Snow Hill Coal Corp., 511 Merchants Natl. Bank Bldg., Terre Haute, Ind.

MOORE, ROSCOE, State Mine Insp.....301 E. Washington, Benton, Ill.

MORONI, GENE, Gen. Supt.....Old Ben Coal Corp., Benton, Ill.

MORRIS, ALBERT H., State Mine Inspector.....807 W. Elm., Taylorville, Ill.

MORRIS, BUDDIE R., Ind. Engr. .....
Bell & Zoller Coal Co., 1738 E. Main, West Frankfort, Ill.

MORRIS, JAMES, Mgr.....DuQuoin Tire Mart, P.O. Box 26, DuQuoin, Ill.

*MORROW, J. D. A., Board Chmn.....Joy Manufacturing Co., Franklin, Pa.

MULLEN, JOHN M., Office Mgr.....Little Sister Coal Corp., St. David, Ill.

MULLINS, RICHARD A., Prep. Mgr.....
Enos Coal Mining Co., Oakland City, Ind.

MURKEN, ARLO F., Mgr.....Hanselman Tire Co., 230 E. Monroe, Springfield, Ill.

*MURPHY, FRANCIS B.....1335 Chestnut Ave., Wilmette, Ill.

*MURPHY, H. C., President.....
Burlington Lines, 547 W. Jackson Blvd., Chicago 6, Ill.

NEIBCH, KENNETH W., M.M.....Moffatt Coal Co., Newman, Ill.

NIEBRUEGGE, ELBERT F., Sales Mgr. .....
Hopcroft Electric Inc., R.R. 4, Edwardsville, Ill.

NOEL, HAROLD F., Field Engr.....Long-Airdox Corp., Benton, Ill.

NOEL, WILLIAM, Dist. Mgr.....Long-Airdox Corp., Box 537, Benton, Ill.

NORRIS, STANLEY W., Sales Mgr.....
Harmony Tool & Die, Inc., P.O. Box 96, Mingo Junction, Ohio

NORTON, J. W., Salesman.....J. Schonthal & Assoc., R.F.D. No. 1, Herrin, Ill.

NOWERS, HENRY, Labor Commissioner.....
Illinois Coal Operators Assoc., Annawan, Ill.

*NUGENT, FRANK, Pres.....
Freeman Coal Mining Corp., 300 West Washington, Chicago 6, Ill.

OLSON, H. ROBERT, Sales Engr.....
Bates Sales Co., 9124 E. Milton, Overland 14, Mo.

O'NEAL, BYRON.....Mt. Olive & Staunton Coal Co., Staunton, Ill.

O'REAR, ROBERT M.....C. F. Gharst Supply Co., 550 N. 9th St., Terre Haute, Ind.

ORLANDI, WILLIAM J., Dir.....
Mines and Minerals, 9 Sunnyside Dr., Springfield, Ill.

ORR, J. WILLIAM, Sales Rep.....
Penna. & West Virginia Supply Corp., P.O. Box 871, Wheeling, W. Va.

O'SULLIVAN, JAMES J.....
American Steel & Wire Co., 7921 Kimlough Dr., Indianapolis, Ind.

PADAVIC, FRANK J. .....Old Ben Coal Corp., 1001 Election, Benton, Ill.

PADGETT, C. WARD, Gen. Supt.....
Lone Star Steel, 1016 Newton Dr., McAlester, Okla.

PAGE, FARRELL.....J. Schonthal & Assoc., Box 504, Sesser, Ill.

PARK, HOWARD N., Sales Engr.....
Anaconda Wire & Cable Co., 20 N. Wacker Dr., Chicago 6, Ill.

PATTISON, THOMAS T., Sales Mgr. .....
Nat. Mine Service Co., 2530 Koppers Bldg., Pittsburgh 19, Pa.

PATTON, JOHN M., Engr.....
Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 2, Ill.

PATTY, W. A., Purchasing Dept.....
United Electric Coal Co., 307 N. Michigan Ave., Chicago 1, Ill.

*PEABODY, STUYVESANT, JR. .....
Peabody Coal Co., 209 S. La Salle St., Chicago 4, Ill.

PEARSALL, ROBERT P., JR., Field Engr.....
Wedge Wire Corp., 9 Judy Circle, Madison 4, Wis.

PEPER, M. E., Mchdse. Mgr., Comml.....
Standard Oil Div. American Oil Co., 1201 E. 111th St., Indianapolis 80, Ind.

PETERSEN, WILLIAM L., Genl. Traffic Agent.....
Commonwealth Edison Co., 72 W. Adams St., Chicago 90, Ill.

PETERSON, C. A.....Bethlehem Steel Co., Prudential Bldg., Chicago 11, Ill.

PETTER, STANLEY D., Gen. Mgr.....
Henry A. Petter Supply Co., 117 S. First St., Paducah, Ky.

†PFAHLER, F. S.....Route 2, Bourbonnais, Ill.

PFARRER, W. H., Dist. Mgr. .....
Morris Machine Works, 205 W. Wacker Dr., Chicago 6, Ill.

PHEE, FRANK J., Pres.....Centralia Petro. Co., Box 506, Centralia, Ill.

PHILIPPI, L. B., Truck Sales Mgr.....
LeTourneau-Westinghouse Co., 2301 N. Adams, Peoria, Ill.

PICKARD, ALFRED E.....Pickard Industries, Inc., 218-24 S. Third, Mt. Vernon, Ill.

PIERCE, DRELUS, Supt.....Bell & Zoller Coal Co., 1026 N. Market St., Marion, Ill.

PIROK, STEPHEN, SR., Face Boss....Mt. Olive & Staunton Coal Co., Worden, Ill.

*PLATTS, E. M.....2035 E. Montebello, Phoenix, Ariz.

PLOTT, C. W., Service Repr.....
Roof Bolt Dept., H. K. Porter Co., 1115 5th Ave., Huntington, W. Va.

PLUMLEE, THEO. A., St. Mine Insp.....
State of Illinois, RFD 1, West Frankfort, Ill.

POHLER, MILTON S., Dist. Mgr.....
Marion Power Shovel Co., 4378 Lindell Blvd., St. Louis 8, Mo.

*POLING, GILBERT .....
Evansville Elec. & Mfg. Co., 600 W. Eichel Ave., Evansville, Ind.

POLLACK, CHARLEY, Co-Owner.....Pollack Bros., Box 28, West Frankfort, Ill.

POLLOCK, B. L., Safety Engr. .....
Underwriters Safety & Claims Inc., 214 W. Poplar, West Frankfort, Ill.

POTTER, ROBERT L., Field Engr.....
Hewitt-Robins, Inc., 2305 N. Meridian, Indianapolis 8, Ind.

PRICE, BILL, Service Engr.....Jeffrey Mfg. Co., Evansville, Ind.

PRICE, HARRY H.....
American Steel & Wire, Div. U. S. Steel Corp., 208 S. La Salle St., Chicago 4, Ill.

PROX, ROBERT F., JR., Secy. Treas.....
Frank Prox Co., 1201 S. First St., Terre Haute, Ind.

PURICELLIO, CHARLES J.....Chase Welding Supply Co., Benton, Ill.

PURMORT, A. S.....Hewitt-Robins, Inc., 4030 Chouteau Ave., St. Louis 10, Mo.

PURSELL, ARTHUR P., Supply Clerk.....
Truax-Traer Coal Co., 808 County Road, Pinckneyville, Ill.

PURSGLOVE, JOSEPH, JR., Vice Pres.....
Consolidation Coal Co., Koppers Bldg., Pittsburgh 19, Pa.

QUENON, E. E., Dir. of Safety.....Peabody Coal Co., 301 Olive St., St. Louis 2, Mo.

RAMER, RALPH W., Mgr., Central Dist.....
W. S. Tyler, 200 S. Michigan, Chicago 4, Ill.

RASSIEUR, CHARLES L., Sales Engr. .....
Central Mine Equipment Co., 6200 N. Broadway, St. Louis 15, Mo.

RASSIEUR, T. E., Pres.....
Central Mine Equipment Co., 6200 N. Broadway, St. Louis 15, Mo.

READ, DAVIS, Mining Consulting Engr.....1020 Adams St., Sturgis, Ky.

READ, THOMAS.....Dept. Mining & Met., University of Ill., Urbana, Ill.

REAK, MURRELL.....1604 E. Oak, West Frankfort, Ill.

REECE, CARL F.....2207 Ponderosa, Apt. 8-D, Santa Ana, Calif.

REED, KERT E.....Kert E. Reed Co., P.O. Box 415, Madisonville, Ky.

REED, R. E., Sales.....Hercules Powder Co., 322 S. Michigan Ave., Chicago 4, Ill.

REES, O. W., Chemist.....
Ill. State Geological Survey, Natural Resources Bldg., Urbana, Ill.

REINERTSEN, DAVID L., Asst. Geol. .....
Ill. Geological Survey, 203 Natural Resources Bldg., Urbana, Ill.

REISEN, KENNETH E., Salesman & Serv. Engr.....
J. H. Fletcher Co., 23 S. Queen Ct., Huntington 5, W. Va.

RENFRO, A. J., Sales.....
Peoria Tractor & Equip. Co., 2319 E. War Memorial Dr., Peoria, Ill.

RETTENMAYER, J. C., Elec. Engr. .....
United Electric Coal Co., 64 S. First St., Canton, Ill.

REYNOLDS, ERNEST, Mgr.....
Central Mine Supply Co., 423 S. 8th St., Mt. Vernon, Ill.

RICE, FRED.....Peabody Coal Co., 915 E. Ester, Taylorville, Ill.

*RICHARDS, L. O.....1016 N. Haines Rd., Clearwater, Fla.

RICHARDS, P. L., Mgr. Prep., Coal Div. .....
U. S. Steel, 525 Wm. Penn Pl., Pittsburgh, Penn.

RICHART, HUGH M., Drilling Foreman.....
Truax-Traer Coal Co., 414 E. Water, Pinckneyville, Ill.

RICHMOND, HAROLD, Mine Insp.....
State of Illinois, 33 Crown View, Mount Vernon, Ill.

RISSER, HUBERT E., Mineral Econ.....
Ill. Geological Survey, 201 Natural Resources Bldg., Urbana, Ill.

RITCHIE, GEORGE D., Purch. Agt.....
Evansville Electric & Mfg. Co., 600 W. Eichel Ave., Evansville 7, Ind.

ROBERTS, H. P. (TOD).....
C. F. Gharst Supply Co., 550 N. Ninth St., Terre Haute, Ind.

ROBERTSON, MARSHALL L.....
Evansville Electric & Mfg. Co., 190 Northwest 2nd St., Linton, Ind.

ROESCH, JOSEPH A., Salesman.....Mississippi Lime Co., 7 Alby St., Alton, Ill.

*ROMAN, F. W.....4820 Remington Dr., Sarasota, Fla.

ROMAN, HOMER E., State Mine Inspector.....721 Auburn Dr., Macomb, Ill.

ROMINE, JOHN L.....State of Illinois, 606 S. Monroe, West Frankfort, Ill.

RONK, R. K., Gen. Supt.....Midland Electric Coal Corp., Box 265, Farmington, Ill.

ROSE, C. G., Prod. Mgr.....Bixby-Zimmer Engineering Co., Galesburg, Ill.

*ROSING, BORGE, Mgr. Sales.....
West Va. Works, Connors Steel Div., Box 118, Huntington 6, W. Va.

ROWLAND, LEE, Owner.....Big Ben Coal Co., 401 W. Main St., Knoxville, Iowa

RUDER, FRANK G., Sales Engr.....
Nordberg Mfg. Co., 3300 S. Second St., St. Louis, Mo.

RUFF, L. LEON, Supt. .....Lumaghi Coal Co., Collinsville, Ill.

*RYAN, J. T., JR., Pres. .....
Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

RYERSON, ROBERT W., Sales Repr.....
Raybestos-Manhattan, Inc., 6010 Northwest Hwy., Chicago 31, Ill.

SANFORD, CHARLES E., Ind. Engr.....
Freeman Coal Mining Corp., Box 120, West Frankfort, Ill.

SAYLOR, LLOYD, Mech. Supvr.....
Freeman Coal Mining Co., No. 2 Orient, 706 E. Fifth St., West Frankfort, Ill.

SCHATZ, WARNER, Dist. Sales Repr.
Hammermills, Inc., 141 W. Jackson Blvd., Chicago 4, Ill.

SCHICKEDANZ, L. H., Mech. Engr.
United Electric Coal Companies, 505 N. Main St., Canton, Ill.

SCHLENK, E. B., Large Excavator Sales
Bucyrus-Erie Co., P.O. Box 161, Geneva, Ill.

SCHMIDT, W. E.....Columbia Quarry Co., 1007 Washington Ave., St. Louis 1, Mo.

*SCHONTHAL, D. C. .....West Va. Steel & Mfg. Co., Huntington 6, W. Va.

*SCHONTHAL, JOSEPH
J. Schonthal & Associates, Inc., 224 S. Michigan, Chicago 4, Ill.

SCHOTT, W. DEAN, Representative
Euclid Sales & Service, 5231 Manchester, St. Louis 10, Mo.

SCHRODER, FRED R., Supt.....Peabody Coal Co., Midwest Mine, Millstadt, Ill.

*SCHUBERT, R. R., V. P. and Gen. Mgr.
National Mine Service Co., P.O. Box 1447, Ashland, Ky.

*SCHULL, B. H.....621 W. Cedar St., Springfield, Ill.

SCHULLER, FRED, Truck Tire Salesman
Goodyear Tire & Rubber Co., 6513 Galena Road, Peoria, Ill.

SCHULZ, HOWARD.....Freeman Coal Mining Corp., 306 W. 5th, Benton, Ill.

SCULLY, T. ALVIN (Retired).....625 E. C. St., Belleville, Ill.

*SEE, FRED O., Vice Pres., Mining Div.
Cardox Corp., 307 N. Michigan Ave., Chicago 1, Ill.

SERENO, SAM, Sales.....Hercules Powder Co., 335 S. Laurel Dr., Jacksonville, Ill.

SHARKNESS, JOHN, Mine Mgr.
Old Ben Coal Corp. Mine No. 9, 410 E. Fifth St., West Frankfort, Ill.

SHARP, J. W., JR.....Peabody Coal Co., Rochester, Ill.

SHEPHERD, HARLEY H., Office Mgr.
Sahara Coal Co., Inc., P.O. Box 431, Harrisburg, Ill.

SHIMKUS, TONY.....Peabody Coal Co., 1540 N. 43rd St., East St. Louis, Ill.

SHUTT, WILLIAM S., Sales....Hercules Powder Co., 1206 Laura Lane, Marion, Ill.

SIDES, SILAS H., Lubrication Engr.....Shell Oil Co., P. O. Box 97, Marine, Ill.

SIMMONS, ROBERT C., Sales Engr.
Westinghouse Electric Corp., Merchandise Mart Plaza, Chicago 54, Ill.

SIMON, JACK A., Head, Coal Div.
Illinois State Geological Survey, Natural Resources Bldg., Urbana, Ill.

SLOAN, WALTER E., Roadman
Cincinnati Mine Mach., 714 Purcell Ave., Cincinnati, Ohio

SLOAN, WM., JR., Serv. Dept.
Mine Safety Appliances Co., 2 W. Lincoln, Harrisburg, Ill.

SMITH, ARTHUR A., Salesman
American Steel & Wire, 1806 W. Clarewood, Peoria, Ill.

Play ball with the Advertisers who play ball with you.

SMITH, CLOYD M. .....Munsey Building, Washington 4, D. C.

SMITH, F. J. .....U. S. Bureau of Mines, Vincennes, Ind.

SMITH, HARRY L., Service Engr.....
Youngstown Sheet & Tube Co., Youngstown, Ohio

SMITH, HERBERT H., Mgr. Mine Sales.....
National Castings Co., 9603 Miles Ave., Cleveland Ohio

SMITH, WILLIAM H., Assoc. Geologist.....
Ill. State Geological Survey, Urbana, Ill.

SNARR, J. W., Sales Eng.....
Allis Chalmers Mfg. Co., 135 S. La Salle St., Chicago, Ill.

SNEDDON, GEO. W., Supv. Chem. .....
State Dept. Mines & Minerals, 413 E. Main, West Frankfort, Ill.

SNYDER, JOHN S., Comptroller....Paul Weir Co., 20 N. Wacker Dr., Chicago 6, Ill.

SOLOMON, HARRY.....Roberts & Schaefer, 201 N. Wells St., Chicago 6, Ill.

SOMERS, BYRON.....Rt. 1, Canton, Ill.

SOMERS, HOWARD.....Truax-Traer Coal Co., Fiatt, Ill.

SOPER, ROY, Sales.....Goodman Mfg. Co., 1503 Brown Lane, Marion, Ill.

SORENSEN, RICHARD C. G., Chicago Dist. Mgr.....
Marion Power Shovel Co., 332 S. Michigan Ave., Chicago 4, Ill.

SOUTH, COY L., Safety Dir. ....Bell & Zoller Coal Co., 122 McCann St., Benton, Ill.

SPANI, EUGENE....Airdox-Cardox Products Co., 202 E. Elm, West Frankfort, Ill.

SPARTIN, PETER E., Engr. .....
United Electric Coal, 307 N. Michigan, Chicago 1, Ill.

SPIKINGS, R. Y., Div. Pur. Agent.....
Old Ben Coal Corp., 603 S. Emma St., Christopher, Ill.

SPOTTE, WALTER V., Asst. Dist. Mgr.....
Joy Mfg. Co., 560 W. Washington St., Chicago 6, Ill.

STECKER, EDGAR A., Salesman.....
Helwig Company, 2550 N. 30th St., Milwaukee 10, Wis.

STELZRIEDE, HOWARD R., Prep. Mgr.....
Freeman Coal Mining Corp., West Frankfort, Ill.

*STEVENS, E. F.....Binkley Mining Co., 4th Floor, 1006 Olive St., St. Louis, Mo.

STEWART, ROBERT M., Service.....
Long Airdox Co., 21 Murphy Ave., Madisonville, Ky.

STEWART, WM. M.....Jeffrey Mfg. Co., 305 Park Lane, Herrin, Ill.

STONE, S. A., Ch. Engr.....Deister Concentrator Co., P.O. Box 28, Fort Wayne, Ind.

STOPPEL, LLOYD A., Sales.....
Bethlehem Steel Co., 27th Floor—Prudential Bldg., Chicago, Ill.

STOTLAR, JAMES C., V. P. Sales.....
Mechanization, Inc., Munsey Bldg., Washington 4, D.C.

*STOVER, HOLLY, Exec. Asst. Pres.....C.B.&.Q.R.R., 547 W. Jackson, Chicago 6, Ill.

STUM, C. A., Mine Service Engr.....
Birmingham Bolt Co., East View Acres, Madisonville, Ky.

*SULLIVAN, J. L.....P. O. Box 62, Tappahannoc, Va.

SWALLOW, R. H., Vice Pres. & Chief Engr.....
Fairview Collieries Corp., 430 Big Four Bldg., Indianapolis 5, Ind.

SWEENEY, J. R., Asst. Production Mgr. .....
Bixby-Zimmer Engr. Co., 961 Abingdon St., Galesburg, Ill.

SYLJEBECK, NORMAN P., Dir. Purch. .....
Freeman Coal Mining Corp., 4226 S. Lawndale Ave., Lyons, Ill.

TABOR, JOSEPH C.....
Dept. of Mines & Minerals, State of Illinois, State Office Bldg., Springfield, Ill.

TAUCHER, R. A.....Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 2, Ill.

*TAYLOR, H. H. .....2042 Stella St., Fort Myers, Fla.

TAYLOR, HERBERT L., Div. Mgr.....
Fitzsimons & Connel Dredge & Dock Div., Merritt-Chapman & Scott Corp., 3025 E. 104th St., Chicago 17, Ill.

TAYLOR, W. C., Pres.....Midvale Coal Co., 721 Olive St., St. Louis 1, Mo.

TAYLOR, WILLIAM, Salesman.....
Vascoloy-Ramet Corp., 704 Election St., Benton, Ill.

THOMPSON, C. C., Asst. Sales Mgr.....
Hulburt Oil & Grease Co., Box 611, Harlan, Ky.

THOMPSON, M. L., Prin. Geologist.....
State Geological Survey, Natural Resources Bldg., Urbana, Ill.

THORSEN, J. O., Spec. Engr.....
Gould-National Batteries, Inc., 2311 Hampton Ave., St. Louis 10, Mo.

TIBBS, HARRY M., Vice Pres., Oper.....
Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 2, Ill.

TIMMERMAN, GEORGE.....Mt. Olive & Staunton Coal Co., Staunton, Ill.

TISDALE, JACK EDWARD, Prod. Engr.....
Freeman Coal Mining Corp., 414 E. Webster, Benton, Ill.

TOLLIVER, RALPH T., Supt.....
Truax-Traer Coal Co., 408 Mason, Pinckneyville, Ill.

TOWLES, ARTHUR L., Supt. Maint. .....
Bell & Zoller Coal Co., 700 Hadfield, Marion, Ill.

*TRUAX, A. H., Pres.....Truax-Traer Coal Co., 111 N. Wabash Ave., Chicago 1, Ill.

TRUAX, CHESTER N., JR., Asst. Editor.....
Mining Congress Journal, 1102 Ring Bldg., Washington 6, D. C.

TRUDEAU, FRANCIS E., Sales Engr.....
Kensington Steel Div. of Poor & Co., 505 E. Kensington Ave., Chicago 28, Ill.

TULLOCH, ROBERT, Sales Repr.....DuPont Co., 5 Horseshoe Dr., Springfield, Ill.

TURNER, JAMES K., Sales.....
American Brattice Cloth Corp., 2301 E. Market St., Warsaw, Ind.

TYLER, RICHARD S., Sales Repr.
Atlas Chemical Ind., Inc., 1 Payson Hts., Quincy, Ill.

UECKERMANN, F. H., Dist. Mgr.
John A. Roebling's Sons Corp., 5525 W. Roosevelt Rd., Chicago 50, Ill.

UNDERDAHL, TOM, Vice Pres.
Hanselman Tire Co., P.O. Box 36, Winona, Minn.

UTTERBACK, GENE H., Secy.-Treas.
United Electric Coal Co's., 307 N. Michigan Ave., Chicago 1, Ill.

VAN SLYCK, CLIFFORD E., Chief Elect.
Old Ben Coal Corp., 508 N. Emma St., Christopher, Ill.

*VON MEDING, WILLIAM, Pres.
Allen & Garcia Co., 332 S. Michigan Ave., Chicago 4, Ill.

*VON PERBANDT, L. K. 7955 S. Albany, Chicago 29, Ill.

WAGNER, JOHN E., Safety Engr.
Peabody Coal Co., 701 N. Powers, Taylorville, Ill.

WAKEFIELD, R. V., Mgr.
Armstrong Plant, Olin-Mathieson Chemical Corp., East Alton, Ill.

*WALKER, HAROLD L. 5101 Royene, N.E., Albuquerque, N. Mex.

WALKER, JOS. L., JR.,
Heyl & Patterson, Inc., 55 Fort Pitt Blvd., Pittsburgh 22, Pa.

WALLS, MARION B. 2936 Flanders Rd., Riverside, Calif.

WALTERS, D. H.
John A. Roebling's Sons Div., 5147 Dresden, St. Louis 16, Mo.

WALTERS, HOWARD A.
Hulburt Oil & Grease Co., 1242 Ridge Dr., So. Charleston, W. Va.

WAMPLER, W. K., Service
Joy Manufacturing Co., 404 S. Van Buren St., New Athens, Ill.

*WANNER, E. W. Kenilworth Apartments, Philadelphia 44, Pa.

WARD, JAMES J., Salesman
National Mines Service Co., 4410 Claremont Ave., Birmingham 5, Ala.

*WARE, LOUIS, Pres.
International Minerals & Chem. Corp., 20 N. Wacker Dr., Chicago 6, Ill.

WAYHAM, CHARLES F., Mgr., Industrial Dept.
Central Ill. Public Service Co., Illinois Bldg., Springfield, Ill.

*WEARLY, WM. L., Pres.
Joy Manufacturing Co., 333 Oliver Bldg., Pittsburgh 22, Pa.

WEBER, L. S.
Midwest Coal Producers Institute, Inc., 24 Wildwood Rd., Springfield, Ill.

WEBSTER, ALFRED JACK
Old Ben Coal Corp., 610 N. Emma St., Christopher, Ill.

WEIMER, W. A., Ch. Engr. Peabody Coal Corp., 301 Olive St., St. Louis 2, Mo.
Republic Steel Corp., Bolt & Chain Div., 332 S. Michigan Ave., Chicago 4, Ill.

*WEIR, CHARLES R., Salesman
Johns-Mansville Sales Corp., Merchandise Mart Plaza, Chicago 54, Ill.

*WEIR, J. P. .....Paul Weir Company, 20 N. Wacker Dr., Chicago 6, Ill.

†WEIR, PAUL, Board Chairman.....
Paul Weir Company, 20 N. Wacker Dr., Chicago 6, Ill.

WELCH, DICK W., Dist. Sales Mgr.....
Kennametal, Inc., P.O. Box 289, Riversburg, Pa.

WEST, THOS. F., JR., Dist. Sales Mgr. .....
Roberts & Schaefer Co., 130 N. Wells St., Chicago 6, Ill.

WEYSSER, JOHN L. G.....
Usom-Pierce Management Corp., APO-301, San Francisco, Calif.

WHENNEN, W. K. ....McLaughlin Mfg. Co., 3508 South Park Ave., Springfield, Ill.

WHITAKER, D. C., Sales Mgr.....
Oberjuerge Rubber Distrib. Co., Third & Walnut Sts., St. Louis 2, Mo.

WHITE, E. M., Sales Mgr., Mining Dept.....
Mine Safety Appl. Co., 201 N. Braddock, Pittsburgh 8, Pa.

*WHITE, FRANK L.....Cadillac Motel, Daytona Beach, Fla.

*WHITE, HUGH, Pres., Dist. 12.....
United Mine Workers of America, United Mine Workers Bldg., Springfield, Ill

WIECHER, HARVEY W., Dist. Repr.....
Broderick & Bascom Rope Co., 2428 Caver Hill Dr., St. Louis 36, Mo.

WIGNALL, TOM, Supt.-Partner.....Lovilia Coal Co., R.R. 1, Knoxville, Iowa

†WILKEY, FRED S., Secy.....
Illinois Coal Operators Assn., 307 N. Michigan Ave., Chicago 1, Ill.

WILKISON, T. A.....Sunray D-X Oil Co., P.O. Box 417, Harrisburg, Ill.

WILL, WILLIAM E., Asst. Field Engr.....
Peabody Coal Co., 711 N. Webster St., Taylorville, Ill.

WILLIAMS, ELMOS, Supt.....Bell & Zoller Coal Co., P.O. Box 162, Newman, Ill.

WILLIAMS, L. R.....Egyptian Sales Agency, 401 S. 17th St., Murphysboro, Ill.

WILLIAMS, MAURICE, Supt. .....Carmac Coal Co., Box 151, Marion, Ill.

WILLIAMSON, DON M., Asst. Mgr.....
Chicago Dist., Du Pont Co., 7250 N. Cicero, Chicago 30, Ill.

WILLIAMSON, HARRY, JR., Gen. Supt.....
Freeman Coal Mining Corp., 215 S. Main, Benton, Ill.

WILLIAMSON, RICHARD D., Engr.....Snow Hill Coal Corp., Terre Haute, Ind.

WILLIS, W. E., Chief Engr.....Lumaghi Coal Co., Collinsville, Ill.

WILLS, BENJAMIN E., Mine Examiner.....
Peabody Coal Co., 1509 S. State, Springfield, Ill.

WILSON, GEORGE M.....
Ill. Geological Survey, Natural Resources Bldg., Urbana, Ill.

WILSON, JOHN R., Contr. Engr.....
Heyl & Patterson, Inc., 55 Fort Pitt Blvd., Pittsburgh 22, Pa.

WILSON, R. P., Top Foreman.... Bell & Zoller Coal Co., 208 W. Blvd., Marion, Ill.

WILSON, ROLAND, V. P. Operations.....
Bell & Zoller Coal Co., 411 E. Main, Marion, Ill.

WINGARD, JOHN, Field Repr.....Kennametal, Inc., 505 E. Lawrence St., Benton, Ill.

WINN, C. H., Fuel Buyer.....C.I.P.S. Co., 1501 Illinois Bldg., Springfield, Ill.

WINTERS, WILLIAM J., Div. Engr.-So. Ill.....
Truax-Traer Coal Co., DuQuoin, Ill.

*WOMMACK, A. J. .....
Bearings-Belting & Supplies Co., 3144 Olive St., St. Louis 3, Mo.

*WOODS, HENRY C., Chmn. of the Board.....
Sahara Coal Co., 59 E. Van Buren St., Chicago 5, Ill.

WOODS, M. C.....Pennzoil-South Penn Oil Co., P.O. Box 78, Oil City, Pa.

WOODYARD, WILLIAM W., Salesman.....
Conners Steel, H. K. Porter, 1100 S. Beninghof Ave., Evansville, Ind.

WOOMER, TIMOTHY C., Sales.....Joy Mfg. Co., 1112 N. Maple, Benton, Ill.

WRIGHT, FRED D., Prof.....Univ. of Illinois, 707 Ohio St., Urbana, Ill.

YANCIK, JAMES R., Mining Engr.....
Sahara Coal Co., 19 S. Jackson, Harrisburg, Ill.

YERKES, J. H.....Jos. H. Yerkes & Co., 3624 Enright Ave., St. Louis 8, Mo.

YOHE, G. R., Chemist.....
State Geological Survey, Natural Resources Bldg., Urbana, Ill.

YOUNG, E. J., Mgr., Industrial Prod.....Shell Oil Co., 212 S. Central, Clayton 5, Mo.

YOUNG, W. P. (Retired).....595 Longwood Ave., Glencoe, Ill.

ZIMMER, WALTER .....
Bixby-Zimmer Engineering Co., 961 Abingdon St., Galesburg, Ill.

ZIMMERMAN, RAY E., Vice Pres...Paul Weir Co., 20 N. Wacker Dr., Chicago 6, Ill.

* Life Members

÷ Honorary Members

Buyer meets Seller in the back of this book.

Members,

Meet Your Friends

Much of the success of our Institute is due to the support we have had from our friends. We want to continue meriting it.

We urge our membership to consult the Advertising Section in this and other issues of our Proceedings when in need of equipment.

Many of our friends — the advertisers — have carried copy with us in each issue. They have expressed satisfaction with the results obtained through their support.

This is the thirty-third consecutive yearbook we have published.

LOKGRIP*:

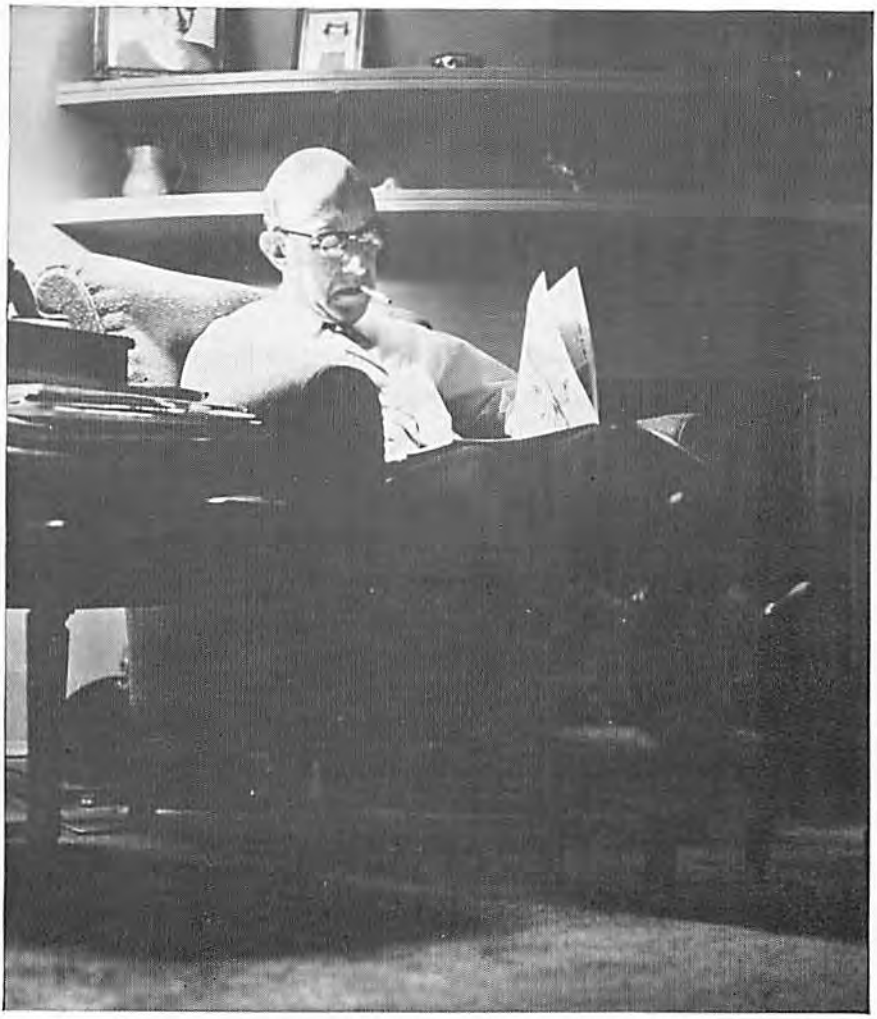
A PERMANENT FIXTURE IN SAFE MINES

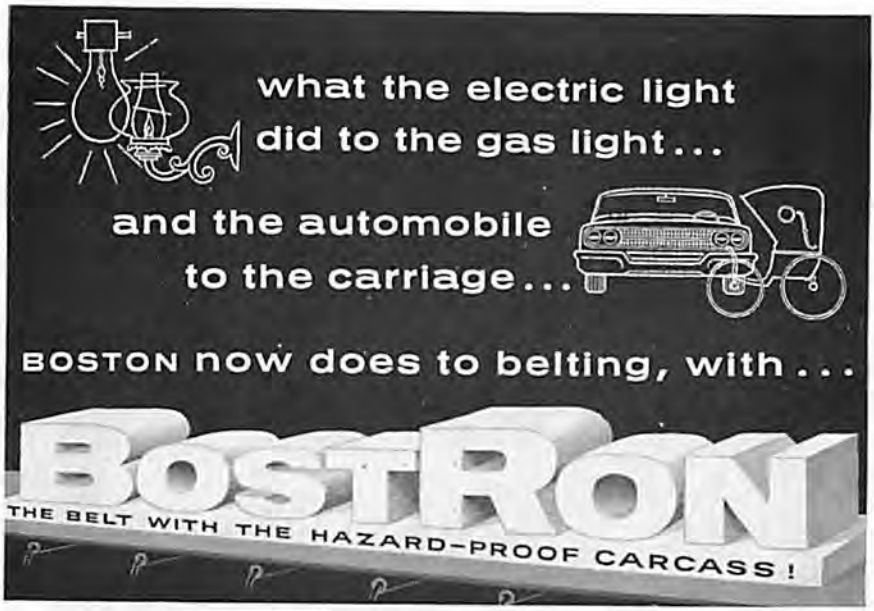
West Virginia's LOKGRIP Mine Roof Bolt represents more than an economical unit for the mining industry. Research, development and countless hours at the mine face in cooperation with key mining officials have brought about this economical and practical roof control unit. We invite inquiries, write or call: Connors Steel Division, P. O. Box 118, Huntington, West Va., phone JAckson 9-7171.

PORTER

CONNORS STEEL DIVISION
H.K. PORTER COMPANY, INC.

*PATENT PENDING





BOSTRON HAZARD-PROOF CARCASS MAKES ORDINARY BELTING OBSOLETE

- BOSTRON Belts will not rot or mildew . . . are completely resistant to the deteriorating effects of moisture.
- BostRon Belts' impact resistance has proven superior to ordinary belts in severe field service.
- BostRon Belts' amazing carcass flexibility permits troughing up to 45° instead of the usual 20°. This permits larger loads, lower handling costs and narrower conveyor widths.
- BOSTRON Belts are not affected by belt fastener rust, acids or chemicals normally encountered.
- BOSTRON Belts can be thinner and lighter because of their superior strength. Handling, installing and storing are easier. Less headroom is required, and pulley diameters can be reduced up to one-third.
- BOSTRON Belts' ability to resist fatigue substantially prolongs mechanical splice life.

BOSTRON plies are stronger than steel yet have all the advantages of fabric. New BOSTRON Belts combine a hazard-proof carcass with Balanced Belt Construction and make your investment in a superior Dulon Cover the most sensible and dollar-saving way to purchase belts today!

An exclusive research milestone by

BOSTON
SINCE 1880

AMERICAN BILTRITE RUBBER COMPANY
BOSTON WOVEN HOSE & RUBBER DIVISION
BOSTON 3 MASSACHUSETTS

AMERICAN BILTRITE RUBBER COMPANY
BOSTON WOVEN HOSE & RUBBER DIVISION
Boston 3, Massachusetts

Please send free illustrated literature about the new hazard-proof BostRon Belts.

Company Name _____
Street _____
City _____ State _____
Attention _____

EXCLUSIVE DISTRIBUTORS

GOODING RUBBER CO.

806 E. 31st ST. LA GRANGE PARK, ILL.

Phones: Chicago — BIshop 2-3444
LaGrange Pk. — FLeetwood 4-2270

The Marion 5761 can lift a load as high as a 14-story building, swing it the length of a football field and drop it on top of a 12-story building . . . without moving a crawler. It carries a 170-foot boom, swings a 65-yard dipper and weighs over 3200 tons.

LOOK TO

MARION

For Coal Stripping and Loading Machines

A Complete Range of Types and Sizes for Every Need

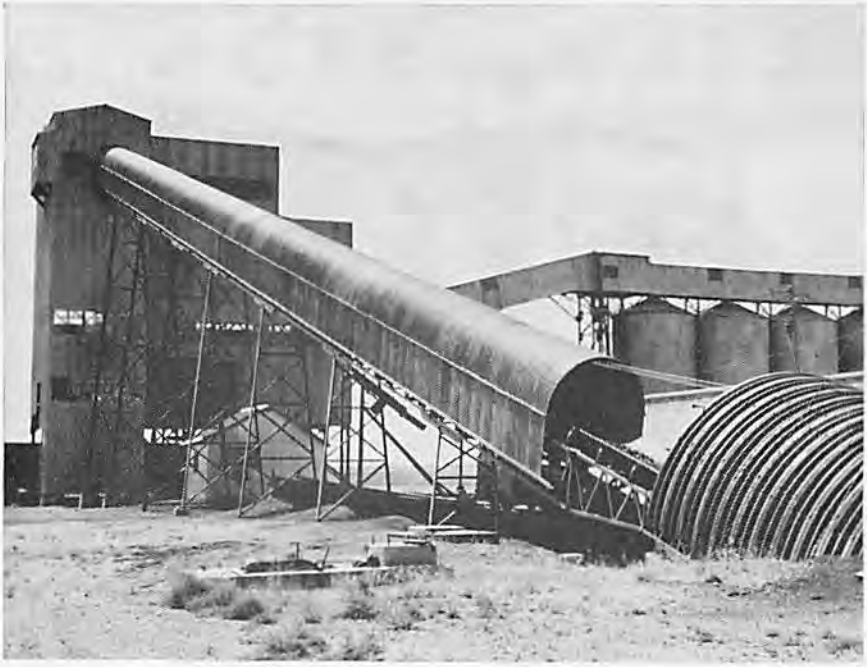
THE MARION LINE

Type	Capacity	Type	Capacity
35-M	¾ cu. yd.	191-M	11 cu. yd.
43-M	1 cu. yd.	7200 Walker	6-7 cu. yd.
45-M	1¼ cu. yd.	7400 Walker	7-14 cu. yd.
362	1½ cu. yd.	7800 Walker	20-35 cu. yd.
65-M	1¾ cu. yd.	7900 Walker	24-45 cu. yd.
75-M	2 cu. yd.	8700 Walker	50-70 cu. yd.
93-M	2½ cu. yd.	8800 Walker	65-100 cu. yd.
101-M	3 cu. yd.	5323	20 cu. yd.
111-M	4½-5 cu. yd.	5561	45-50 cu. yd.
4161	6 cu. yd.	5760	65-70 cu. yd.
151-M	7 cu. yd.	5761 (Long Range)	65-70 cu. yd.
181-M	9 cu. yd.	5990	120-150 cu. yd.
183-M	9 cu. yd.		

TELL US YOUR NEEDS

Marion Power Shovel Co. • Marion, Ohio

A Division of Universal Marion Corporation



12-Year Report on Clayton Coal Co. Conveyors:

- **$40,000.00 SAVINGS AT INSTALLATION**
- **1/15c PER TON IDLER MAINTENANCE**
- **NO BELT REPLACEMENT**

"Barber-Greene conveyor engineers saved us $40,000 on our system in the design stage by using two main entry belts instead of one, and we've been saving money with the same conveyors every year since 1949," says President H. B. Crandell, Clayton Coal Co., St. Vrains, Colo.

No belt replacements and idler maintenance held to 1/15¢ per ton have helped keep materials handling costs of 1,500,000 tons of coal to the absolute minimum for this mining company.

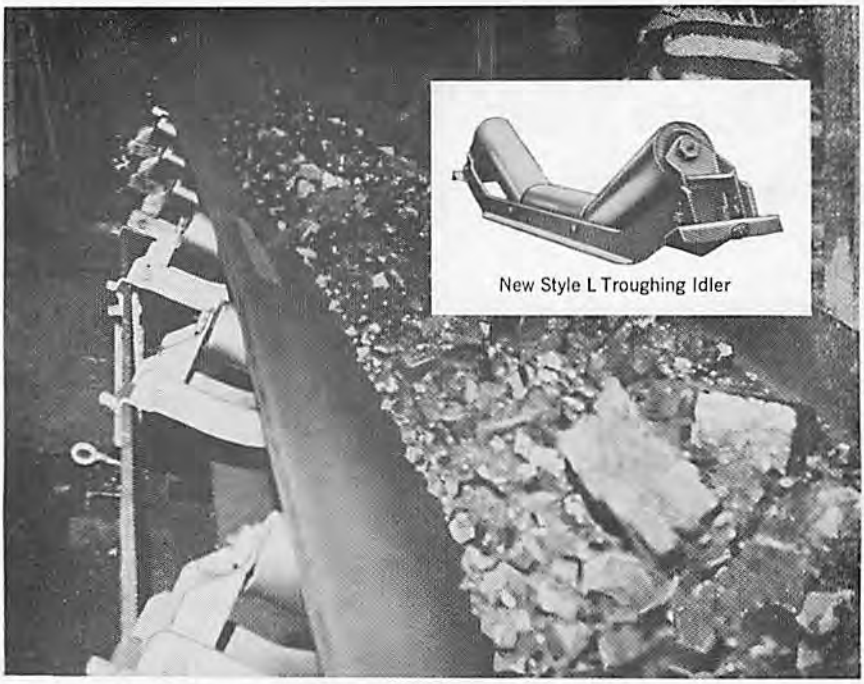
Call your Barber-Greene conveyor specialist for a quote on your next conveyor system. You'll get both price and performance whether your system calls for standard or specially engineered equipment or a combination of both.

Representatives in Principal Cities of the World

Barber-Greene

Main Office and Plant AURORA, ILLINOIS, U. S. A.
Other Plants: DeKalb, Milwaukee, Canada, England, Brazil, Australia

CONVEYORS . . . LOADERS . . . DITCHERS . . . ASPHALT PAVING EQUIPMENT



H-R manufactures the broadest line of wire rope conveyors...

SEE ONE NOW!

Contact your H-R Field Engineer to arrange an inspection tour of an H-R wire rope conveyor installation in operation.

DESIGN RANGE:

- New Style L idlers—2¾" to 6" dia.
- Belt widths of 24", 30", 36", 42", 48".
- Speeds from 250 to 650 ft./min.
- Feed rates from 125 to 2,250 TPH.
- Power ratings from 5 to 300 hp.
- Above and below ground installation.

MONEY-SAVING HINTS! New pocket-size H-R booklet, packed with useful information on mining belt conveyor operation and maintenance. Write Hewitt-Robins, Stamford, Connecticut for Bulletin 68.

HEWITT-ROBINS

THE NAME THAT MEANS EVERYTHING IN BULK MATERIALS HANDLING SYSTEMS...

CONVEYOR BELTING AND IDLERS • INDUSTRIAL HOSE • VIBRATING FEEDERS, SCREENS AND SHAKEOUTS • POWER TRANSMISSION EQUIPMENT

NEW MODEL S ELECTRIC CAP LAMP. 15% more light output in the world's most popular cap lamp assures greater safety for the miner, more tons per shift for the operator. New headpiece is smaller, lighter weight. M-S-A.® Low-Voltage Charging Equipment makes charging completely automatic.

MSA's complete product line helps increase safety and production

M-S-A® MINEPHONE. Transmits orders instantly and simultaneously to motormen who can receive and reply while trips are in motion. Provides an extra margin of safety plus better traffic control. M-S-A HoistPhone is available for dependable, coordinated voice communication between hoisting engineer and the cage crew.

M-S-A MINE LIGHTING SYSTEM. These new permissible systems promise fewer accidents and greater productivity for mines. Available in ungrounded, isolated two-wire and grounded three-wire circuits.

M-S-A® PAGER. Gives convenience and flexibility of a telephone with amplification of a loud speaker. Fully transistorized. Uses existing telephone lines. Ten or more pagers can be installed on a single line.

CHOOSE FROM MSA'S COMPLETE LINE SELECTION . . . OVER 3600 ITEMS

Dust and Gas Detecting Instruments; Clothing; Respirators; Oxygen Breathing Apparatus; Self-Rescuers; Gas Masks; Flame Safety Lamps; First Aid Materials; Head Protection; Resuscitators; Ventilation Equipment.

MINE SAFETY APPLIANCES COMPANY

Pittsburgh 8, Pennsylvania

MSA

The best wire rope "round the clock"

USS Tiger Brand

This 32-cu.-yd. dragline operates "round the clock" and needs absolutely dependable wire rope in four different locations—the drag ropes, main hoists, upper boom supports and lower boom supports.

Each job takes a different kind of wire rope—drag ropes for abrasion resistance and shock, hoist ropes for strength and flexibility, boom supports for resistance to vibration and fatigue. Each of these USS Tiger Brand Ropes is especially designed to do its job, for the longest time at the lowest cost.

For the latest information, call the USS Tiger Brand distributor near you or write American Steel and Wire, Rockefeller Building, Cleveland 13, Ohio. USS and Tiger Brand are registered trademarks.

Tiger Brand Wire Rope • Boom Support Assemblies on shovels and draglines
Tiger Brand Amerclad portable shovel cable • Tiger Brand Power Cable.

American Steel and Wire
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors,
Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors,
United States Steel Export Company, Distributors Abroad

TOP PRODUCERS

New 29-ton Lee-Norse CM38 and CM48 Miners cut seams 42" to 120".

Lee-Norse MINERS

with Power Smooth Cutter Action

Gather and Load as Fast as They Cut!

1 Cutter Heads equipped with evenly spaced "Rap-Lok"* Bit Holders.

2 Exclusive "dual gathering arms."

3 16" wide crawlers with heavy-duty gearing.

4 Compact hydraulic-electric controls.

5 Sturdily built, unit assemblies assures low maintenance.

*Trade Mark of The Cincinnati Mine Machinery Co.

LN

Lee-Norse Company

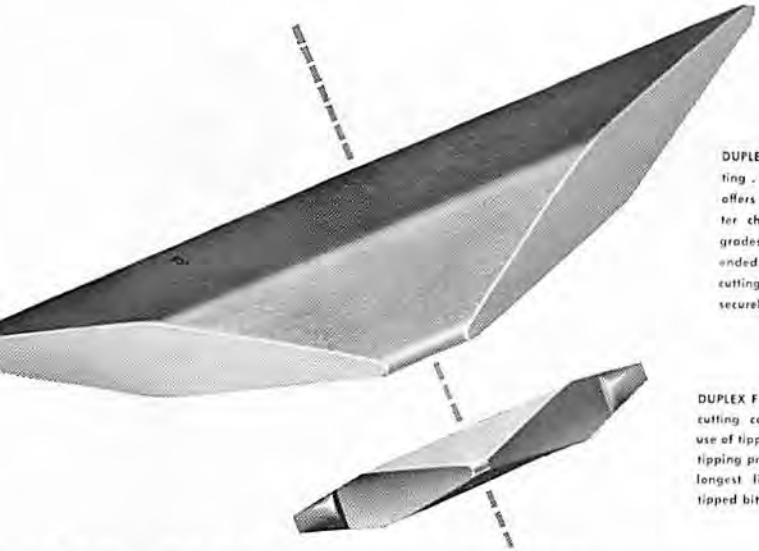
CHARLEROI, PENNSYLVANIA

Specialists in Coal Mining Equipment

Extra-Strength "POWERSTEEL" Stands Up Better

In today's fast tempo in coal production, there's no time for downtime of equipment. You can insure against shutdowns by using the best machines — and highest quality, longer-lasting wire rope. B&B Yellow Strand "POWERSTEEL" is made of higher-carbon-content steels — to stand the abuse of tough loads and steady operation — built to give greatly increased service. Get the extra-service built into Yellow Strand "POWER-STEEL" and be sure of longer rope life. Stocks on hand for immediate delivery. Broderick & Bascom Rope Co., 4203 Union Blvd., St. Louis 15, Mo.

Yellow Strand®



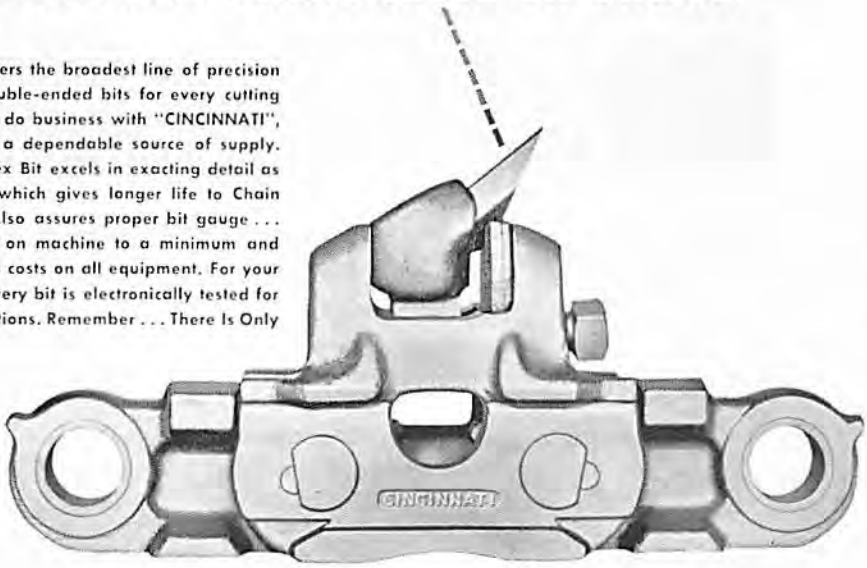
DUPLEX C-11 . . . for all purpose cutting . . . this superior CINCINNATI BIT offers the best obtainable value in cutter chain bits. Available in various grades . . . is reversible and double ended. It has sharp points . . . keen cutting edges . . . long life . . . locks securely . . . easily removed.

DUPLEX F TYPE . . . TIPPED BIT . . . where cutting conditions are applicable to the use of tipped bits . . . Cincinnati's exclusive tipping process makes this the lowest cost, longest life, throw-away type carbide tipped bit available.

CINCINNATI MINE ... *pioneered and developed the DUPLEX BIT*

. . . still the finest *double-ended* bit offered.

"CINCINNATI" offers the broadest line of precision reversible, double-ended bits for every cutting roblem. When you do business with "CINCINNATI", ou are assured of a dependable source of supply. he Cincinnati Duplex Bit excels in exacting detail as size and shape which gives longer life to Chain lock and Holder. Also assures proper bit gauge . . . hich reduces load on machine to a minimum and uts down operating costs on all equipment. For your pecial protection every bit is electronically tested for ze or any imperfections. Remember . . . There Is Only ne Duplex Bit.



Cincinnati Duplex Bits in conjunction with the Cincinnati Duplex Chains guarantee you the best combination available.

NCINNATI MINE MACHINERY CO.
CINCINNATI 25, OHIO

ecialists in cutting equipment for over 35 years

Ohio Brass

MANUFACTURERS OF MINING MATERIALS AND EQUIPMENT

Would you like to read a copy of O-B Haulage Ways regularly? It is a magazine written for and sent to 8000 mine men each month, free of charge. Use the coupon to tell us where to send your copy.

OHIO BRASS COMPANY
MANSFIELD, OHIO

I'd like to be a regular reader of O-B Haulage Ways. Please send copies to me at this address:

Name_____
Title_____
Company_____
Address_____
City_____ State_____

10053-M

Ohio Brass

HOLAN

EXPANSION SHELLS AND PLUGS • LINE MATERIALS • SAFETY AND CONTROL EQUIPMENT • ELECTRIC HAULAGE MATERIALS

Kennametal Roof Bits assure speed and efficiency of rotary drilling in medium, hard, and severe roof. Available in several tip and shank designs.

Kennametal Drill Bits are produced in 20 tip and shank designs, for low cost drilling in coal, clay, slate, shale.

Kennametal Cutter Bits are available in more than 30 tip and shank designs, for medium, hard, and severe cutting. Shank styles to fit all popular chains.

KENNAMETAL* CARBIDE BITS

stay sharp longer . . . reduce costs

Kennametal has pioneered and developed the most extensive line of carbide-tipped mining bits and accessories . . . engineered and designed for economical service in any cutting or drilling condition. Tough Kennametal tips stay sharp longer, take harder knocks than any other tungsten carbide. Kennametal representatives—men with years of actual mining experience—will help you select the right bit for each job and demonstrate proper application, *in the mine.*

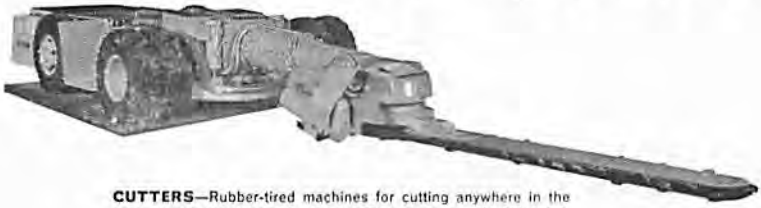
See your Kennametal Representative or contact KENNAMETAL INC., Mining Tool Division, Bedford, Pennsylvania. Phone Bedford 623-5134.

*Trademark 33518

INDUSTRY AND
KENNAMETAL
...Partners in Progress

GOODMAN MINING MACHINERY

For conventional and continuous mining systems - AC or DC



CUTTERS—Rubber-tired machines for cutting anywhere in the seam, moving anywhere in the mine. Three heights—29", 40½", 42".

LOADERS—For high capacity loading at the face or behind continuous miners. Four basic heights—24", 26½", 34", 38".

SHUTTLE CARS—All Goodman cars, from the low (26") to the high (54"), are known for structural strength and capacity.

LOCOMOTIVES—For main line haulage—from 60 hp, two motors to 680 hp, four motors.

CONTINUOUS MINERS—Goodman miners have put face efficiency on a new profit level in scores of mines. The 300 for coal from 48" to 66", the 400 series for coal from 66" up.

BELT CONVEYORS—The Goodman Ropebelt conveyor that has revolutionized conveyor haulage. Also available, extensible belt conveyors for use with continuous miners and loaders.

GOODMAN

MANUFACTURING COMPANY

Halsted Street and 48th Place, Chicago 9, Illinois

YArds 7-7420

BRANCH OFFICES

Wilkes-Barre, Pennsylvania
35 New Bennett St.
VAlley 3-3013

Huntington 16, West Virginia
831 Second Ave.
JAckson 5-9189

Birmingham 4, Alabama
812 Fifth Ave., North
FAirfax 3-3222

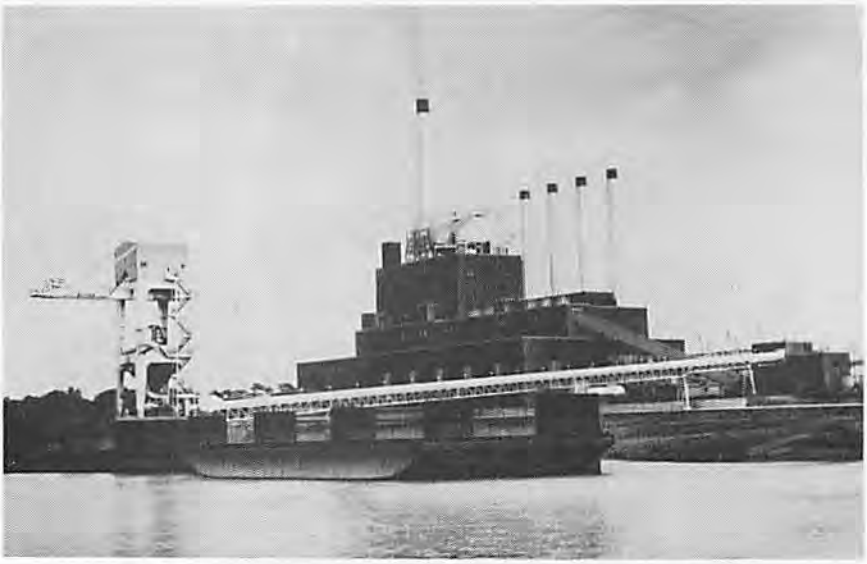
Pittsburgh 33, Pennsylvania
1714 Liverpool St.
CEdar 1-1356

Harlan, Kentucky
U.S. Highway 119 and L&N Ry.
Phone 416

West Frankfort, Illinois
304 West Main St.
Phone 107

Other Goodman coal mining machinery: COMPRESSOR TRUCKS, CHAIN CONVEYORS, SHAKER CONVEYORS and SHORTWALLS.

"Use Genuine Goodman Replacement Parts"



The towering stack identifies the new 238,000-kilowatt (net capability) unit addition to the Meredosia Power Station of CIPS. The unit consumes more than half a million tons of coal annually. Giant barge unloader in the foreground unloads ten tons of coal in one scoop.

From Coal . . . To Kilowatts

Every time a CIPS customer pushes a button, flips a switch or turns a dial to put his electric service to work, he's using Illinois coal.

CIPS power stations are now burning an average of more than 110,000 tons of Illinois coal a month to convert water into superheated steam. This steam turns the turbine-generators which produce the electricity used daily in central and southern Illinois homes, businesses and industries.

Illinois coal mines . . . and the kilowatts they help produce . . . work together for the progress of Illinois.

CIPS **CENTRAL ILLINOIS PUBLIC SERVICE COMPANY**

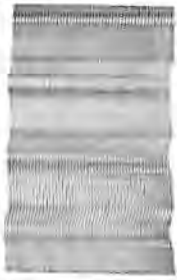
GENERAL OFFICES: ILLINOIS BUILDING, SPRINGFIELD, ILLINOIS

Helps Keep America Powerful

HENDRICK SCREENS

for every coal production requirement

Hendrick Wedge Wire Screens—ideal for screening, sifting, dewatering and filtering operations where it is important for screen openings to be minutely fine yet have excellent draining qualities. Also available with riffle top markings to increase agitation and screen life.



Hendrick Cascade Wedge Wire Screens—unexcelled for screening and dewatering coal. Cascade's unique "step" construction eliminates flooding caused by overloads... increases the weight of solids processed as well as the amount of water in screen underflow. Can be mounted on any equipment presently using profile type screens. Openings from ¼ to 1½ MM in stainless steel.

Hendrick Perforated Metal Screens—clean-cut holes prevent time delays caused by blinding. Precise uniformity of mesh and high product strength assure extra long screen life—cut down time losses due to deck changes.

HENDRICK WEDGE SLOT

TAPERED "12" is ideal for heavy-duty dewatering service on shakers and vibrators; in chutes, drags, sluiceways; in wash boxes and heavy media separators.

TAPERED "9" is the new companion to the TAPERED "12" profile. Designed for similar installations where more open area is required.

PROFILE B. For dewatering sludge, silt and fine coal on shakers, vibrators, classifiers, dryers, filters, anti-stream-pollution equipment.

PROFILE D. For heat dryers and dewatering of irregular shaped grains; also for retarding surge of water and material.

Hendrick Perforated Screens For Centrifugal Coal Dryers

Hendrick produces a complete line of perforated screens for every type of Centrifugal Dryer.

Partial List—Standard Perforations

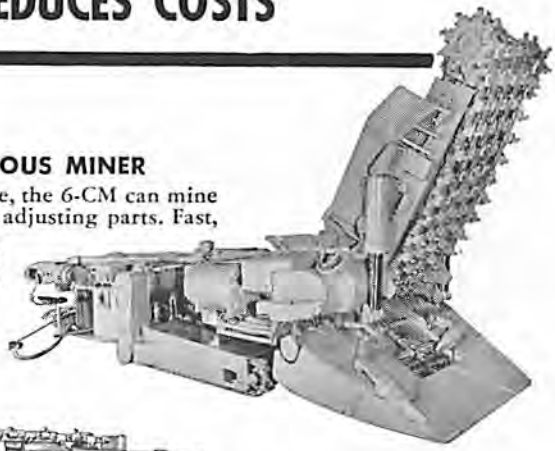
Perforations	Standard Gage
1 MM	22-20
.036"	22
3/64"	20-18
1/16"	16-14
3/32"	16-14

HENDRICK

Manufacturing Company
Carbondale, Penna.

Perforated Metals • Perforated Metal Screens • Wedge-Slot and Wedge Wire • Architectural Grilles • Mitco Open Steel Flooring • Shur-Site Treads • Armorgrids • Hendrick Hydro Dehazer

JOY MECHANIZED MINING EQUIPMENT INCREASES TONNAGE— REDUCES COSTS



THE 6-CM... JOY'S NEWEST CONTINUOUS MINER

Mining 5 to 5½ tons per minute, the 6-CM can mine any seam without changing or adjusting parts. Fast, gathering-arm cleanup works independently of ripper head and conveyor for auxiliary cleanup.

MOBILE CUTTERS

Built in three sizes for high, medium and low coal, these rugged trackless machines can make cuts anywhere in the face and stay ahead of any loader.

LOADERS

JOY offers loaders for all seam heights with capacities up to 20 tons per minute. The 14BU-10 line is available in basic heights of 24", 33", and 38". High seam and hard rock units also available.

SHUTTLE CARS

A new line of shuttle cars, the 18-SC, hauls twice as much with a new 6-wheeled design that bends in the middle. Available in several heights to suit your seam.

Write for Bulletins

1020

WORLD'S LARGEST MANUFACTURER OF UNDERGROUND MINING MACHINERY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

NEW ROYAL GOLD BURRO BELTING

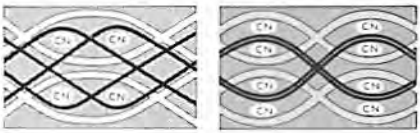
Built better to last longer

When all the facts are in, it's clear that no other interwoven belting can match U. S. Royal Gold Burro. This new belting has not only been made highly fire resistant without sacrificing strength, but its high-visibility gold cover insures maximum safety in dimly lit underground areas.

And unlike other belting, whose strength members are covered by only one layer of base yarn, the yarn-dipped, all-PVC Royal Gold Burro has an extra layer of cotton-nylon fillers beneath its tough cover to give maximum protection to its extremely high-strength nylon tension members.

Extra strands of filament nylon on the belt's edges provide greater rip and tear resistance, add to Royal Gold Burro's excellent troughability and training characteristics.

Low-cost Royal Gold Burro Belting is available in standard widths and in lengths to 1,200 ft. For further information and on-the-spot assistance, call your nearest US Distributor.



While inferior belts (left) have only one base layer to protect tension members after the PVC layer is worn through, the Royal Gold Burro (right) has an extra layer of cotton-nylon fillers to give added protection to the tension members — longer life to the belt. Note central placement of nylon tension members for maximum pulling strength.

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

United States Rubber

MECHANICAL GOODS DIVISION

Rockefeller Center, New York 20, N. Y.

U.S. ROYAL TIRES

SAFETY 1st

CONTRAKTOR

Specifically designed for all mining operations or wherever rock service conditions predominate. Also available in SRT (Steel Reinforced Tread) which protects the All Nylon Cord Body from cuts, snags and ruptures in the tread and shoulder areas, provides tremendous savings in down time and more carcasses for retreading.

SUPER FLEETMASTER

An all job, all wheel, all Nylon Tire with extra body strength and extreme tread toughness for additional milage and service in the toughest off-road jobs. Ideal on front wheels when mated with the CONTRAKTOR on drive wheels. It is easy steering because of the massive center rib and also is highly resistant to sideslipping.

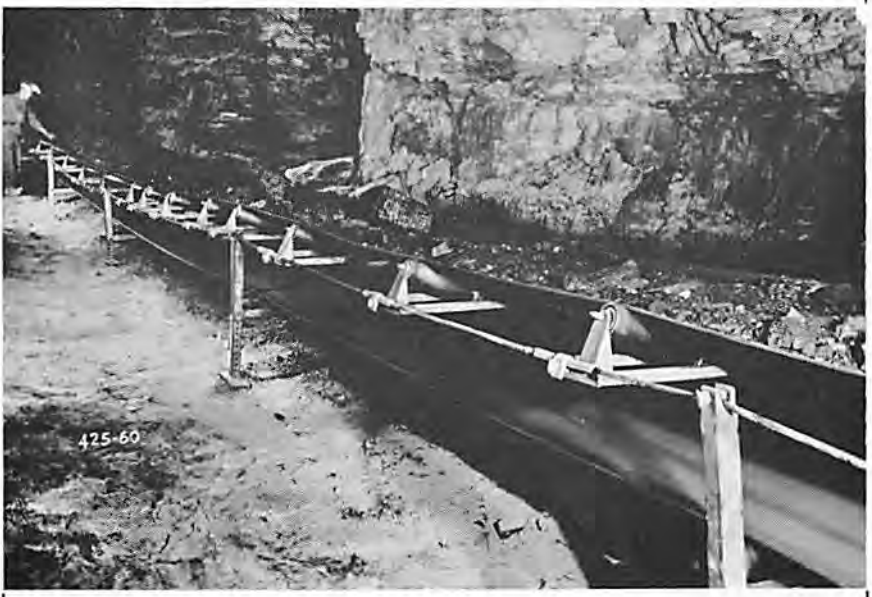
US RUBBER

JAKE'S TIRE & RECAP

1001 N. COURT ST. • PHONE WYANDOTTE 3-8136
MARION, ILLINOIS

Jake Sells the Best and Repairs the Rest

This Jeffrey Conveyor *(Rope Belt Type)* is VERSATILE



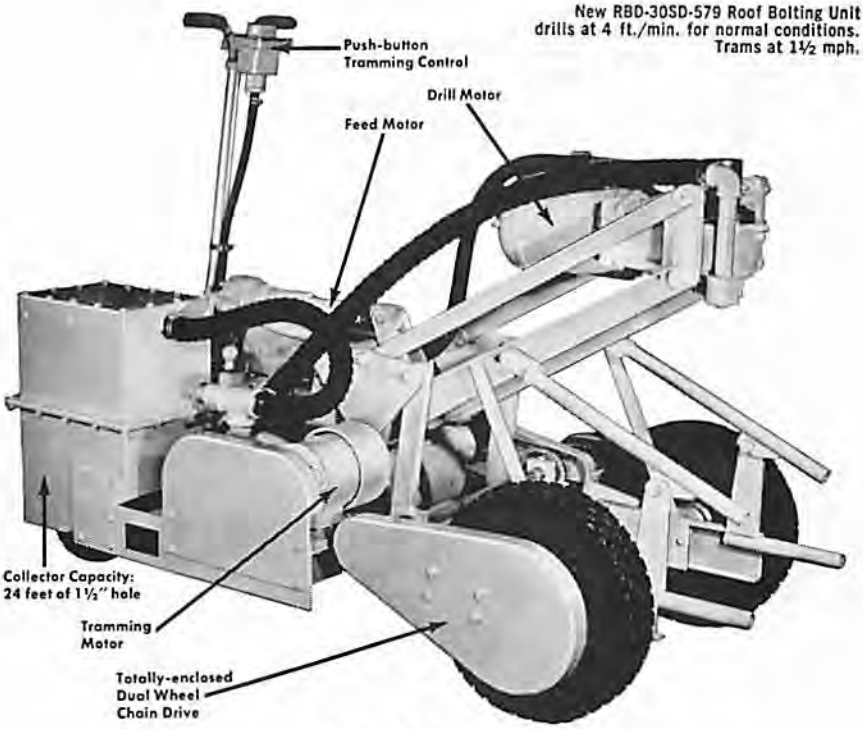
Install it above or below ground—to handle coal, salt, gypsum, ore, clay, shale, sand, gravel and other materials. You'll find it surprisingly low in first cost and easy to install. Easy to relocate, too.

Belts last longer on these Jeffrey rope type belt conveyors, because of the spring action of the flexible support as loads pass over troughing idlers. And the Permaseal Idlers are sealed to keep out dirt; prelubricated for years of maintenance-free operation.

For bulletin 970 containing detailed information on these conveyors, write The Jeffrey Manufacturing Company, 953 North Fourth Street, Columbus 16, Ohio.

If it's conveyed, processed or mined it's a job for Jeffrey.

JEFFREY



NEW CP ROOF BOLTING UNIT

features "AUGERMATIC" dust collection system!

RBD-30SD-579 completes entire bolting cycle in less than 3 minutes . . . trams itself anywhere!

The new RBD-30SD-579 Roof Bolting Unit has an all new "Augermatic" thru-the-auger dust collection system with a capacity of 24 feet of 1½" hole. Push-button tramming controls, handle-mounted for ease of positioning unit. Drill motor, with 30% more power, is fully enclosed . . . permits unit to complete cycle from drilling to bolt setting in less than 3 minutes. 40% increase in gear strength means beefed-up capacity in auger and bolt setter gear train. Internal spindle drives drill at efficient speed for Tungsten Carbide cutter heads. External spindle drives low-speed bolt setting socket. Operates on 250-500 volts, ac.

A Kentucky mine averaged 100 roof bolting installations per shift, drilling 1¼" to 1½" holes to 42" depth in formations of rock, slate and shale.

Chicago Pneumatic

8 East 44th Street, New York 17, N. Y.

PNEUMATIC TOOLS • AIR COMPRESSORS • ELECTRIC TOOLS • DIESEL ENGINES
ROCK DRILLS • HAND HELD HYDRAULIC DRILLS • VACUUM PUMPS • REICHDRILLS

More Tonnage from WHYTE STRAND WIRE ROPE

These ropes tried and proved on hundreds of installations like yours are built of the finest steels and Internally Lubricated.

Give these ropes a real trial on your equipment.

Save time and money—order WHYTE STRAND.

Stocked by Macwhyte Wire Rope Company and Macwhyte distributors.

Manufactured by MACWHYTE WIRE ROPE COMPANY
KENOSHA, WISCONSIN. MFRS. OF WIRE,
WIRE ROPE, AND BRAIDED WIRE ROPE SLINGS

USE	ROPE DESCRIPTION
Shaft Hoists	6x25 Filler Wire, 6x21 Filler Wire; *PRE*formed Whyte Strand with Fiber Core
Incline or Slope Hoists	6x19 Seale, 6x21 Filler Wire, 6x7; *PRE*formed Whyte Strand with Fiber Core
Mining Machines and Loaders	6x36 Warrington Seale *PRE*formed Whyte Strand with Fiber Core or *PRE*formed Whyte Strand* IWRC
Stripping and Loading, Shovels	6x25 Filler Wire, 6x41 Filler Wire; Lang Lay *PRE*formed Whyte Strand* with IWRC
Stripping Draglines	6x21 Filler Wire, 6x25 Filler Wire; Lang Lay *PRE*formed Whyte Strand* with IWRC
Shaft Sinking	18x7 Non-Rotating "Kilindo" *PRE*formed Whyte-Strand
Blast Hole Drilling	6x21 Filler Wire "Hi-Lastic" Drilling Line 6x7 Mild Plow Steel Sand Line
Car Pullers	6x25 Filler Wire, 6x19 Seale; *PRE*formed Whyte Strand* with IWRC
Scraper Loaders, Tuggers and Slushers	6x19 Seale, 6x25 Filler Wire; *PRE*formed Whyte Strand* with IWRC

*Whyte Strand is stocked in either *PRE*mium or Monarch grades. *PRE*mium is used for application where additional tensile strength (15% over Monarch) is indicated for greater factor of safety.

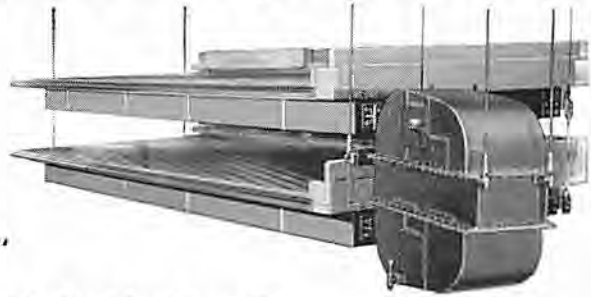
Get WHYTE Strand *PRE*formed Internally Lubricated WIRE ROPE

MACWHYTE Wire Rope COMPANY

Main Office and Works — KENOSHA, WISCONSIN

CHICAGO OFFICE AND LARGE STOCK — 228 SOUTH DESPLAINES STREET

CONCENCO* PREPARATION EQUIPMENT



Patents Pending

The New CONCENCO "77" Diagonal-Deck Coal Washing Table Doubles Capacity

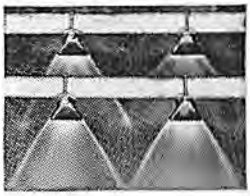
Here is a revolutionary concept embodying twin DIAGONAL-DECK* construction in floating suspension. All the advantages of the famous DIAGONAL-DECK Table are duplicated in each of the "77's" twin decks. In addition, the decks in floating suspension are actuated by a single head motion that operates quietly and smoothly with power consumption of less than 3 H.P.

The SuperDuty* DIAGONAL-DECK Table continues to lead the field where single deck tables are required.

CONCENCO* FEED DISTRIBUTORS — The Concenco Revolving Feed Distributor is used wherever equal distribution of feed to batteries of tables or other machines is desired. This heavily fabricated, all steel distributor operates with a 1 H.P. motor.

LEAHY SCREENS—The New Model E Leahy* No-Blind* Vibrating Screen has no equal in fine mesh screening—recovery of heavy media—desanding. Leahy screens are built in . . . open, totally enclosed or dust proof types with single or double surface.

Now available with FlexElex* *integrated* screen jacket heating for high capacity and efficiency in screening damp coal at fine meshes.



CONCENCO SPRAY NOZZLES—These handy nozzles are simple, flexible and economical. All you do is drill holes, clamp on and get results. They can be definitely aligned for washing, sluicing or spraying according to the need. They are removed or replaced in a moment's time.

CONCENCO SUPERSORTER—The Concenco SuperSorter is a multiple cell giant classifier for the hydraulic classification of coal table feeds and the cleaning of coal.

CONCENCO PRODUCTS

* Trade Marks Registered

The Deister Concentrator Company, Inc.

The ORIGINAL Deister Company

INCORPORATED 1906

941 GLASGOW AVENUE **FORT WAYNE, INDIANA**

Coal Washing Tables — Vibrating Screens — Feeders — Classifiers — Spray Nozzles

Long-Airdox's development of the "Lo-Rope" principle to perfect modern wire rope side frame design offers many important benefits. Savings in time and labor for installation and maintenance plus greater load-carrying capacity reduce haulage costs to a minimum.

In this design, precision roller bearings are combined with a highly effective labyrinth seal to provide an idler roll that's unequalled in performance. Low idler drag holds pull requirements to a minimum. The floating nylon labyrinth seal offers the advantages of a modern sealed bearing while retaining free-turning and re-greasing ability.

Here are a few more reasons why you can move more coal more profitably with a Long-Airdox "Lo-Rope" belt conveyor.

Reduced labor costs—conveyor stays aligned—platform rocker support stands can't walk out of position.

Increased belt capacity—fixed deep troughing angle (20°, 27°, or 35°) gives greater payload without spillage.

Belt stays centered—design provides automatic self training.

Automatic leveling of belt—made possible by adjustable support stands. Blocking for uneven bottom is eliminated.

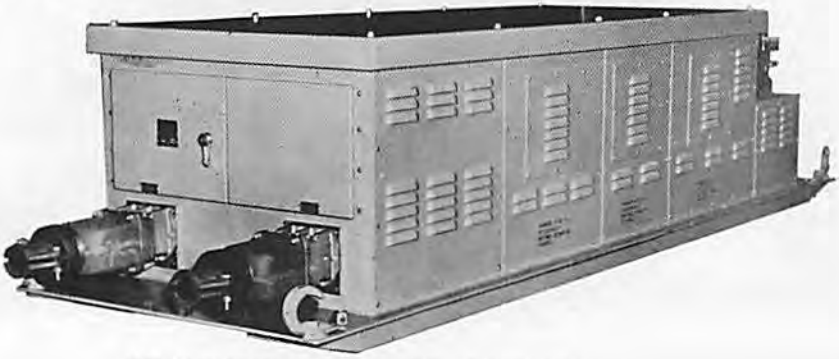
Conveyor moves simplified—the "Lo-Rope" has fewer components.

Belting lasts longer—no possible contact with idler or stand connections to wire rope.

For complete information, write the Long-Airdox Company, Division of Marmon-Herrington Company, Inc., Oak Hill, West Virginia.

LONG-AIRDOX

ENSIGN ELECTRICAL EQUIPMENT
FOR A.C. MINING



300 KVA Ventilated Underground Power Transformer

Neutral Grounding Resistor

Disconnecting Junction Box with High Voltage Plugs and Kirk Interlock

Multi-Circuit Low Voltage Underground Distribution Box

High Voltage Underground Switch House

ENSIGN

ELECTRIC AND MANUFACTURING COMPANY

914 Adams Avenue Huntington, West Virginia

Northern Illinois and Northern Indiana

HEADQUARTERS

for the finest in construction and mining equipment

ALLIS-CHALMERS
Tractors, Motor Graders, Motor Scrapers, Gas Engines, Diesel Power Units and Generators
Tracto-Shovels and Tracto-Loaders, Side Booms

BETHLEHEM STEEL CO.
Wire Rope

BLAW-KNOX
(Construction Equipment Division)
Concrete Construction Machinery, Clamshell Buckets, Street Forms, Truck Mixers, Asphalt and Concrete Finishers

BUCYRUS-ERIE CO.
All size Shovels, Cranes and Draglines
Rock Drills
Hydro Cranes

BUFFALO-SPRINGFIELD
Rollers
Kompactors

CLEVELAND TRENCHER
Ditchers, Backfillers and Tampers

GRADALL
Multi-Purpose Excavators

IOWA MFG. CO. (Chicago Territory)
Cedarapids Asphalt Plants, Aggregate Plants and Crushers
Soil Compactors
Bituminous Pavers

LA CROSSE TRAILERS
Heavy-Duty Trailers

PACIFIC CAR AND FOUNDRY
Winches and Hoists

SHOVEL SUPPLY
Disc Harrows, Tampers, Rubber Tired Rollers

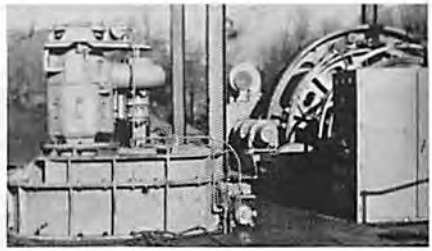
D. D. KENNEDY, INC.

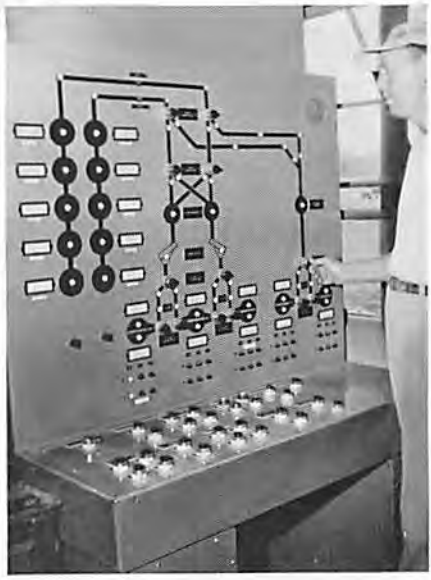
Mannheim Road (U. S. 45) at Madison St.
P. O. Box 177, Bellwood, Illinois
Phone: (Chicago) AUstin 7-4300 (Suburban) LInden 4-5600

2605 Huffman Blvd.
Box 238, Rockford, Illinois
Phone: WOodland 5-8759

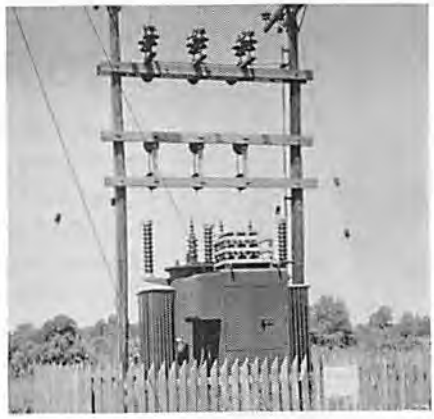
255 5th Ave.
Milan, Illinois
Phone: 787-1910

6915 W. Chicago Ave.
Gary, Indiana
Phone: TUrner 6-3778





A WESTINGHOUSE
COORDINATED
ELECTRICAL SYSTEM
IS TAILORED TO
YOUR PROCESS EVERY
STEP OF THE WAY



Westinghouse

9834

TOOL STEEL GEAR & PINION CO. HARDENED PRODUCTS ARE WIDELY USED IN MINING INDUSTRY

Guaranteed to deliver longer life in the same service than any other competitive product.

Hundreds of "Tool Steel Process" products used in the Mining Industry include all types of gears and pinions, sprockets, sheave wheels and pins, walking pinions, cab rollers, cat drive clutches, conveyor rolls, vertical swing gears, spur gears and shaft pinions, rotating shafts, shipper shafts and pinions, etc. The Tool Steel Gear & Pinion Co. has supplied these phenomenally long wearing hardened steel products to the Mining Industry since 1909. They are famous as TSP products (an abbreviation of "Tool Steel Process"). The wearing surface is converted by our own process from low carbon steel, plain or alloy, to high carbon steel having approximately the same physical properties as the best grades of tool steel. This wearing surface (85-100 sclerescope) is of a depth to allow full permissible wear. It is supported by a specially treated and refined ductile core.

Complete information is available by writing The Tool Steel Gear & Pinion Co., Cincinnati 16, Ohio.

Let us know when you're ready to bolt your roof

...WE'LL SEND A BETHLEHEM ENGINEER TO DISCUSS IT WITH YOU

Our roof bolt engineers are specialists. By testing strata, they can recommend proper bolting procedures, and torque.

They'll help to get your men started on the bolting. And they'll check back with you to test and inspect.

The assistance of our able engineers—and the use of dependable Bethlehem roof bolts—can increase both safety and efficiency in your haulageways and tunnels.

When you're ready . . . just tell us when and where.

Steel

for Strength
. . . Economy
. . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

V-R RED BITS

It's the carbide that cuts!

The best carbide pays off in better cutting performance . . . that's why V-R Red Bits cut faster and last longer than all others.

The superior carbide in V-R Red Bits is quality controlled from the ore to the finished product and backed by 30 years of V-R carbide research and manufacturing experience.

Put these rugged bits to work in your mine for continuous trouble-free production. Quality carbide . . . plus engineering knowledge . . . plus complete V-R service add up to better cutting performance.

CREATING
THE METALS
THAT SHAPE
THE FUTURE

V-R VASCOLOY-RAMET

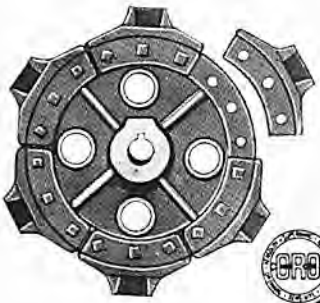
800 MARKET STREET • WAUKEGAN, ILLINOIS

M-825

NEW from Kensington LONGER WEARING Rivetless Chain

The first innovation in Rivetless chain in years — a new design to give you longer chain life in tough operating situations. Made from KENKROME, already proved as an excellent metal for wear and shock resistance, Kensington's new "Long Wear" Rivetless chain is another example of design improvement and quality products to help solve your chain operating problems.

Kensington "Long Wear" Rivetless chain has 20% more metal in the side-bars to give you more strength, and a wearing area 50% larger than that of ordinary rivetless chain. Made in all standard sizes, "Long Wear" chain means less chain maintenance, increased service life, and real savings in your operating costs.



Kensington Renewable Tooth Sprockets can save you those extra maintenance hours on premium time. No need to change out hubs — within a lunch hour, you can replace a complete set of tooth segments without removing your chain.

Kensington STEEL

Division of Poor & Co.

505 E. Kensington Ave. Chicago 28, Ill.
Phone PUllman 5-9280 Cable Address Kensteel

The Sincere

Thanks

of the Officers and Members of the
ILLINOIS MINING INSTITUTE

goes to

THE ADVERTISING COMMITTEE
J. W. Broadway, *Chairman*

W. D. Butts
William Campbell
R. A. Dodds
Ray L. Fiedler
Carl T. Hayden
R. J. Hepburn
L. B. Hyett
W. A. Patty
R. Y. Spikings
Norman Syljebeck
R. A. Taucher

Their willingness and efficient cooperation
have helped make this yearbook possible.

INDEX TO ADVERTISERS

Page

D

E

F

Page

G

H

I

J

Page

K

L

M

N

O

Page

P

R

S

T

Page

U

V

W

Y