PROCEEDINGS

of the

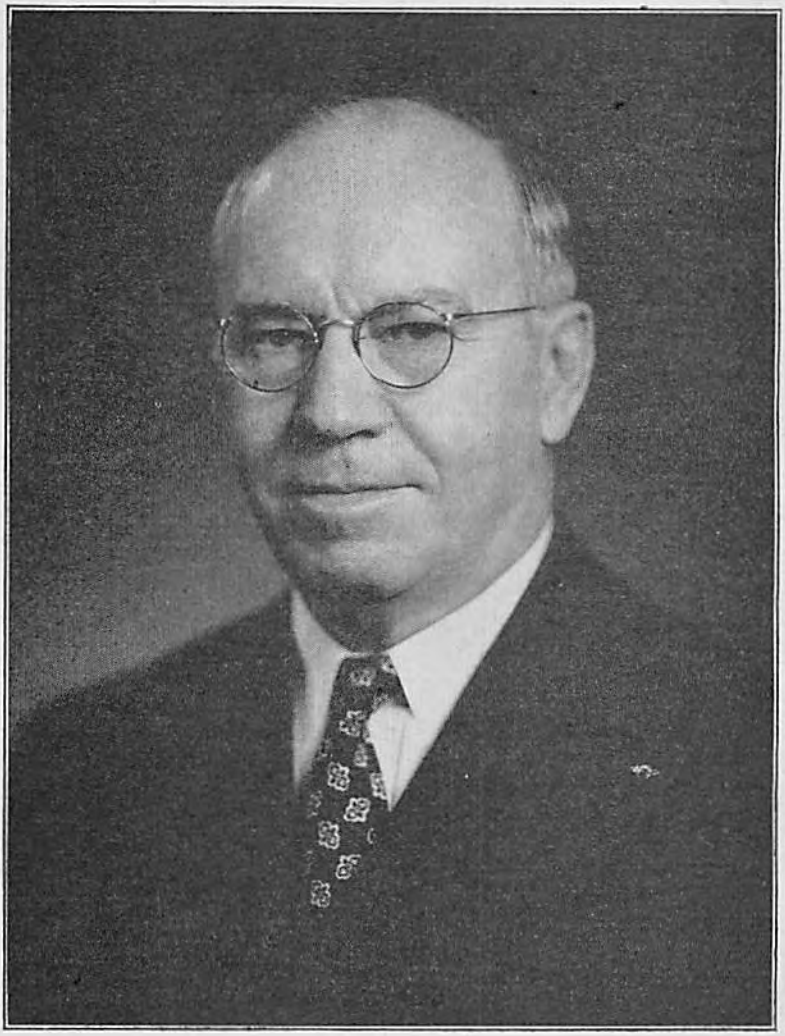
ILLINOIS MINING INSTITUTE

FOUNDED FEBRUARY, 1892

Fifty-Fifth Year

1947

Annual Meeting
SPRINGFIELD, ILLINOIS
October 31



Robert M. Medill

President, 1947

In Loving Remembrance

WILLIAM ORTMAN, Feb. 22, 1931
S. W. FARNHAM, March 12, 1931
H. C. PERRY, April 13, 1931
A. J. SAYERS, Oct. 11, 1931
C. E. KARSTROM, March 24, 1932
JOSEPH D. ZOOK, May 28, 1932
EDWARD CAHILL, Aug. 4, 1932
JOSEPH VIANO, Dec. 12, 1932
JOHN ROLLO, Feb. 6, 1933
DAVID I. ROCK, Aug. 2, 1933
WM. HUTTON, Aug. 18, 1934
FRED K. CLARK, Oct. 24, 1934
ERWIN CHINN, April 16, 1935
ADAM CURRIE, June 12, 1935
W. H. SLINGLUFF, Sept. 10, 1935
CHAS. B. SPICER, Oct. 26, 1935
NELSON P. MORRIS, Sept. 3, 1936
DON WILLIS, Dec. 9, 1936
T. E. COULEHAN, Jan. 11, 1937
ALBERT WEBB, March 5, 1937
H. B. COOLEY, March 23, 1937
C. W. SWANSON, July, 1937
JOSEPH McFADDEN, Sept. 15, 1937
E. G. LEWIS, Sept. 21, 1937
E. L. STEVENS, Sept. 28, 1937
W. C. ARGUST, Dec. 17, 1937
H. H. TAYLOR, SR., Dec. 28, 1937
E. L. BERGER, May 27, 1938
J. I. THOMPSON, June 24, 1938
P. W. MacMURDO, July 11, 1938
J. A. EDE, July 26, 1938
M. C. MITCHELL, Sept. 11, 1938
C. F. HAMILTON, Sept. 22, 1938
H. C. LONGSTAFF, Oct. 12, 1938
JOHN JOHNSON, Jan. 2, 1939
C. A. BLOMQUIST, Jan. 9, 1939
JOHN WHITE, April 15, 1939
CHARLES HAFFTER, May 21, 1939
BRUNO F. MEYER, July 21, 1939
JOHN A. GARCIA, Aug. 11, 1939
A. J. MOORSHEAD, Oct. 16, 1939
HARVEY E. SMITH, Nov. 6, 1939
C. W. McREAKEN, Nov. 30, 1939
C. C. HUBBART, March 4, 1940
SAMUEL HANTMAN, Sept. 13, 1940
SIMON A. BOEDEKER, Oct. 12, 1940
JOHN H. DAVIS, Oct. 21, 1940
S. J. WILLS, Oct. 22, 1940
HARRY HANTMAN, Nov. 5, 1940
J. W. GLENWRIGHT, Nov 27, 1940
J. C. WILSON, Dec. 18, 1940
NICHOLAS CHRISTENSEN, Dec. 26, 1940
JOHN W. POLING, Jan. 31, 1941
JOHN T. RYAN, Feb. 20, 1941
M. F. PELTIER, April 2, 1941
F. M. BEAN, April 30, 1941
F. M. SCHULL, Aug. 20, 1941
C. J. SANDOE, Aug. 29, 1941
F. F. SCHLINK, March 15, 1942
FRED F. GERMANN, March 31, 1942
JOHN MENTLER, April 28, 1942
HUGH MURRAY, June 5, 1942
G. D. COWIN, June 14, 1942
JAMES M. ROLLO, June 15, 1942
SYDNEY A. HALE, Aug. 12, 1942
BYRON BROWN, Sept. 17, 1942
J. E. SEYMOUR, Nov. 21, 1942
OTTO AWE, Dec. 6, 1942
A. F. ALLARD, Dec. 29, 1942
THOMAS R. STOCKETT, Feb. 15, 1943
A. R. JOYCE, April 7, 1943
W. S. BURRIS, April 9, 1943
A. H. MALSBERGER, May 7, 1943
J. B. FLEMING, May 19, 1943
H. T. MORGAN, May 29, 1943
E. W. HASENJAEGER, July 29, 1943
C. W. WATERMAN, Aug. 7, 1943
J. R. HURLBURT, Sept. 6, 1943
JAMES S. ANDERSON, Sept., 1943
F. F. JORGENSEN, Nov., 1943
E. W. BEARD, Jan. 5, 1944
W. M. ELDERS, Jan. 22, 1944
THOMAS ENGLISH, April 3, 1944
FRANK TIRRE, May 22, 1944
*J. K. CHILDS, June 10, 1944
W. S. STINTON, Dec. 6, 1944
E. W. HAWLEY, Jan. 29, 1945
J. C. ANDERSON, July 7, 1945
F. A. FLASKAMP, Aug. 12, 1945
JOHN M. DILLAVOU, Aug. 19, 1945
STANLEY A. TRENGOVE, Dec. 28, 1945
H. A. ZELLER, Jan. 22, 1946
M. K. HERRINGTON, May 11, 1946
L. W. BALDWIN, May 14, 1946
C. P. HOY, May 30, 1946
STUYVESANT PEABODY, June 7, 1946
PETER A. CASSADY, June 18, 1946
JOHN F. GOALBY, July 7, 1946
OSCAR WINTER, Sept. 21, 1946
GEORGE HOOK, Sept. 29, 1946
E. J. KRAUSE, Sept. 30, 1946
H. E. MABRY, Nov. 8, 1946
J. R. PEARCE, Dec. 10, 1946
E. R. ARMSTRONG, February 17, 1947
JOS. P. LENZINI, February 20, 1947
JOHN H. BAUER, March 12, 1947
ARTHUR PHILLIPS, June 27, 1947
LEE HASKINS, September 19, 1947
C. H. BURKHALTER, October 18, 1947
JETT J. WEST, November 11, 1947

* Killed in Action

PAST PRESIDENTS OF ILLINOIS MINING INSTITUTE

FOUNDED FEBRUARY, 1892

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

OFFICERS 1947

PRESIDENT

Robert M. Medill

Springfield, Illinois

VICE-PRESIDENT

Harry M. Moses

Pittsburgh, Pennsylvania

SECRETARY-TREASURER

B. E. Schonthal

28 E. Jackson Boulevard

Chicago 4, Illinois

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Alex Duncan **	H. A. Treadwell *
G. S. Jenkins **	A. H. Truax ***
E. R. Keeler **	L. A. Wasson ***
J. W. Starks *	W. P. Young *

* Term expires 1947
** Term expires 1948
*** Term expires 1949

OFFICERS 1948

PRESIDENT

Harry M. Moses
Pittsburgh, Pennsylvania

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B. E. Schonthal
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Alex Duncan *	A. H. Truax **
C. T. Hayden ***	H. L. Walker ***
G. S. Jenkins *	L. A. Wasson **

* Term expires 1948
** Term expires 1949
*** Term expires 1950

CONTENTS

FIFTY-FIFTH ANNUAL MEETING

EVENING MEETING

REPRINTS

PROCEEDINGS OF ILLINOIS MINING INSTITUTE
FIFTY-FIFTH ANNUAL MEETING

Held in Springfield, Illinois

FRIDAY, OCTOBER 31, 1947

MORNING SESSION

10 O'clock A.M.

The opening session of the Fifty-Fifth Annual meeting of the Illinois Mining Institute, convened in the Ballroom, Abraham Lincoln Hotel, Springfield, Illinois, at ten o'clock, President Robert M. Medill, Springfield, Illinois, presiding.

President Medill: Gentlemen, it is a pleasure to see you all here this morning. We know that a lot of the members are not in yet, but we are going to start the meeting as scheduled.

With your approval, we will dispense with the reading of the minutes of our last meeting this morning.

We will now have the report of the Committee on Scholarship. Dr. Walker, I believe, will report on that.

Mr. B. E. Schonthal (Secretary): Dr. Walker has not reported in as yet, Mr. Medill.

President Medill: We will let that go then until Dr. Walker comes in.

The next item to be considered, I believe, is that of unfinished business.

Mr. Schonthal: I have no unfinished business to submit.

President Medill: We will then have our Secretary's report.

SECRETARY'S REPORT

Your Secretary attended a very interesting and instructive meeting of the Indiana Coal Preparation and Utilization Society at Terre Haute, Indiana, on September 26. Inasmuch as the problems presented to that organization are common ones with those of our membership, it has been arranged that the papers presented there will be reprinted, with full permission of the Indiana organization, in our 1947 Proceedings, which we hope will be off the press early after the first of the year.

Unfortunately our Boat Trip was canceled again this year, because the boat met with a rather serious accident. At this moment it is doubtful the boat trips will be resumed, although we are in touch with a packet company which has been reported as putting a boat on the River. At the time of the accident to the boat we had ninety reservations.

The notice and program for today's meeting indicated it has been necessary to discontinue the practice of complimentary dinners to members, because of continually rising costs. This, of course, is very much regretted; but it is just one of those things that cannot be carried on any longer. The charge for the dinner is our actual outlay, and the Institute is not making any profit on that item.

We were unfortunate to lose three of our members by death this past year. The usual messages of condolence were sent their families. We depend upon advice from our members about any losses by death and hope that we have not overlooked any who have passed away during the period.

Our membership at the present time is 1092, including seven Life Members added during the year. Sixteen members resigned because of moving out of the territory. The year shows a net gain of 57 members since our last meeting.

Our financial position remains good. At the present time we have on hand bonds amounting to $10,000.00, and cash of $1,392.84.

We hope to have our Scholarship Plan more active next year. Conditions at the University of Illinois have been very crowded, but we still hope it will be possible to get several of our companies, as well as the young boys graduating from high school, interested in the plan. It will be helpful if the operating companies will cooperate with our organization by giving summer employment to the boys attending school.

I am reluctant to touch on a matter that I think is of considerable importance to the welfare of this organization and the benefits of this meeting. It is not an easy job to prepare for a meeting such as this one. It is quite disturbing to the members in attendance, to say nothing about the disrespect to the speakers at both the technical and the evening sessions, to have the noise that occurs in the outer halls of this meeting room. It is my belief that this is not willful on the part of those who disturb the meetings; but I should like to call it to the attention of everyone here so that each of those in attendance will help eliminate the noises in the back hall and back room. Many of you will recall that last year, when we had a most interesting speaker at the evening meeting, it was necessary to close the doors, shutting off the back half of the meeting hall so that those in the back room were not privileged to hear the speaker. It would be a very easy matter for those not interested in the program or the evening meeting to retire to other rooms or to the lobby. I wonder if I can ask the support of everyone here, and of everyone he comes in contact with, to help eliminate this disturbance, which borders on being a nuisance. If you will stop to realize the time and effort put forth by your officers to prepare this meeting, and the work and cooperation of those who have prepared the papers, anyone who is careless about the noises would promptly be more considerate.

Your Secretary wishes to thank the officers, the executive board members, and the committees—as well as the general membership—for all cooperation received during the year.

Respectfully submitted,

B. E. SCHONTHAL, *Secretary-Treasurer*

President Medill: A motion will be in order for the adoption of the Secretary's report.

Mr. W. R. Chedsey: Mr. President, I move that the report be adopted.

Mr. R. R. Clayton: I second that motion, Mr. President.

President Medill: Gentlemen, the motion for the adoption of the Secretary's report has been made. Do we have any discussion on it? If not, those in favor signify by saying, "Aye." Opposed, "No." The motion is carried unanimously and it is so ordered.

Mr. Schonthal: Mr. President, before we proceed further, I would like to make one additional statement.

I would like to report that our good friend Jeff called me on the telephone yesterday. He has been confined to his bed for the last ten days or two weeks with a very painful back ailment. He went downstairs yesterday, for the first time since his illness, to call me, and informed me that he would be unable to be here. Jeff has been a very loyal member of this organization. He has always helped whenever we needed him. He has never missed a meeting of this organization since becoming a member of it.

He was very sad that he was unable to be here, and I could not help hear him weeping over the telephone about it. He asked me to tell you boys how sorry he was that he would not be able to be here. He has been after his company for a year or two to retire, and the company finally agreed to give him his voluntary retirement as of the first of November. He wants us all to know that his company has given him a very wonderful retirement, and he is going down to Piedmont, Missouri, to live with his son. He wants everybody to know that his company is taking wonderful care of him and that he has nothing to worry about for the rest of his life.

I, personally, feel bad about his not being here because I have known Jeff since my early days in the business, and we formed a very dear friendship.

He is a very grand person and I want to pay tribute to him now.

I have a letter from Mr. Bluth, Manager of the Chicago Office of the National Coal Association, which he has asked me to present at the meeting. I am not going to read it as it would take too much time. It is a letter received from J. A. Krug, Secretary of the Interior, making an appeal to the coal industry to ship their scrap to the mills because there is a definite shortage of it, and it is felt if the coal mining industry would cooperate, and I have every reason to believe they will, and are, it would relieve the situation. He asked me to present the matter and to pass the word along.

That is all I have, Mr. President.

As I have the report of the Nominating Committee here, I might as well present that at this time.

REPORT OF NOMINATING COMMITTEE

Mr. B. E. Schonthal, Sec'y-Treas.,
Illinois Mining Institute,
28 E. Jackson Blvd.
Chicago 4, Ill.

Dear Bale:

The following is the report of your Nominating Committee for officers and Board of Directors for the Illinois Mining Institute for the coming year.

We have given this very careful consideration and feel sure our recommendations should have the hearty approval of the Institute.

PRESIDENT:

Harry M. Moses, President
H. C. Frick Coal Company,
1322 Frick Building,
Pittsburgh, Pennsylvania

VICE PRESIDENT:

J. Roy Browning, Vice Pres. and Commissioner
Illinois Coal Operators Assn.,
307 N. Michigan Avenue,
Chicago 1, Illinois

SECRETARY-TREASURER:

B. E. Schonthal
28 E. Jackson Blvd.,
Chicago 4, Ill.

THREE-YEAR TERM ON THE EXECUTIVE BOARD:

D. H. Devonald, Vice Pres. in Charge of Operations,
Peabody Coal Company,
231 S. La Salle Street
Chicago 4, Ill.

Carl T. Hayden, General Manager
Sahara Coal Company
59 E. Van Buren St.,
Chicago 5, Ill.

John Rodenbush, General Superintendent
Chicago, Wilmington & Franklin Coal Co.
Benton, Illinois

Professor Harold L. Walker, Head of the Dept. of Mining & Metallurgical Engineering
University of Illinois
Urbana, Illinois

Yours truly,

F. S. Pfahler, *Chairman*
J. A. Jefferis
J. W. Starks

I ask, Mr. President, that the report of the Nominating Committee be accepted.

Mr. Fred Pfahler: Mr. President, I move that the nominations be accepted, and that they be elected by voice vote.

Mr. John MacDonald: I second that motion, Mr. President.

President Medill: You have heard the motion. All in favor signify by saying, "Aye." Contrary, "No." The motion is carried and it is so ordered.

That winds up our preliminary work, with the exception of the report from Dr. Walker. We will now have the report on the Scholarship Committee by Dr. Walker.

Professor Harold L. Walker (Department of Mining and Metallurgical Engineering, Urbana, Illinois): We have only one active scholarship in mining at the University of Illinois during this semester, Mr. Robert Stephens of Benton, who is here this morning.

Another scholarship student graduated during the summer session, Mr. Robert Morris, who is now employed by the Sahara Coal Company in Harrisburgh, Ill. Mr. Morris is doing a very fine job. Another scholarship will become active during the present semester, and has been approved for Mr. Bruce Gilbert. He is a very fine young man. I like his history and his scholastic work; he was valedictorian of his class in high school, and he has a lot of outside interests. He attended the international Boy Scouts jamboree in France this summer, and I am sure he benefited greatly by it.

While student enrollment in Mining Engineering is not increasing such as Electrical, Civil, Sanitary and Chemical Engineering, and to some extent Metallurgical Engineering, there is some reason for that; one of the reasons for it being that during the war curricula in the mineral industries were not supported by the Government. Many of the boys coming back from military service had received some instruction in the universities in other engineering curricula, that is, Civil, Electrical, Chemical and Sanitary Engineering. They would rather continue with those courses than change and lose time. On the other hand, you just can not seem to get the young people interested in Mining Engineering. We have tried to do something about this, but we have not succeeded too well, as yet. I hope in time we may. We certainly have a good staff at the State University and we have good laboratory facilities. Everything is available for good instruction, but in a great number of cases the boys prefer to go to the mining schools rather than to large universities, and that may have some bearing on the problem.

I think that is about all I have to say, Bob.

President Medill: Mr. Roy Adams will you please come up here? I am now going to turn the meeting over to Mr. Adams.

Mr. R. L. Adams (Old Ben Coal Corporation, West Frankfort, Illinois): Gentlemen, I believe you have a copy of the first number of our program this morning before you. If you have not, I am sure you can find one so that you can follow the reading, and perhaps make such notes as you may desire as Mr. Bailey proceeds with the reading of it.

The first number is, "New Developments in Underground Fire Fighting Equipment," by Mr. Fred J. Bailey, Safety Director, Mining Division, Cardox Corporation, Chicago, Illinois. Mr. Bailey. (Applause.)

Mr. Bailey: Mr. President, members of the Illinois Mining Institute, this is a paper concerning mine fires, which is one of the most serious problems confronting mining men today.

(Applause.)

NEW DEVELOPMENTS IN UNDERGROUND FIRE-FIGHTING EQUIPMENT

By FRED J. BAILEY

Safety Director, Mining Division, Cardox Corp., Chicago, Illinois

The unusually large number of fires in underground coal mines in recent years has focused the attention of all mining men on the cause and extinguishment of mine fires. Some of these fires could possibly have been eliminated by improved safety procedures, however, no one can doubt that fires will continue to occur even in the best regulated mines. Improved fire fighting equipment and technique is therefore of prime importance in the struggle to save lives and dollars.

During the year 1944 a total of 88 fatalities occurred in three major mine fires. This does not include a large number of small fires in which less than 5 men were killed and much production time was lost. From the period 1869 to 1945 inclusive, there were 46 major disasters resulting in the loss of 1,258 lives. As a matter of record, this information has been detailed in Table I which gives the date, name of the mine, location, nature of the disaster, and the total number of persons killed in each disaster. The distribution of the fires and losses by states is shown in Table II.

This record indicates that the problem is serious and shows no signs of abatement. Because of the highly combustible nature of coal, dry timbers, explosives and other materials usually present in coal mines, the potential hazard of fire is always present. This is true whether the mine is dry or wet and whether it is gassy or non-gassy. The only factor needed is a source of ignition which may be provided by electricity, explosives, open lights or even by spontaneous combustion under certain conditions.

Obviously, fires cannot be eliminated, but a great deal can be done to control and extinguish them before they can become dangerous. Incipient fires can be extinguished fairly easily if the proper extinguishing agent is applied soon enough.

The choice of the proper extinguishing agent is not a simple matter. The nature of the fire itself is variable since it may involve coal, wood, oil or electrical equipment. In each case the conditions and requirements are different and no one known agent is satisfactory for all types.

Coal and wood produce smouldering deep seated fires containing great amounts of heat which must be removed before extinguishment is complete. This can be done by applying water copiously, however, the heavy clouds of steam generated tend to obscure vision and weaken the roof structure. A better method is to cover or seal in the burning material so as to prevent the entrance of oxygen necessary for combustion.

The contained heat will then be dissipated slowly by conduction to adjacent material.

Oil fires on the other hand are surface fires and do not in themselves involve deep seated embers. Foam can be used to cover open pools, but it is not effective on three dimensional fires such as occur on hydraulic machinery. Water is only useful when applied in the form of a fine spray or fog. Carbon dioxide and dry powder are the most effective extinguishing agents commonly available.

Electrical fires present an additional requirement in that the extinguishing agent must not conduct electricity. Carbon dioxide and dry powder fulfill this requirement. Carbon tetrachloride could also be used but because of its toxicity is undesirable in closed spaces. Carbon dioxide is most desirable because of the fact that it is effective and leaves no residue.

The greatest difficulty in extinguishing any mine fire lies in getting to the fire as quickly as possible after it is discovered. Obviously, the equipment must be compact and mobile. Further than that, the possibility of encountering heat, smoke and gas must be considered. Means must therefore be available for personnel to work in this atmosphere or to improve conditions by ventilation.

All of these problems have been considered by Cardox Corporation in the development of a new Mine-Fire Car. Two types of extinguishing agents are provided—a sealing or covering material called Fire Coat and carbon dioxide. By means of these two agents it is possible to effectively fight any type of fire that may be encountered. In addition to this the carbon dioxide can be utilized for ventilating purposes so as to clear away smoke and make approach to the fire easier and faster.

The Fire Coat sealing material consists of two water solutions of inorganic compounds which are stored in separate tanks. These solutions are conveyed to a special nozzle by means of a double hose line and mixed together as they are discharged. Immediately after being applied, the mixed solutions gel so as to form an air tight coating which seals all cracks and crevices.

Although the viscosities of the separate solutions are low enough for free flowing application, each contains a large percentage of solid material so that even after the water has been removed by evaporation a complete nonporous coating remains. Furthermore, the gel is sufficiently elastic so that there is no tendency for cracks to appear as the Fire Coat dries. The coating is therefore of a fairly permanent nature and will last for months under normal atmospheric conditions.

The use of Fire Coat has been found to be very effective in extinguishing deep seated coal fires. The material is easily applied by simply spraying over the surface. Because of the rapid gelling action the material does not penetrate deeply and therefore very little steam is formed. The generation of smoke is also quickly reduced and finally eliminated even though the coal below the coating may be at combustion temperature. At this stage the fire can be considered under control inasmuch as normal visibility and ventilation will be restored.

Another important use of the Fire Coat seal involves its application on brattice cloth to effect quick temporary seals. In case it is impossible to fight a fire directly the space involved must be closed off from the rest of the mine. Brattice cloth seals can be erected quickly and made air tight by spraying with Fire Coat. The speed with which an effective seal can be constructed is an important factor when fighting fires by this method.

The effectiveness of carbon dioxide in extinguishing oil and electrical fires is well known. The use of carbon dioxide can also be of considerable value in connection with fires which must be sealed in with temporary stops. By injecting the carbon dioxide into the sealed in space the chances of an explosion due to methane gas can be greatly reduced or completely eliminated, depending on the concentration obtained. The presence of carbon dioxide will also hasten the complete extinguishment of the fire by reducing the percentage of oxygen in the air.

A convenient ventilating means is provided in the form of an aspirator. Carbon dioxide is discharged through a nozzle located near the throat of a venturi. In this way air is drawn into the venturi tube and discharged from the outer end at high velocity. When this stream of air and carbon dioxide is directed towards a door or passageway a general movement of air is set up which provides efficient ventilation. It is believed that this device will be especially valuable in blowing smoke out of passageways so that the fire fighters can see what they are doing.

The Mine-Fire Car shown on the attached bulletin carries two 100 gallon tanks for the gel solutions. A double hose line 250 feet long is provided on one reel. Energy for discharging the solutions is obtained by pressurizing the storage tanks with a cylinder of nitrogen.

The unit also carries 1500 pounds of low pressure carbon dioxide in an insulated and refrigerated pressure vessel. The carbon dioxide is conveyed to the discharge nozzle by means of 250 feet of hose. In order to facilitate the use of the carbon dioxide the functions of the ventilating aspirator and a horn type discharge nozzle are combined in a single convenient unit. This unit also contains a "bayonet" nozzle which can be used to inject carbon dioxide through a brattice seal or into any restricted opening. The model Mine-Fire Car as described was thoroughly tested both in the open and in a simulated coal mine entry constructed of blocks of coal. Typical results of these tests are as follows:

Test No. 1: A fairly large coal pile fire was ignited in the simulated mine entry and after this fire had burned for approximately 6 hours, fuel oil was sprayed on it to accelerate the burning. The equipment operators then used the flexible hose containing carbon dioxide, with the nozzle adjusted for ventilating purposes, to advance to the fire. Another man followed closely with the Fire Coat nozzle, the coal pile was covered with the gel solutions and, within a few minutes, the fire was extinguished. Where the coal ribs were burning very freely, the gel solution was sprayed on them forming an elastic air tight coating which extinguished the fire.

Test No. 2: Loose canvas bags, with a number of holes in them, were hung on a wooden framework to represent a temporary stopping that

TABLE I: Major Disasters Caused by Mine Fires in United States Coal Mines
From 1869 to 1945 Inclusive

Date	*Name of Mine*	*Location of Mine*	*Nature of Disaster*	*Persons Killed*
1869, Sept. 6	Avondale	Plymouth, Pa.	Mine Fire	179
1884, Aug. 21	Buck Ridge	Shamokin, Pa.	Mine Fire	7
1890, June 16	Hill Farm	Dunbar, Pa.	Mine Fire	31
1891, Feb. 4	Spring Mountain	Jeansville, Pa.	Mine Fire	13
1893, Aug. 1	Neilsen	Shamokin, Pa.	Mine Fire	10
1894, Aug. 24	Franklin	Franklin, Wash.	Mine Fire	37
1894, Oct. 8	Luke Fidler	Shamokin, Pa.	Mine Fire	5
1897, Sept. 20	Belle Ellen	Belle Ellen, Ala.	Mine Fire	5
1897, Sept. 28	Jermyn No. 1	Rendham, Pa.	Mine Fire	5
1897, Oct. 30	Von Storch	Scranton, Pa.	Mine Fire	6
1898, Oct. 1	Midvale	Wilkes Barre, Pa.	Mine Fire	5
1900, Aug. 21	Issaquah No. 4	Issaquah, Wash.	Smoke from burning air shaft	5
1901, Feb. 25	Diamondville No. 1	Diamondville, Wyo.	Mine Fire	28
1901, Nov. 14	Pocahontas	Pocahontas, Va.	Mine Fire & Expl.	9
1901, Nov. 22	Pocahontas	Pocahontas, Va.	Mine Fire	8
1902, Jan. 13	Milby and Dow	Dow, Oklahoma	Mine Fire	10
1903, June 30	Hanna No. 1	Hanna, Wyo.	Explosion & Fire	169
1904, May 5	Locust Gap	Locust Gap, Pa.	Mine Fire	5
1905, Jan. 16	Decatur	Decatur, Ill.	Mine Fire	6
1905, Oct. 13	Clyde	Frederickston, Pa.	Mine Fire	6
1905, Dec. 4	Horton	Horton, Pa.	Mine Fire	7
1906, June 7	Red Lodge	Red Lodge, Mont.	Mine Fire	8
1907, May 19	Engleville	Engleville, Colo.	Mine Fire	5

Date	*Name of Mine*	*Location of Mine*	*Nature of Disaster*	*Persons Killed*
1908, Aug. 26	Hailey-Ola	Haileyville, Okla.	Mine Fire	29
1908, Nov. 20	Red Lodge	Red Lodge, Mont.	Mine Fire	9
1909, Jan. 10	Zeigler	Zeigler, Ill.	Expl. & Mine Fire	26
1909, Nov. 9	Auchincloss	Nantocoke, Pa.	Mine Fire	9
1909, Nov. 13	St. Paul No. 2	Cherry, Ill.	Mine Fire	259
1910, Nov. 8	Victor-American No. 2	Delagua, Colo.	Expl. & Mine Fire	79
1910, Dec. 14	Leyden	Leyden, Colo.	Mine Fire	10
1911, Apr. 7	Price Pancoast	Throop, Pa.	Mine Fire	72
1912, Feb. 22	Western No. 5	Lehigh, Okla.	Mine Fire	9
1914, June 30	Cinderella	Cinderella, W. Va.	Suffocated by fumes from fire in fanhouse	5
1918, May 20	Villa	Charleston, W. Va.	Mine Fire	13
1919, Oct. 29	Amsterdam No. 2	Amsterdam, Ohio	Mine Fire	20
1920, Nov. 16	Arnold	Earlington, Ky.	Mine Fire	6
1921, Feb. 23	Kathleen	Dowell, Ill.	Mine Fire	7
1921, Dec. 13	Satanic	Morrison, Colo.	Mine Fire	6
1925, Dec. 23	Webb	Bellaire, Ohio	Mine Fire	9
1934, Mar. 12	No. 10	Wheatcroft, Ky.	Mine Fire	5
1935, May 11	Barrackville	Barrackville, W. Va.	Fire in hoisting shaft	6
1936, Aug. 1	Kathleen	Dowell, Ill.	Mine Fire	9
1943, Jan. 8	No. 15	Pursglove, W. Va.	Mine Fire	13
1944, Mar. 25	Katherine No. 4	Lumberport, W. Va.	Explosion following a mine fire	16
1944, June 7	Emerald	Clarksville, Pa.	Mine Fire	6
1944, July 5	Powhattan	Powhattan, Ohio	Mine Fire	66

TOTAL major mine fires.....................46   TOTAL lives lost.....................1,258 would be used in the temporary sealing of a mine fire area. The Fire Coat nozzle was then used and the canvas was sprayed with the Fire Coat. All holes in the canvas were immediately closed and within one-half of a minute the entire surface representing the stopping was covered with a flexible fire proof coating. In one instance a crack about 4 feet in length and about 1½ inches in width was filled and made solid and air tight with the solution.

The tests described are indicative of what might be accomplished in an actual mine fire. The unit in question has great flexibility for coping with variable conditions.

First—It provides a ventilating means driven with carbon dioxide to drive the smoke and heat from the area where the fire exists.

Second—It provides a sealing material, Fire Coat, which is effective in controlling and extinguishing deep seated coal fires.

Third—It provides carbon dioxide for quick extinguishment of oil and electrical fires.

Fourth—It provides a means to quickly construct air tight temporary seals by spraying Fire Coat over brattice cloth or other materials.

Fifth—It provides a means of reducing or eliminating the possibility of explosion in sealed off areas by injecting carbon dioxide.

It is believed that these features will make this unit particularly effective in combating mine fires of all types.

TABLE II: Summary, Showing the Total Major Disasters Caused by Mine Fires, and the Total Lives Lost in the Mine Fires in Each State, From 1869 to 1944 Inclusive

State	*Total Major Disasters Caused by Mine Fires*	*Total Lives Lost in the Major Disasters Caused by Mine Fires*
Pennsylvania	14	359
Illinois	5	307
Wyoming	2	197
Colorado	4	100
Ohio	3	95
West Virginia	6	60
Oklahoma	3	48
Washington	2	42
Virginia	2	17
Montana	2	17
Kentucky	2	16
Alabama	1	5
TOTAL Major Mine Fires	46	TOTAL Lives Lost 1,258

Chairman Adams: Now, Mr. Bailey will show his film in connection with the paper just presented.

(The film was then shown.)

Chairman Adams: Gentlemen, this paper is now ready for discussion. Does anyone have any questions to ask on this matter?

Professor Walker: I think this has been a very excellent demonstration of an effective method of fighting mine fires. You will notice that emphasis has been made on the use of gels for smothering fires and that is proper.

The thing I want to do is to bring to your attention, if I may impose a little theory on you, is erroneous opinion that many may have of the use of carbon dioxide for such an application. The firm of Cardox Corporation does not make any claim for extinguishing fires by carbon dioxide; but I have heard of cases where men wanted to flood an area in a mine with a fire in it with the expectation of putting out the fire.

Carbon dioxide is, in certain cases, an effective fire extinguisher. It is good for oil. Why? First of all, the oil is not at a temperature high enough to cause a reaction with the carbon dioxide; secondly, because of the large volume of cold gases, the temperature of the combustion gases is reduced and, thirdly, the carbon dioxide forms a blanket over the oil excluding the oxygen. This is not the case, gentlemen, when you have a coal fire or a wood fire, and carbon dioxide is not an effective extinguisher, and I do not think that Mr. Bailey would disagree with that.

Now, I should like to caution you not to attempt to go into a mine area and by merely throwing carbon dioxide gas from a cylinder on a hot fire, expect it to be effective; it just will not do it. You are liable to get into difficulty with the air resulting from it, that is, the resulting gases that go into the air. In the metallurgical industry the reaction

$$CO_2 + C = 2CO$$

is well known and takes place in the blast furnace. The equation tells us that when one mol of carbon dioxide gas comes in contact with incandescent carbon that two mols of carbon monoxide are formed. You will recognize the carbon monoxide gas as a poisonous and combustible gas. Carbon monoxide gas will burn if it remains above the kindling temperature and is furnished oxygen. You will also notice that one volume of carbon dioxide gas produces two volumes of carbon monoxide gas when the reaction takes place. Carbon dioxide gas is not considered to be an effective and desirable fire extinguisher for coal or wood fires.

The basis for the use of carbon dioxide gas in the Cardox mine fire equipment is the removal of smoke and fumes from the area by blowing in CO_2 under high pressure. This permits increased visibility and may to some extent lower the temperature of the immediate area. The fire is extinguished by the use of the gel which hardens on the surface of the burning coal and thereby excludes oxygen from the combustion zone. Since oxygen is excluded further combustion can not take place. Again I wish to caution you in the use of carbon dioxide gas alone for fighting carbonaceous fires.

I should like to go a little bit further, also, on the use of carbon tetrachloride. The implication in the paper is that it is noxious; so it is.

However, in contact with fire, it decomposes rapidly, and a much worse and more deadly gas, phosgene, is formed. It may be good against certain types of fires, but I would not recommend it for coal fires or for timber fires in a mine. I have no intention of detracting from the value of Mr. Bailey's paper because I think it is an excellent paper on combating mine fires. (Applause.)

Chairman Adams: Do we have any further remarks? If not, we will pass on to the next subject on this morning's program, which is, "Cyclonic Washing of Fine Coal," by Mr. J. W. MacDonald, Chief Engineer, Old Ben Coal Corporation, Christopher, Illinois.

(Applause.)

CYCLONIC WASHING OF FINE COAL

By J. W. MacDONALD

Chief Engineer, Old Ben Coal Corporation, Christopher, Illinois

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Fine coal, being the least in dimension of the coal sizes usually made, is also the last to receive serious consideration with regard to cleaning.

Similar lack of consideration in some Eastern fields is not objectionable due to the normal high quality of their fine coal.

We find some Eastern coals where the ash content of the raw fines is equal to, or lower than, found in their larger sizes after washing.

Equal advantage is not provided in the Illinois field. Our fine coal ash content on a raw basis is generally about double the amount which remains after washing the larger sizes.

The history of coal preparation shows initial attention was directed to improvement of the lump coal. The furnace, egg and nut coals receiving consideration of lesser extent with each reduction of size during the early days.

Screenings, being the smallest of early sizing, was given a minimum of consideration by most operators. In many instances the screenings were considered as being near a waste product with disposition made well below the cost of production.

A similar situation is now provided with regard to the fines from dedusting or washing. We may also anticipate similarity of future experience. Improved preparation should provide a product with sufficient quality to warrant a sales realization at least equal to the cost of production.

The present general trend toward breaking or crushing of lump to within the size limits for convenient washing and the extent of crushing the nut coals to stoker sizes, have together provided a material increase in the ratio of fine coal produced.

Disposition of the fines has presented a difficult task where price concessions have not avoided the necessity of wasting this material in some instances.

Fine coal for the purpose of this discussion will be taken as the minus 10 Mesh product made from dedusting, and the so-called -28M. product passing through the dewatering screens after washing.

Washability data show the difficulties of separation are lessened with each reduction of coal size until reaching the 10M. division.

Fine coal will provide a minimum of pieces with adhering impurities. The smaller pieces also present an increased percentage of material within a range of ten points above and below the specific gravity normally used for separation.

Fine coal from dedusting and sludge or the fines from dewatering washed coal present sufficient difference to require separate consideration.

The -10M. material from dedusting or stoker coal preparation amounts to nearly a tenth of the mine output on a normal basis of sizing. This unfavorable ratio is increased in those plants equipped to provide increased domestic stoker by crushing the nut coals or lump coal reduction.

The normally dry products from dedusting provides sufficient advantage in the better grade coals to preclude the expense of washing and subsequent drying.

Pneumatic cleaning affords beneficiation which is limited in general to the 10M. x 48M. division. Extraneous or surface moisture beyond the limits secured from relatively dry mining operations entails reduced efficiency of cleaning.

Water spray application to the coal face or on the mining machine cutter bar with attendant increase of the fine coal surface moisture, may suffice to govern the future choice as between pneumatic or hydro cleaning.

Washery sludge or the fine coal which passes through the dewatering screens with subsequent general disposal as waste presents opportunity of salvage, which merits increased attention.

The usual dewatering screens are equipped with ½ mm. slotted aperture considered equivalent to 28 Mesh. The 28M. x 0 portion of 1½" screenings approximates a tenth of product and amounts to 4 or 5% of the total hoisted.

These ratios approximate the amount of fine coal which obtains when using new dewatering screen. Subsequent screen wear provides increase of fine coal loss, as occasionally continued after replacement of the expensive screen cloth becomes economically desirable.

Fine coal loss in dewatering washed coal is reduced in some operations by removal, so far as practicable, before washing. Separations are made by screening or pneumatic removal. Extraneous moisture proves a critical factor in limiting the efficiency of separation in either case.

Pneumatic removal of the finest affords advantage by providing nearly normal efficiency after handling real damp material, where most screens would instead remain blinded.

Some oversize due to fracture shape will be found in the fines removed by aspiration. Similar oversize flat pieces are found in the sludge. Maximum economy of operation is provided by avoiding oversize in the salvaged fines beyond those dimensions which would otherwise be lost in the sludge waste.

Removal of fines, so far as practicable before washing, does not entirely eliminate the opportunity of subsequent salvage. The efficiency secured in attempted removal and the volume remaining will govern the need and justification of salvage in each plant.

Washery sludge, or the so-called minus 28M. fines, will frequently contain 30 to 50% of oversize, as determined by sieve analyses. It will also contain about 10% or less of -100M. material after loss of nearly half the real fine dust in the water wasted or passing to the clarification system.

Sludge from washing a better than average coal has been found to carry around 85% material which floats at 1.50 Sp.G. Assuming 80% recovery to provide a premium grade product, it would amount to better than 70% reduction of the general loss after allowance for slime wasted.

Sieve analyses show the material to be substantially a 14 or 20M. x 100M. product, due to inclusion of the slabby pieces which pass through a normally worn ½ mm. slotted aperture.

Cleaning this material is handicapped by the effect of particle size and shape with consequent reduction in the rate of hindered settling.

Augmenting the normal rate of precipitation by centrifugal force provides material advantage over the results obtained by gravity alone. This advantage with consequent increased unit feed capacity, has reduced the principal difficulty in cleaning fine coal.

A detail review of the theory involved will be avoided. We, who are interested or held responsible for coal preparation, must be governed in the end by the operating results obtained.

The ash content of the cleaned coal together with limiting the loss of merchantable product in the reject will continue to govern the operation of most preparation plants.

Suffice it to say: The centrifugal force developed by spiral or cyclonic action provides sufficient increase in the settling or sedimentation rate to enable separation of fine material within a reasonably compact unit.

Baum type jig operation shows efficient cleaning of the coal which passes over a ½ mm. slotted aperture in subsequent dewatering.

The practical limitations of this type equipment appear to be reached in this division. Ash content of the through product is more than double the amount in the 5/16″ x 28M. washed coal passing over the screen.

A slight increase of ash content is found in the succeeding larger sizes as expected from washability data and general experience. Attention must, therefore, be directed to equipment better adapted to the need when washing fine coal.

Most conical type washing units provide advantage of centrifugal force, as limited by the velocity of material passage. Fine coal washing is improved by development of sufficient velocity to provide centrifugal force, which more than offsets the reduced rate of precipitation due to particle size or shape.

Three of the forms of equipment presently available, where centrifugal force or cyclonic action is utilized in their operation, are reviewed as follows:

The Humphreys spiral concentrator, as developed by The Humphreys Investment Company of Denver, Colorado, presents attractive possibilities for fine coal beneficiation.

Recommended operation is limited to a raw feed top size of 3/16″ or 4M., being well above that provided in recovery of washery sludge or fine coal.

This equipment was operated in Oregon during 1943 to separate fine gold and chrome bearing material from tailings and fine sand.

Early in 1944 the plant was moved to Florida and later enlarged to provide a total of 174 spirals for recovery of minerals from Atlantic Coast sands by washing.

A pilot plant consists of three spirals was installed by the Hudson Coal Company in the anthracite field during the fall of 1945.

Each spiral unit with support framing occupies a space 3′-0″ x 2′-4″ with nearly eight feet of height for the six turn design having a capacity of around 1.5 T.p.h.

Segregation of material results from flowing down the spiral, where the high gravity impurities are concentrated along the inner radius. Removal of the refuse concentrate is controlled by adjustable ports.

Test operation, as reported in a joint paper by Messers H. H. Otto, V. H. Wilson and William L. Dennen of the Hudson organization, shows 60% recovery carrying 18.2% ash from a raw silt feed with 39.4% ash.

These figures provide an approximate average of the several tests where 32% refuse and 8% slime together contained 70.5% ash.

Operation provides a cleaned coal, a middlings product similar to the raw feed as recirculated and a first stage refuse as retreated to provide a coal and refuse division.

A second stage spiral for retreatment of refuse from two first stage spirals provided a final refuse and coal division.

Operation of the test plant proved sufficiently desirable to warrant the later construction of a working plant with a total of 48 spirals. The new plant will use 12 spirals for second stage cleaning, where each will retreat the refuse from three first stage units compared to pilot plant operation from two units.

Tests have been made in cleaning Illinois fine coal where those data available show around 80% recovery with approximately half the ash content of the raw feed input.

The local work proved quite similar to experience reported in the anthracite field with regard to the ratio of ash content in the raw feed input and cleaned product. Cleaning provided a washed product with about half the original ash content in both cases.

The hydraulic sizer has also been used in test work with indications of merit in cleaning fine coal.

The unit, as constructed of pipe and tubing, is otherwise similar to a cyclone in the principles of operation.

The raw product or pulp is delivered within and tangential to the outer case, passing around and down along an inner tube which terminates above the unit base.

A controlled volume withdrawn from the unit base necessitates passage of the remaining material up through the inner tube with overflow at the top.

A division of sizes is provided in conformity with the designation of the unit, or with a limited size range of raw coal input we instead have a separation with a cleaned coal overflow.

Test operation in retreatment of a middlings product has shown a reduction of the feed input ash content by over a third.

The extent of beneficiation being governed largely by the range of particle size.

The cyclone washer, as developed by the Dutch State Mines organization, utilizes centrifugal force to provide efficient cleaning of coal.

The unit, operating principles and performance data are well described in a comprehensive paper presented by M. G. Driessen, Chief of the Mining Research Department before the Institute of Fuel in London on September 19, 1945.

This unit is similar to the common cyclone in design with a tangential delivery of input, where the lighter material overflows from the top and heavier precipitate is drawn from the cone apex at the bottom.

A media of loess suspension in water was used in the European operation reported.

The outstandingly conspicuous feature of their test operation is provided through capacity of cleaning up to 3.5 T.p.h. of feed input in a 200 mm. or approximately 8″ diameter cone.

A diameter of 350 mm. or approximately 14″ has provided efficient cleaning of 12 T.p.h. feed input carrying 10% ash, where the cleaned coal contained 3.4% ash together with having 51.3% ash in the reject.

A hydrostatic head of 32 to 48 feet is needed to provide the velocity of coal, media and water as used in the European operation.

Reported tests cover a feed coal size from 0.5 to 3 mm. being 1/50th to about 1/8th inch and containing 25% undersize. Additional data cover operating with a feed input having a top size up to 15 mm. or about 5/8 inch.

Performance was equally well in the several reported tests and without appreciable reduction of efficiency from the particle size range.

Loess, as used for the dense media, is a type of soil derived from terminal moraines with subsequent transportation by winds to the place of deposition.

It is of nearly uniform size consist as a result of grading when transported, varying from 20 to 100 microns exclusive of a clay type admixture amounting to about 25%.

Loess is also reported to be available from the central part of the Mississippi Valley and from the Northwestern Coast states. It is found in Iowa, Kansas and Nebraska covering thousands of square miles.

The yellowish-brown earth varies from 10′ to 20′ in general depth, though occasional sections of 100′ thickness are reported.

The material of angular fracture is finer than ordinary sand. The particles are not rounded as normal to material transported by wind or water. This characteristic appears responsible for the advantage provided by increased stability of a loess media solution.

The European loess with a top size of 100 microns would be one tenth of a millimeter or 0.004 inch. Usage in treating a coal smaller than 0.5 mm., or five times the maximum size of the media, would entail complications in the subsequent division of media and coal.

A projected European installation would remove the -0.7 mm. coal before washing. Our need is concentrated within a product size which they will remove. It appears to require a media other than loess to facilitate convenient separation from the washed product.

The excellent separating performance reported when using a media of loess suspension provides reason to expect control of the slime density should enable acceptable separation of fine coal without use of foreign materials for a media.

Decanting would then suffice for the final separation of fine cleaned coal and the slime media. The encouraging results of operation with the Hydraulic Sizer indicate improvement is probable when using the cyclone washer design as developed in Europe.

Recent announcement from the Dutch State Mines advises appointment of the American Cyanamid Company, as technical representative for their processes and apparatus in the United States and certain other countries.

Early assistance may be expected from this organization in making the described equipment available for local usage or test work.

Improved future preparation of fine coal is needed to provide a product quality comparable with the larger sizes. Sales realization should then equal or exceed the true value of the material as based on the cost of production.

The present inequality from wasting the fines or disposal at low cost has necessitated a greater charge for the larger coals. Relief would be advantageous with respect to competitive fuels.

* * *

Chairman Adams: Gentlemen, this paper is now open for discussion. Are there any questions? If not, this concludes the technical part of our program for this morning.

Mr. Schonthal has a rather important announcement to make at this time.

Mr. Schonthal: I would like to recommend that all of you who expect to be here for the dinner this evening get your tickets because we are looking for a very large crowd. We had a large crowd last year, and we hope to have as many or more this year; so, if you are planning on attending the meeting, you had better get your ticket as soon as possible.

President Medill: Just a word about this afternoon's session. We want to meet promptly at two o'clock because we have some very interesting papers to be presented, and, no doubt, both of them will invite considerable discussion.

Then, following the afternoon session, dinner will begin promptly at 6:30. This is the high spot of our one day program, and we anticipate a very large attendance. Mr. J. Roy Browning will be the toastmaster, and the speaker of the evening will be Mr. James Gheen of New York City, whose subject will be, "Little Do We Know."

I wish to thank those who have contributed to the program this morning, and all of you for the very close attention you paid to the papers.

If there is nothing more, we stand adjourned until two o'clock this afternoon. (The meeting then adjourned at eleven thirty o'clock.)

AFTERNOON SESSION

October 31, 1947

The meeting reconvened at two o'clock, Mr. Robert M. Medill presiding.

President Medill: Gentlemen, Mr. Crawford of the Valier Coal Company will act as the presiding officer this afternoon, and it gives me a great deal of pleasure to introduce Mr. Crawford at this time. (Applause.)

Chairman Crawford: The meeting will be opened with a paper on "Illinois Stoker Coal—Demand, Supply and Distribution," by Mr. Howard Herder, Fuel Engineer of the Sahara Coal Company, Chicago, Illinois.

I think, from the producers' point of view, there is no subject of more importance than the furnishing of the proper kind and size of coal for each and every stoker, and in order to get the opinion of an expert on this subject I take great pleasure in presenting Mr. Herder. (Applause.)

(Applause.)

* * *

ILLINOIS STOKER COAL — DEMAND, SUPPLY AND DISTRIBUTION

By HOWARD HERDER

Fuel Engineer, Sahara Coal Co., Chicago, Illinois

Quite often, when we are around a coal preparation plant and see cars loaded, released and then moved down over the scale and to the load tracks, we wonder just where all the coal goes. This is particularly true if you have some visitors and they see the loads all collected after a shift or just before they are pulled out. I know just how these visitors feel, because this spring I made a trip through a steel and wire company's plant. Among other things, we saw them making nails. It seemed that acres were covered with machines making nails of all sizes and shapes. Just before that trip I was trying to get some nails and couldn't find them in any store, while in this plant they were hauling them around in 1000-pound lots.

When I was asked to prepare this paper I suggested it cover the distribution, demand and supply of stoker coal. During this year a lot of work has been done by a number of individuals on statistics of the stoker coal market, and I have drawn from this work for my information.

Distribution

First, let's see what the normal distribution of Illinois coal is. Just where is the consuming market? The bulk of the coal produced in Illinois is consumed in the following states: Illinois, Arkansas, Missouri, Iowa, Nebraska, South Dakota, Minnesota, Wisconsin and Indiana. The boundary would start just north of Memphis, cut across to Kansas City, then north just to the west of Omaha and on up around Huron, South Dakota, then a little north of east across Minnesota, north of Minneapolis and St. Paul, down around Wausau, Wisconsin to Lake Michigan just north of Milwaukee. Then pick up on the east side of Lake Michigan near South Bend, Indiana, and angle over to about Danville, Illinois and swing down along the Illinois-Indiana state line, continuing to point of beginning. If you will trace this out on a map you will just about circle the territory that makes up the normal market for Illinois coal. This includes many large industrial areas that are large consumers of fuel. Some of these are: Chicago, St. Louis, Minneapolis and St. Paul, Rock Island, Davenport and Moline, Kansas City, Omaha and Milwaukee. The extreme distance for a car of coal to travel is probably 1000 miles, with freight rates up around $5.50 per ton. However, most of the coal moves a considerably shorter distance and the freight rate will probably average out under $3.00 per ton. As you all know, the boundary for our market area is established by competing fuels coming in from other areas.

Stoker Coal Demand

The demand for stoker coal naturally follows the curve of stoker sales. The development and sale of stokers was a natural result of the demand of people to get away from inefficient hand-firing and their demand for uniform temperature with a minimum of effort.

Stokers are divided into five classifications, based on burning capacity, as follows:

Class 1	Less than 61 pounds per hour
Class 2	61 to 100 pounds per hour
Class 3	101 to 300 pounds per hour
Class 4	301 to 1200 pounds per hour
Class 5	Over 1200 pounds per hour

The coal required for stokers in Classes 1, 2 and 3, and a part of those in Class 4, is handled through retail dealers. Above that we get into 250 H.P. boilers and up, and their coal burning equipment will usually handle regular screenings. Time will not permit a discussion of the larger units, and these remarks will be limited to the smaller stokers which require a double screened stoker coal for satisfactory operation.

The census bureau of the Department of Commerce published a report on the sale of stokers by size by years since 1931. The Stoker Manufacturers Association has compiled the distribution by states. The coal consumption per stoker per year by size classification has been agreed to by a study of experiences.

In the years 1931 thru 1946 there were reported 1,332,522 stokers sold. These units were divided as follows:

Class 1	1,073,886	or	80.59%	of the total
Class 2	127,498	or	9.57%	of the total
Class 3	79,904	or	6.00%	of the total
Total 1-2-3	1,281,288	or	96.16%	of the total

It has been checked and rechecked that 25% of Class 1, 2 and 3 stokers fall in the Illinois coal market area and 16% of Class 4 units and 13% of Class 5 units fall in the same area. These figures are based on reported sales and checked against actual distribution per 1,000 population.

The agreed annual consumption is 11.5 tons for Class 1 stokers; 41 tons for Class 2; and 112 tons for Class 3 units.

Applying the above figures to the total stoker sales, it shows a demand of 6½ million tons per year for the Class 1, 2 and 3 units, 3 million tons of which is needed for stokers with a burning rate less than 61 pounds per hour. These are primarily home stokers. To that 6½ million tons would have to be added about 2 million tons for application in the stokers larger than Class 3 units. The 6½ million tons referred to would require 130 thousand 50-ton railroad cars for loading, and if we use 8½ million tons demand, it would require 170,000 cars.

Although this represents the demand in the Illinois coal market area, this demand is not all met with Illinois stoker coal. Coal from Missouri, Kansas, Kentucky, Indiana and West Virginia also comes into this area.

Before we leave the requirements for stoker coal in our market area I want to go back to 1940. Using the same source of data, the computed demand for stoker coal for Class 1, 2 and 3 stokers in 1940 was 3 million tons. That means the demand has more than doubled in the past 6 years. The manufacture of stokers was curtailed the latter part of 1942 and released again early in 1945. In 1941 and again in 1946 stoker sales were just under 200,000 per year. About the first of this year stoker sales took a dive and hit a low that compares with 1934 figures. No doubt this decline is partly due to the short supply of suitable stoker coal. This curve has now turned and the rate of sale is about 3 times what it was in February, but still only 50% of what it was in 1946.

Supply of Illinois Stoker Coal

The supply of stoker coal is inadequate. The seriousness of this situation is shown by two examples of the past few weeks: 1, One stoker manufacturer had a survey made in downstate Illinois and reported many stoker dealers sold stokers in May and June but they were still not installed because they were unable to get stoker coal. 2, Another manufacturer has had carload orders for stokers for dealers held up for months because no stoker coal was available.

We have seen where the demand for stoker coal in our area has increased from 3 million tons in 1940 to 6½ million tons at the end of 1946. You men know how much you have increased the production of stoker coal during those years.

It was not possible to get figures on the stoker coal production over the entire state of Illinois. However, I think it can be conceded that the bulk of the specially prepared double screened stoker coal comes from Southern Illinois. Southern Illinois in 1946 produced about 3 million tons of this stoker coal with a top size of 1″ or less. This size coal could be applied to Class 1 stokers—those with a burning rate of 60 pounds per hour or less—and that 3 million tons would just match the calculated demand. But 1″ stop size coal also works very well in Class 2 and 3 and 4 stokers, and they have to be fueled. The larger stokers can also use 1¼″ or 1½″ top size, but the production of that size was only one million tons in 1946. The total production then in Southern Illinois of all the double screened stoker coals was 4 million tons, and the demand for use in only Class 1, 2 and 3 stokers was 6½ million tons. And don't forget an estimated 2 million tons more is needed for Class 4 stokers.

The demand is no greater because the shortage of stoker coal has curtailed the sale of stokers. With an adequate supply of suitable stoker coal the increased demand would amount to about 10% per year. Additional facilities for producing more stoker coal have been installed by many operators and a 15% increase in stoker coal production is expected this year.

Summary

Summarizing these statements, we find Illinois coal is consumed in 9 states along the Mississippi Valley. The demand for stoker coal in stokers of Class 1, 2 and 3, burning less than 300 pounds of coal per hour, in this area is 6½ million tons, and an estimated 2 million tons for larger stokers. The supply of stoker coal for these units is 4 million tons from Illinois. The situation is not very good. The demand is there and will increase, and an increased supply must be forthcoming to preserve that business for the coal industry.

Chairman Crawford: Thank you, Mr. Herder. The paper is now open for discussion. Are there any questions? I understand Mr. Bluth is in the room. I wonder if he has anything to say on the subject?

Mr. Marc Bluth: I was not going to say anything on this except, Mr. Herder, I wonder in making your study if you have taken into account the increased demand for coal as a result of the converting from oil to coal?

Mr. Herder: Those of 1946 do, but 1947 conversions do not get into it.

Mr. Bluth: I think another factor that is important, particularly in the larger plants in the middle west and especially in those states that you mentioned, is that there is a very definite shortage of heavy burning oils. And, then, there are hundreds of plants that have recently converted from oil to coal, and many of those plants are in the Illinois territory. I am wondering what effect that would immediately have on your figures, particularly on the number four size stoker?

Another factor I might mention is that the stoker industry is going on an all out program to try to make up some of the deficit for the double screened domestic stoker coal by asking retail coal outlets and dealers in the stoker industry everywhere to try to get those who have been using the double screened domestic coal in the past, especially larger sizes, to go to the inch and a half screening at least on a temporary basis until increased facilities from Illinois and other stoker coal producing states can catch up with the demand, and it is having some effect here and there; so, whatever the mining industry can do to alleviate this particular situation this coming winter will be helpful.

Here is a typical example of what we are getting all over the country; just yesterday I received a letter from the editor of "Better Homes and Gardens" magazine in which he sent me a letter he received from a woman, written something like this:—I have a 96 year old mother; she needs to be comfortable. She has a stoker and she has only one half ton of coal for this year. She is unable to purchase stoker coal from her dealer from whom she has been buying coal for forty years. We have tried to get coal from the other dealers in town, but find they can not supply the stoker coal either, and we have been promised none for this coming winter.

The question to us, and the question to the editor of that magazine was—"What can we do?" Now, that is typical of what is happening. We recommended that she take the stoker out if she is unable to get stoker coal, and go back to hand firing; and try to find some person in the local community to take care of the furnace for her, with the idea that we might save a customer for coal when the shortage period is over.

I do definitely believe that in this particular market area that you mentioned, Illinois has a responsibility and burden of taking care of a considerable amount of tonnage for the stoker business.

Chairman Crawford: Do we have any further remarks on this subject? If not, we will proceed to the next paper. The subject of the next paper is "Possibilities of Liquid and Gaseous Fuels from Coal," and it will be delivered by Mr. Joseph Pursglove, Jr., Vice President, Research and Development, Pittsburgh Consolidation Coal Company, Pittsburgh, Pennsylvania.

We have heard more about this particular subject within the last twenty-five years than, I guess, the people heard in the previous one hundred years or so.

It now gives me a great deal of pleasure to introduce you to Mr. Pursglove. (Applause.)

(Applause.)

POSSIBILITIES FOR LIQUID AND GASEOUS FUELS FROM COAL

By JOSEPH PURSGLOVE, Jr.

Vice President, Pittsburgh Consolidation Coal Company, Research and Development Division, Pittsburgh, Pennsylvania

One of our great national magazines in a recent issue referred to a certain industry as "The Industry Capitalism Forgot." This was an apt title for a field which, the publication reported, is characterized by feudalistic practices, shoe-string operations, and the failure to utilize the modern tools and efficiency and research that capital brings.

If we examine the history of the coal industry closely and candidly, it is apparent that our own field of endeavor has come uncomfortably close to justifying this same title and the same fate. It is my hope that such a fate is not in the future of coal and that it will never be said that coal is an industry bypassed or lost by capitalism. Moreover, I believe it to be one of the most important functions for all of us concerned with the management of this industry to see that coal remains an industry which capital cannot and will not forget.

But what has this to do, you may ask, with my subject here today? My quick answer is . . . PLENTY! And I'll explain more completely in a moment.

Some six weeks ago, at the request of your program chairman, I assigned my talk the title, "Possibilities for Liquid and Gaseous Fuels from Coal." It is my purpose to give you an appraisal of these possibilities. But these technical possibilities are themselves contingent upon much more than the basic research effort involved in developing a new future for the coal industry.

If the coal industry is to carve for itself a greater and more important future, it must embrace certain concepts of greatness and be willing to accept the need for change and new developments. It must also achieve and maintain financial health—we can't be little and do a big job. Without a healthy financial operation we will neither deserve nor receive the good regard of the public community and of the investor community.

In a recent speech before representatives of the gas industry, I made reference to the part coal seems destined to play in the future energy picture. There is an element of inevitability in the future role of coal, if only because our nation is blessed with such large reserves of this solid fuel. But there is still the question of who will receive the business rewards of bringing about what I call this inevitable and greater future of coal. Will it be us, the coal people, the logical stewards of this better coal future? Or will it be, as has happened in the past, some other group . . . which had to be drafted for the job . . . or else saw the opportunity with greater vision than we, or had greater capacity than we to do the necessary job?

For quite some years there has been greater and greater utility extracted from coal. Many of coal's famous byproducts have come about through no effort of the coal industry. We have received no credit for their development AND DESERVE NONE. But I ask you, if I may think out loud among members of the same industry, isn't it a shame just the same?

There are few basic industries in our position, few producers who have confined themselves so exclusively to the sale of a raw product and who exercised so little influence on developments in the final use of that raw product. And yet COAL is a magical gift from nature whose limitations are difficult to portray. Despite the inadequate stewardship and management that we have given over the centuries to this remarkable material, it has still managed to be a major seedcorn of industry. Think of it—a 20th Century economy could not be possible without coal. Had there been the creative genius to develop a mechanized industrial network centuries ago, it would still have not been worthwhile to do so . . . until coal gave men plenty of iron with which to make machines . . . and plenty of power with which to run them.

I am not saying that there should not be an electric utility industry to make kilowatt-hours out of coal. And there will probably be other new conversion utility fields in the future. But certainly, the coal industry should be a factor in the evolution of such conversion industries. We ought to look past that lump of coal and usher it on to a greater destiny . . . we ought to have a part in all that coal can and must perform . . . and it should be good business to do so.

Here again I must clarify. Our black lump of coal has a long future ahead of it as solid fuel. I can assume no part of any blue-sky dreaming that predicts the end of solid fuels in the foreseeable future. In fact, there is reason for feeling that solid fuels have yet to make some of their greatest contributions. That black lump of coal gives us our bread and butter, and should do so for many generations.

But certain specific changes in the use of coal seem to be inevitable. Certain conversions now appear essential in the interest of general industrial development and to meet indispensable needs for fuel and energy in many forms. Coal will be called upon increasingly as a source material for essential chemicals. These and other equally important needs constitute a challenge to our efforts and thoughts today. They are over and beyond the tremendous job that we must perform in order that coal will be able to do the immediate job required of it. At the same time we must push the developments into improved mining techniques while sponsoring moves to improve consumer efficiency in the use of coal. Then there is the very essential subject of safety. This important work in the coal mining industry can never again lag for a moment. While attaining the goal of the "safest industry" may appear as an unattainable one, to accomplish it will be worth all the cost, and for many reasons. From all these sources of challenge, it is easy to see that the future of coal is stacked with both severe responsibilities and great opportunities, unequaled in many other industries.

Meanwhile, the easily accessible coal deposits are being rapidly exhausted and new mines, to get into the deeper and otherwise more remote blocks of coal, are going to require much greater development costs. Mechanization of mining is now an absolute necessity, and it is a large factor in increasing the capital expenditures required for new mine development.

As many of you know, a coal operator at the end of World War I could open a new mine with a few thousand dollars in cash. In that period, it cost considerably less than one dollar per ton of annual capacity to get into the coal producing business. It now costs five to six dollars per ton of annual capacity, and this assumes that you already own a large enough block of coal to give sufficient life to the property to warrant such huge initial investments.

The trend towards highly mechanized and costly coal producing operations accentuates the need for large and well-placed tracts of coal reserves. This also is a factor for increasing capital costs.

It is important you understand that I'm talking of capital costs, and not production costs, because in the latter case there is still hope of reversing the trend (at least on a relative basis) through more efficient mining techniques and better national labor relations.

It was tough at the time, but perhaps it was good for the long-range destiny of the U. S. coal industry that we had a private depression long before the debacle of the 1930's hit everyone else. Other industries have an excuse . . . but we had absolutely no alibis. We know today, beyond the shadow of a doubt, that the long depression for the bituminous coal industry which began in the 1920's was produced in part by our industry's own lack of preparedness, by its lack of the modern tools of capital and management.

I hope we have learned what fire-sale prices and lack of long-range planning can do. One of our jobs, in common with the function of all industries, is to make the meaning of a long-range price understandable. Americans must realize that natural riches grow more expensive as the nation matures and cuts down its initial reserves. Unless we pay the total price, the true price that covers a cost representative of the full life cycle of an operation, we are just deferring charges to unborn generations and, what is worse, bequeathing them debris instead of healthy industries and opportunity. A true price covers not only the cost of cutting a tree, but that of a tree regrown. A true price covers not only the cost of the first easy tons of coal, but of those that we must laboriously pull out of the earth. It covers the increasing costs of development, of machines and safety, of cleaning plants and of exhaustive research itself.

Some of you may feel that there is a buyer's market around the corner. Well, this may be so, even though we were supposed to turn that corner a number of times in the two years since the war ended. And I must admit that our demand some years hence may ease off from the tremendous totals of the past several years.

Fuel for comfort, and fuel for energy to drive the wheels of industry, are subjects of keen public interest today. Striking evidence of this popular interest was to be seen in the reaction to a joint announcement made last March by Pittsburgh Consolidation and Standard Oil Development Company. This announcement told of our research plans in the field of coal gasification and liquefaction.

Because these plans committed my company to expenditures for research heretofore uncommon in the coal industry, it was expected that lively interest would be shown by our stockholders and directors. The broad general interest demonstrates, however, that serious thought is warranted by all of us in the business of supplying fuel and energy as to how these growing requirements are to be met in the future.

The result of investigations my company made of the expanding energy status was a factor in formulating plans for research into converting coal into other usable forms of fuel, or energy.

First, I would like to deal with our findings as they pertain to coal. By including gasoline as an energy source, coal in 1945 made available about 54% of the country's total energy production. Coal supplied some 6% less of the total energy production as compared with ten years earlier. The figures for 1946 have revealed a further drop for coal. By excluding gasoline, coal made available in 1945 about 61% of the energy required by industry and commerce, or a drop of about 7% since 1936.

Now let us take a brief look at conditions in the oil industry affecting present and future supply. At the peak of the wartime demand for oil, which occurred during the first quarter of 1945, U. S. oil consumption for military, civilian and lend-lease purposes reached an all-time high figure of 5,358,000 barrels a day. From many authoritative sources at that time confident pronouncements that with the return of peace this demand would taper off to some reasonable prewar level.

Today, however, in the face of unprecedented production and refinery activity, the oil industry is making a gigantic effort to meet a demand that has spiraled to an average daily consumption of more than 5,870,000 barrels in the first three months of 1947—or more than most authoritative sources has estimated would be the daily requirements for oil by about 1960. To repeat, average daily consumption of oil during the first quarter of this year was more than a half-million barrels higher than during the peak wartime consumption. On top of that, it is estimated that oil consumption for the first three months of 1948 will average 6,220,000 barrels a day, or nearly a million barrels per day *more* than was consumed during the war period.

Can we assume that this present high demand for oil is due to temporary conditions in the consuming market? If not, there is reason for feeling that the reserves of petroleum in this country are being exhausted at a rate which precludes the possibility of replacing those reserves at costs comparable to today's prices.

It is not difficult to see, I am sure, that the overall demand for gasoline dispensed from service station pump is increasing. More and more automobiles are swarming onto the streets and highways each day, and all cars and trucks are being driven farther and farther. This demand is not likely to decrease in the foreseeable future. Also, a constantly greater use of trucks for freight handling can be expected to develop, so the demand for oil production to meet motor freight needs for gasoline cannot at this time be termed a temporary phenomenon. As work progresses on the planned interstate highway projects, this demand will be even further stimulated.

One of the big increases easily seen in petroleum consumption has come in the demand for light oils. More and more Diesel locomotives are going to work on the railroads. The expanded use of oil for this purpose and a switch to oil burners for home heating accounts for a reported increase in light oil consumption of more than 65% over the 1941 figure. Finally, there is the present-day very sizable consumption of gasoline and lubricating oils by the airplane industry as against a much smaller volume used in the prewar years. Agriculture has been mechanized without much public notice, mostly since 1940. The hay-and-oat burner has been replaced by liquid fuel burning Diesel and gasoline engines. A liquid fuel economy has replaced the pasture economy on our farms.

Thus, it seems logical to say that the present-day requirements for oil is very probably what should be considered as representative of normal demand for this year of 1947, and this demand is likely to grow rather than diminish as the years pass.

Almost daily we read of claims and counter-claims on the subject of crude oil reserves. In spite of this controversy, most oil men agree that the present market price of crude oil is below replacement costs. While the chart shows that the reserves have been holding their own, it is interesting to note the effect of re-appraisals and of the trend in new pools discovered.

The gas industry, too, is confronted with problems for the future. While it appears to have substantial reserves for the next few decades at least, particularly in the newer fields of the Southwest, transmission of the available surplus to large consuming markets seems to present a problem to which, for the present at least, there appears to be no ready solution. Effecting a more satisfactory balance between low and peak load demands seems to be another real problem, the answer to which appears closely tied to the whole problem of how to meet the nation's growing demand for energy.

These particular phases of the gas industry problem, together with the problem of the oil industry in meeting growing demand, provide some basis for understanding the unusual interest demonstrated in the possibility of making gaseous and liquid fuels out of coal.

First, I wish to make it clear that we realize there is nothing new or revolutionary in the idea of making oil from coal. The experiments by Bergius of Germany on the hydrogenation of coal into gasoline date back to about 1910. Various experiments and processes for distilling oil from coal go back to the middle of the 19th Century. In fact, coal oil, which is now a name for kerosene, was at first oil distilled from coal to replace the decreasing supply of whale oil for lamps. Many oil-from-coal plants were in operation in Germany and one large one operated in England before World War II. All those plants in Germany and England produced gasoline and oils at a cost several times greater than these products can be produced from petroleum.

How then, do we propose to do this job? Following the synthesis method, we must first gasify coal . . . that is, convert it into carbon monoxide gas and hydrogen gas. This is what utility men in the gas manufacturing business have been doing for years and years. Generally, they have made coke first in standard types of by-product coke ovens, where the tars were recovered and there was produced a coke oven gas of about 550 BTU per cubic foot. The coke was then gasified in more or less standard water gas sets making gas composed of carbon monoxide and hydrogen, the mixture of which averages about 300 BTU per cubic foot. The gas makers then cracked up oil to enrich this water gas, bringing the mixture up to around 550 BTU. This gas, mixed with the coke oven gas, was then put into the city gas mains. If the gas utility did not have coke ovens nearby or as part of the gas plant, it then purchased coke, gasified it and enriched the gas by cracking oil.

The question naturally occurs to you, since we want carbon monoxide and hydrogen gases, why don't we use these conventional and proven water gas sets? The answer is simple. We just can't afford the known costs of producing these gases by the conventional methods of today, for it would produce gasoline at a cost two to three times the present wholesale market price of petroleum gasoline.

Moreover, we can't afford the cost of the preliminary coking process. We must gasify the coal directly. This must be done in huge quantities of raw coal per hour in single retorts or vessels. All past methods of gasifying coal directly were small, low-capacity units completely unsuited to our American fuel economy based as it is on large, high-capacity units. We are thinking of a relatively large commercial-size gasification vessel in which a bed of fine coal is fluidized by a current of steam and oxygen (or air) passing up through the bottom of the vessel. Such a vessel might consume several thousand tons of coal every 24 hours and would produce many millions of cubic feet of carbon monoxide and hydrogen gases a day; probably in multiples of hundreds of millions of cubic feet. Anyone conversant with modern gas plant operation will appreciate that I'm talking in astronomical figures as compared to present day performances of a gas generator using coke or coal.

We have recently let a contract for the building of a large-scale pilot plant near Pittsburgh to explore the possibilities of making gas out of coal on the vast scale just outlined. It is a big and costly job. The investment and cost of operating this pilot plant experimentally will be in the millions of dollars. Unfortunately, there doesn't appear to be an easy or inexpensive solution to the problem.

In a possible future commercial plant, these synthesis gases (the carbon monoxide and hydrogen are so called because they form the raw material of the final or synthesis step of the process) are scrubbed of impurities such as sulphur and are then carried into another large-size vessel called a synthesis reactor. In this vessel a finely divided catalyst is fluidized by the carbon monoxide and hydrogen gases that are bubbled up through the mass of catalyst particles. Most of the carbon and hydrogen atoms get together in this vessel to form liquid fuels. High octane gasoline comprises about 80% of these liquid fuels. The balance of the liquid fuels consist of Diesel oils and light fuel oils.

Some of the oxygen atoms carried into this reactor with the carbon monoxide gas react with some of the carbon and hydrogen atoms to form a large number of commercial alcohols and other chemical products. Other things also happen, including the combining of hydrogen and carbon atoms to form methane gas; this so-called tail gas has a high BTU value and could be made the equivalent of natural gas.

Here is a brief picture of the process as visualized for a coal refinery. Coal comes from the mine, is crushed to a rather fine size and is then fed directly into the large gas generator where it's converted into carbon monoxide and hydrogen gas, leaving only the inert ash to be removed from the generator. This gas is cleaned so it's free of dust, sulphur and other impurities and then is passed directly into the synthesis reactor filled with a finely powdered catalyst. In this reactor, high-octane gasoline, Diesel oil, fuel oil, alcohols and methane gas are formed. This, Gentlemen, is the coal refinery of the future, stated in simplest terms.

To answer another question that must have occurred to you by now, my company has no research plans for the synthesis reactor end of the conversion process. This is because several groups and companies in the United States have for several years been working on the catalytic reaction of carbon monoxide and hydrogen. Pittsburgh Consolidation's partner in this coal gasification pilot plant project, the Standard Oil Development Company, has operated a large scale synthesis reactor pilot plant at Baton Rouge, La., for about three years. At this pilot plant, the raw material source is natural gas from the Louisiana fields. This natural gas is first broken down by partial burning into carbon monoxide and hydrogen. The carbon monoxide and hydrogen are then fed into the synthesis reactor where they form the same liquid and gaseous products I mentioned previously as being formed in the proposed synthesis reactor part of a coal refinery.

All of the pilot plant work that has been done on the synthesis reaction of carbon monoxide and hydrogen is finally maturing into commercial applications. A large plant is being built near Brownsville, Texas, for the conversion of natural gas into gasoline, fuel oils and alcohols. Standard Oil Company of Indiana has on the drawing board, I am told, plans for a similar plant in Western Kansas. Several other oil companies are reported to be planning plants in Texas to convert natural gas into gasoline. We feel, therefore, that by the time we have perfected a practical and commercial process for converting coal directly into carbon monoxide and hydrogen, the synthesis reactor half of our proposed coal refinery will be completely developed and matured.

And now an additional word of clarification, lest you assume from my comments to this point that we feel an oil-from-coal industry is on the immediate horizon. There are many, many big problems to be solved before any such industry becomes a reality.

What the future, that is the long-time future, holds for an industry of this kind, only time can tell. Another great national emergency involving another global war might foreshorten the time element required for the normal development of such an industry, but here, too, a time schedule would only be a guess. As for the thinking and planning of my own company, we see before us an extensive program of research out of which we hope to obtain the knowledge of how to design a process that will work economically, and then to project this knowledge into the operation of one commercial plant. Even on this one plant basis, there are many problems, not the least of which is the matter of economics tied in with the fuel trends and energy patterns of the whole United States.

There are a few naturally fortunate advantages with which we will work in maturing our own particular project, as we see it. First is the fact that there is available to us close to Pittsburgh a large block of coal as source material for a commercial coal refinery, enough to sustain the operations of the size plant we envision for a long period. Equally important, this tract of coal is in and next to several large metropolitan counties in Western Pennsylvania which are highly industrialized and in which the need for additional supplies of gasoline and liquid fuels may be developing while we are maturing our processes and plans.

While these advantages are being fully weighed, it seems all too clear that they will not offset the all important factor of costs in delivering BTU's from such plant to the consumer. All available means of projecting these costs at this stage of our development program support the belief that high-BTU gas could not be delivered into the mains of local gas companies at prices even close to those which now obtain for natural gas from the Southwest. Thus, we must conclude that the real usefulness (as a supplier of high-BTU gas) of our proposed program lies in having a plant sufficiently flexible in its operations that during summer months, for example, the bulk of the output would be converted into liquid fuels and in the winter months switched to the production of gas. If this arrangement can be perfected, and we hope it can, gas from the coal refinery would then be available to augment the supply of natural gas at a time when the demand is at a higher-than-average level. And it would be available at a time and under conditions when the local gas companies could justify the much higher cost of the coal refinery gas. To design and build flexibility of operation involving major changes in plant operation into a large coal refinery presents a research and development program of considerable magnitude in its own right.

Such a coal refinery of the future, processing 12,000 to 15,000 tons of coal a day might look something like Standard Oil's Baton Rouge catalytic cracking plants.

As for the prospects of a nationwide oil-from-coal industry, the matter of the tremendous requirements in capital investments would have to be seriously considered. Just how much will be needed to place in operation the coal refinery we are thinking about, is still far enough in the future that little would be gained from efforts to attempt close estimates at this time. It is probably safe to say, however, that the amount would be much more than any one corporation could, in my opinion, handle alone.

It is hoped that I have been able to clarify for you my company's thinking in connection with the subject of coal gasification and the role it can assume in supplying the need for liquid and gaseous fuels in the foreseeable future. I have also touched on some of the problems which confront the major energy producing industries in anticipating and keeping abreast of the national requirements.

There is no question but that COAL will have a challenging role for many years to come. First of all, there is the present large and persistent demand for coal tonnages. There is the swirl of change in our activities brought about by changes in mining conditions, by the development and application of new mining techniques, by the effort to make greater strides in the achievement of mine safety, by research with the primary aim of greater efficiency in the use of coal, by the development of smokeless burning equipment, by the crusades in urban centers for smoke abatement, by the improvements in applications of pulverized fuel, and by the effort to mature a coal-fired gas turbine locomotive.

My company's capital outlay for a new Disco plant, which we hope will be in operation by November 1948, is another leg of our own campaign to strengthen the base of the coal industry and to square us with the needs of that emerging future of which I have spoken. Our existing Disco plant, although of experimental size and construction in itself, has proved that the making of low-temperature coke can be good business as well as good evolution for a broader-based coal industry. This new plant will prove, we hope, that a smokeless solid fuel industry, along with its tar refinery can be an important auxiliary to producing coal. However, we realize that such plants may be restricted to areas where they might enjoy special economic advantages.

Every basic material industry needs its finishing or processing auxiliaries. Steel and the metal trades developed these early in their history. Petroleum has its refineries and chemical plant additions. Even natural gas is developing "refineries" or conversion plants where gas is turned into liquid fuels and chemicals. Coal has yet to demonstrate on a large scale that it desires to get close to the ultimate yield than can be extracted from this magic mineral.

We know with reasonable assurance that the need for energy in all its forms will grow. Coal, too, must grow if this need is to be met. Coal seems destined for the role of the most reliable base for the whole energy world. Whether it qualifies for that eventual destiny only time will tell. But in conclusion, it seems appropriate to emphasize that if the coal industry doesn't qualify for this master role, those of us in the industry will be required to sit it out on the sidelines watching the job as it is done by others.

* * *

Chairman Crawford: Thank you Mr. Pursglove. Do we have any questions on this subject? If not, I will turn the meeting back to our President.

President Medill: Gentlemen, this winds up our afternoon session.

I want to again remind you of our dinner this evening, and ask that you be here on time so that we can get started promptly.

(The meeting then adjourned at four thirty o'clock.)

DINNER SESSION

October 31, 1947

The Dinner Meeting convened at seven thirty. President Robert M. Medill presiding.

President Medill: Gentlemen, now that we have enjoyed a delicious meal, I hope you will pay close attention to what goes on from here on out.

At this time, I am going to ask Mr. J. Roy Browning, Vice President and Commissioner of the Illinois Coal Operators' Association to take over as Toastmaster. Mr. Browning. (Applause.)

Toastmaster Browning: Mr. President, Coal Miners, and Peddlers—I believe we have as many peddlers here as we have coal miners, and I do not know why the Program Committee selected me—I did not know why until I sat here and talked to Buzz Schonthal and he told me how they hooked me as toastmaster for this evening. He said they went through the roster of members to see whose birthday came on the same birthday as the Illinois Mining Institute; so, they found that fifty-five years ago on Halloween J. Roy Browning was born and so was the Illinois Mining Institute. That is why I got the job.

He told me some other things also—that the Illinois Mining Institute had grown in stature in these fifty-five years, and I can not say that about myself. I have withered and gone down in my short fifty-five years.

Seriously speaking, the Institute has grown large. I am told by your Secretary that this is the largest meeting or rather the largest attendance that we have ever had at the Institute's annual meeting.

We also know that the papers given today were very instructive and educational, and we hope that each of you will be able to go back to your respective jobs and do a better job from the things you learned here today.

Each of you gentlemen here is entitled to credit for the success of this Institute. There are some men here at this table who have contributed substantially to the Illinois Mining Institute, and at this time I am going to introduce these gentlemen. As they are introduced I want each and every one of them to stand and take a bow so that you can see them. I do not know why I should introduce these people because you perhaps know them better than I do, but since that is the usual procedure I suppose it is the thing to do. Being lefthanded I am going to start on my right.

At the far right end of the table I have the privilege of introducing my good friend Carl T. Hayden who is Vice President and General Manager of the Sahara Coal Company, and a former president of this Institute. (Applause.)

I now have the pleasure of introducing J. W. Starks, a former president of the Institute, and a new member of the Executive Board. Mr. Starks is with the Peabody Coal Company. (Applause.)

We go a little further down in the State, and the next gentleman that I have the privilege to introduce is Mr. Roy Adams of the Old Ben Coal Corporation. Mr. Adams is also a member of the Executive Board of this Institute. (Applause.)

The next gentleman I have the privilege of introducing is from the other end of the State, Mr. Marc G. Bluth, Manager of the Chicago office of the National Coal Association. (Applause.)

I do not think I should introduce the next gentleman because all of you know him and love him, and we are proud of him as an Illinoisan, Dr. M. M. Leighton, Chief of the Illinois Geological Survey.

Next, I have the pleasure of introducing Dr. Harold L. Walker, Head of the Department of Mining and Metallurgical Engineering, University of Illinois. (Applause.)

Really and truly, gentlemen, the success of this Institute, in my opinion, and I think in the opinion of all of you, belongs to our good friend Bale Schonthal. (Applause.)

I have been told to skip the next fellow, but I am not going to. Here is a man who has mined coal for a long time. He is a close friend of mine and of everyone here, and we all love him, Bod Medill. (Applause.)

Now, starting on my left, Mr. Frank W. Moran of the American Mining Congress. (Applause.)

The next gentleman is George C. Lindsay of Mechanization magazine. (Applause.)

I do not know why it is, but it seems as though all the magazine men are on this end of the table.

We next have Mr. Ivan A. Given, editor of "Coal Age" magazine. (Applause.)

We now go down to Saline County where we have one of the outstanding coal miners of Southern Illinois, Mr. Paul Halbersleben, Vice President and General Manager of the Sahara Coal Company. (Applause.)

There are some people who are going to enjoy what I have to say now. We have in Illinois a Coal Operators Association that is just an infant compared to this Institute, but it has had as its President for a great many years—I do not know whether he is its perpetual President or not, but I want to introduce him now. Mr. George F. Campbell. Incidentally, he is a past President of the Illinois Mining Institute. (Applause.)

At times, we have to go out of the State in order to get some of our help in this Institute, and the next man I introduce has been of great assistance for a long time in this organization, Mr. Joseph E. Hitt of St. Louis, Missouri. (Applause.)

I have the honor of having a small job with the Illinois Coal Operators Association, and these men in the field are teaching me the work.

The next man whom I am going to introduce is a man who has contributed greatly to the relationship between the operators of coal mines and the miners in the State of Illinois; he is the oldest living member of this Institute, and a finer gentleman we have never known, Mr. Fred E. Weisenborn. (Applause.)

I did not intend to skip the next gentleman because I have known him for a long time, and I think he is one of the outstanding men in the mining profession in the State of Illinois. He has held many positions of honor, trust and responsibilities. I do not think there is an institute or association of the coal mining industry that he has not headed at one time or another. He comes from a family of coal miners, and his son is following him and is doing a splendid job. We hope that he will measure up to his father. Mr. William J. Jenkins. (Applause.)

Now I am going to skip once more. We have a rather unusual situation here tonight, gentlemen. We have a situation where we have or will have had a father and son who have been President of this Institute.

I am going to take the baby first, and everybody here knows him; he is following rapidly in his father's steps. He is an Illinoisan by birth and raising, but he has a bigger job than just a few mines in Illinois. He is the President of the H. C. Frick Coal Company, and the incoming President of the Illinois Mining Institute, Harry M. Moses. (Applause.)

I have one more gentleman to introduce in this category. We have with us tonight, and we are honored by having with us, the dean of all the coal miners, a man who has risen from the coal mines to the highest position that a man in the coal mining industry could hold. To cap off his career, he has accepted a position on the Governor's Staff as Director of the Department of Mines and Minerals. I now have the privilege of calling him and introducing him as the Honorable Thomas Moses. (Applause.)

While Mr. Moses is on his feet I am going to ask him to say a few words to you gentlemen.

Mr. Moses: Mr. Chairman, I thank you for that nice introduction; it is about the nicest one that I have had, and thank you.

Gentlemen of the Illinois Mining Institute and fellow citizens of Illinois, it is my great pleasure to come back to Illinois as a citizen, having never changed my residence during my absence in the East.

I have come back here to spend the rest of my days. It is a great pleasure to be amongst you. I have had a great time since I have been here.

The position I hold is one of great importance to the mining industry, and whether I can fill it successfully or not remains to be seen; however, if I have a batting average at the conclusion of my term in office that my predecessor had, I will be satisfied.

I thank you very much. (Applause.)

Toastmaster Browning: Gentlemen, you have had today a lot of technical, interesting, education matters presented to you. It has frequently been the trouble of this Institute and other associations, at the end of the day, after a very technical meeting, to have another technical paper or talk given to you.

The Committee on Arrangements this year thought that you should have something for your entertainment rather than to give you some further technical knowledge of coal mining.

They made a careful search and investigation of the outstanding after dinner speakers of the United States; men that give us a thought to take home with us and to use in our daily lives.

They wanted to get away from the coal miner, but I am sorry to say, gentlemen, they got back to a coal miner. While talking to this gentleman I found out that he started his life as a coal miner in Scranton, Pennsylvania. He has done awfully well from his humble start; he has risen to be one of the outstanding after dinner speakers at clubs and organizations throughout the United States.

In looking over the program I noticed that his speech for tonight is. "Little Do We Know."

So, gentlemen, it is my great pleasure and privilege to introduce to you the speaker of the evening, Mr. James E. Gheen of New York City. (Applause.)

* * *

"LITTLE DO WE KNOW"

By JAMES E. GHEEN
New York, N. Y.

Mr. Gheen: Thank you, Roy. Mr. Toastmaster, Mr. President "was," and Mr. President "is," and distinguished Guests, and Gentlemen, I have just been speaking out in South Dakota and North Dakota, and I heard a story out there about two fellows who were in the retail coal business. One of them got religion, and the other one did not. After six months the fellow who had the religion said to his partner, "When are you going to get religious?" The other fellow said, "I do not think I will get it because if we both get religious who will weigh the coal?" (Laughter.)

So, when I realized that you missed a number of speakers that are loose in America, and also the large number of loose speakers in America, I want you to know that I consider it a great honor to be here.

Roy said he did not know for what reason he is here. Well, I do not know why I am here. You see, we after dinner orators, as we call ourselves—other people call us other things. We never know for sure why we were invited and we are not always sure of what we ought to say.

A friend of mine in New York the other night was invited to speak to the poor unfortunate inmates of an insane hospital, and he did not know what to say to them either. But, being an experienced speaker he went down to the file and drawer and found a speech he thought was suitable and adaptable. Going to the auditorium, and being introduced he said, "Men and women, why are we here?" (Laughter.) A little fellow got up and said, "We are here because we are not all there." (Laughter.)

I do not mean to refer to you, but then it could be referring to me because some philosopher said, "You do not have to be crazy to be a public speaker, but it helps." I do not suppose you have to be crazy to be a coal operator, but maybe it helps. I do not think you are crazy because you have the Illinois Mining Institute, and I do not think you are crazy because you are having this fifty-fifth annual meeting; and, that is the reason I choose as my topic, "Little Do We Know."

If you felt that you knew everything you ought to know, and could not learn anything new about your great industry, then I do not think you would have come here today and had the splendid meeting which you have had in order to try to get something in your head that is not there, and try to get something out of your head that is there and that should not be there. That is the reason we have conventions.

Fellows do not take their wives to conventions very often, and I often wonder why. I was at an Atlantic City convention not so long ago, and every man who came was expected to bring his wife; but, one man came in from Denver, Colorado, unaccompanied. At the very opening session of the convention the president called that man up on the carpet, "Why didn't you bring your wife to this convention?" The fellow said, "Double the expense, and half the pleasure." (Laughter.)

Also, you know when you are invited to a meeting like this, you think, well, nobody tells you how long to talk, and my wife always admonishes me when I leave home and says, "Do not talk too long!" For that reason I bring my watch. I have all the equipment here for an after-dinner speech. I have a beautiful audience; I had a fine introduction; I have a glass of water; I have Harry's napkin, and a watch, and I have some notes—the watch is the most important item. All you have to do is remember what time you started. I write it down, and if I did not do that I would forget it.

I have a friend in New York who has a very peculiar hobby—a young woman who goes to the different churches, and notes the various forms of worship, and then she catalogs all those to see just how much they differ. That is her hobby. She happens to be a Protestant and she had a Catholic lady take her to the Catholic church so that she might observe the form of worship. She told her friend, "If anything happens during the service that I do not understand I will ask you what it means." She understood everything until the reverend old father went up on the pulpit, took out his watch, looked at it, and then laid it down. She said, "What does that mean?" The Catholic lady said, "Not a damned thing."

I assure you my watch does. If I talk longer than anybody wants to listen just get up and walk out, it will not make me angry. I will not get angry, this is your party not mine. I get excited sometimes and ramble on.

I was talking down in Winston-Salem, North Carolina, several months ago. I arrived there very early in the morning, and I was around the hotel when a man came in and introduced himself and said, "Mr. Gheen, I belong to the Lions Club of Winston-Salem. The speaker whom we had engaged telegraphed that he could not be here; and, in that you are here, I wonder if you would come over and talk to us?" Well, I thought to myself, why not? Free meal, might as well go. I said, "Where do you meet?" "Over in the other hotel," he said. So, I went over to the other hotel and there were no Lions there at twelve o'clock, the time that I was supposed to address their club. I waited until twelve fifteen, no Lions; I waited until twelve thirty, no Lions. I thought, well, the fellow said the other hotel, and maybe there were three of them, so I thought I had better find out where the third hotel was located.

Just then in came the Lions Club, all talking at once, and where they went before the meeting, I do not know; they came in and sat down and the president rapped for order and said, "We will start right on time again, twenty minutes of one." He told me noon, but times does not seem to make any difference down there. I asked the chairman then how long I should talk, and he said, "You can talk as long as you want to, but we leave here at ten minutes of three."

What time do you leave tonight? I do not know, but maybe I will find out. I know tonight, in the honored position that I hold, my business is to talk, and your business is to listen. If you run out of business I can not help it; it is just up to you, entirely up to you.

I suppose in the life of every person in this room there is something you can not do and do not know why. It might be in your personal life or in your business life—something you can not do and do not know why.

I seldom go to a community in which I do not make my own observations of the people there. I have often said, "Why do you not do so-and-so in your town?" They have said they could not do it. Why? They do not know, but they can not do it. Why do they not find out why they can not do certain things?

And, I say the same thing to you—if you have some business problem, why do you not find out why you can not do it?

In Alabama you must have a license to sell insurance, and a colored man engaged in the business did not know it. One day the law caught up with him, and the judge said to him, "Sam, don't you know you can not sell insurance without a license?" Sam said, "I couldn't sell it, but I never knew why before." So, maybe that may be the answer to your problem.

I know that we speakers have to watch ourselves very carefully when we get a great group of business men before us so that we do not preach; however, there are a lot of people who think that business men should be preached to, but I am not going to preach to you because I am not a preacher.

When I was a very young man in Pennsylvania I had the gift of gab, and dear old dad thought I should utilize it in some way; he thought it was a God-given talent and that I should be a preacher. I wanted to be an auctioneer. I said, "No, dad, I do not want to be paid for being good; I am willing to be good for nothing."

I have been around these United States and Canada, and I am going to brag a bit and tell you I spoke in North Platte, Nebraska the other night, and that was the 889th different city and town in the United States in which I have spoken. I have spoken in practically every town in Illinois, and next week I am going to speak in Charleston, Illinois. So, you see, I get around a lot, and I have met a lot of wonderful people, and I admire them.

I have met a lot of wonderful Catholic priests; I have met a lot of wonderful Jewish rabbis; I have met a lot of wonderful Protestant preachers; and I know of the wonderful work they are all doing for the church and religion. Now, knowing my own limitations, I know that father was wrong. I would not have made a good preacher—I do not get excited enough about it, I do not wave my hands up and down, and I do not try to save people like I saw Billy Sunday do. Yes, he was always trying to save people, but I do not bother with trying to save them.

I do not get excited, and I remember my old pastor down in Pennsylvania—I never saw that old man make but two gestures, he either pointed upward or downward; never in my life did I see that dear old gent point to the North or to the South, West or East, just up and down. One day when I was a lad about fourteen I belonged to the Boys Brigade, that was before the Boy Scouts. I belonged to the Boys Brigade, me and that grand old man who became one of America's greatest soldiers—General Smedley Butler. We were boys together, and we had to go to church every Sunday. I remember one Sunday morning when my dear old pastor preached a very wonderful sermon. I say it was wonderful because until this day I remember something he said, and that makes it wonderful. If you remember anything that I say tonight, that will be wonderful. Had he not stated that beautiful thought which I have carried with me all these years I would still remember that day and that sermon because at the very end my old pastor said, "When the roll is called up yonder, I will be there!" Well, the people laughed, they laughed right in church; they did not laugh loud or long, but they laughed. That sort of bothered me, and in walking home from church with father I said, "Father, wasn't it terrible for those folks to laugh in church this morning?" He said, "Yes, son, that was pretty bad, but you should have learned a lesson from it." I said, "What lesson, father?" He said, "You are just a boy going to school, meeting the boys and girls in the classroom, on the playfield, and in the gymnasium; and, in your association with those boys and girls, have they ever laughed at you?" I said, "Yes." and then father said, "Why do they laugh at you?" I said "I do not know." He said, "Son, I will tell you; they laugh at you every time you make a mistake." That is what people laugh at! You do not laugh at people who are right; you laugh at people who are wrong!

And, I can tell you, as coal operators, when you make mistakes somebody laughs at you; somebody who knows what was right laughed at you. Maybe you do not care, but they laugh just the same. They do not laugh right in your face because that is wrong; however, they go up the street and say "Isn't it too bad that he doesn't know." And, that is the reason we make mistakes, because we do not know. We do not know how to do a lot of things; we do not know how to prevent war, and we do not know how to eliminate poverty—there are so many things that we do not know.

Well, you know, father said, "Son, I do not care where you go or what you do or how you live; if you do not do things right, people who know what is right will laugh at you." Father said, "All humor is based on error.'' We laugh at people because they are wrong or because we think they are wrong; sometimes they are not.

Every great inventor has been laughed at by people like us. Perhaps we do not have inventive minds, and we do not understand what they are trying to do. Westinghouse, that great inventor, laughed when it was first suggested to him that men would fly in the air. As a boy I remember having to learn a recitation, ''Darius Green and the Flying Machine,''—making fun of the idea that people would fly. Now, we know people do fly. In fact, I hope to fly from St. Louis to New York tomorrow morning. Yes, we know people do fly, and laugh at George Westinghouse, so you and I have to be careful when we laugh at new ideas.

There is an old law in psychology which says, ''When a man is not understood, he is a genius.'' If there is any industry who wants to remember that, it is you! Think it over, and take it home with you—''When a man is not understood, he is a genius!''

Perhaps that statement applies to any person. I do not want to be against anybody, but I do not understand everybody. Maybe that is my fault; maybe I do not know enough. I do not know as much as I should because I talk too much. When you are talking you are talking about something that you already know, and I am talking all the time.

So, I say, there are a lot of people in this world that I do not understand. I do not understand Henry Wallace. Do you? I am not going to make fun of Henry Wallace because he has been Vice President of the United States, but I do not understand him.

Henry Wallce, in one of his speeches said there will be no upper class or lower class, there will be just a great middle class. Well, I am not going to debate that with him—I know that could not be, and he does not know that. If there was no upper class and no lower class, how could there be a middle class? What would they be in the middle of?

Henry Wallace is supposed to have written a book—''Sixty Million Jobs for Sixty Million People,'' and he says it is an easy matter to get jobs for sixty million people; maybe that is true, but they had one hell of a time getting a job for Henry Wallace once—they had to fire Jesse Jones!

Yet, I have a friend in New York who thinks that Henry Wallace is a greater man and a greater scientist than Einstein. Well, I wish I had not brought that up because I do not understand Einstein. But, I asked my friend why he thought Henry Walace was a greater man than Einstein, and he said, ''Only twelve people in this world understand Einstein, and nobody understands Henry Wallace.'' Well, it was just a matter of comparison.

I had an experience with Henry Wallace once, and some of you may think this is not true, but it is. September, a year ago, I spoke to the members of the Chamber of Commerce at Carmi, Illinois. I found I could fly home from Evansville, Indiana the next morning. I took that plane and when it stopped at Washington several people got off, and then several people got on. I thought Henry Wallace was one of those people, and he came in and occupied the seat alongside of me. I waited until the hostess came around and I asked the names and destinations of the newcomers. She told me that it was Wallace and that he was going to New York. I knew it was Henry Wallace, and I had never talked to a Vice President in my life. I talked to several men before they were President, and I have talked to Mr. Hoover a couple of times since he was President, but I have never talked to a Vice President.

I thought this was my chance, and I had made up my mind to talk to him, but just as soon as he got seated he took out some papers and started reading them. I have got a good right eye, and I noticed it was a speech. It was written in a half inch type, triple spaced, and you could stand two or three feet away and read it. I wondered what that speech was about, and I looked again and saw the word "Russia" two or three times—I wondered what Henry was thinking about Russia—I kept looking and he kept moving, and I could not read it. He kept reading it over about six or seven times, and I kept sitting there wanting to talk to him.

Finally he put the speech in his pocket and pulled the chair back to take a nap, and I thought to myself, if he goes to sleep I will read it. Then, I realized that I was a gentleman, and I had no right to take it from his pocket. But, if I had taken that speech from his pocket and had not returned it, Henry Wallace would have still been the Secretary of Commerce because, that is the speech he made that night in New York that cost him his job. You can not tell about these things—you never know. I do not know whether I did the right thing.

I might tell you about some of the other men that I know about, but I am not here to discuss the political issues of the day, and I am not going to talk to you about them.

I am going to tell you about the mistakes that other people make—not the people in the coal business. I have a friend down at Rutgers University, a learned professor whose hobby is humor, and he would say, "Tell me what you laugh at and I will tell you your mental age." He says that laughter is an indication of intelligence, and one who can laugh at himself ranks the highest. You do not have a highly developed sense of humor unless you can laugh at yourself.

Think of the number of mistakes you make each day, and which you alone make—I know somebody ought to be laughing all the time. So, I would go a little further and say that not only is laughter an indication of intelligence, but you have to know which is right in order to know which is wrong. That is the reason you come to conventions, to find out what is right and what is wrong in your industry. If something happens that is wrong you can enjoy it and laugh at it. If you did not know what was right, you would not know what was wrong.

I spoke in Skowhegan, Maine one time, and told them a story to illustrate a point—it was about a young American soldier who was decorated on the battle field of France by a great French soldier, and as was customary the French general kissed the young soldier on one cheek and then on the other and said, "Young soldier of the United States, I want to make you a Field Marshal of France." The boy said, "Could you not make me Marshal Field?" Well, the boys and girls to whom I spoke did not laugh, and because they sat there, not even smiling, I later asked the principal of the school why? He said, "I am afraid they have never heard of Marshal Field." If I had mentioned William Filene of Boston they would have laughed. I will bet the boys and girls of Springfield have never heard of William Filene of Boston—you see, you have to know.

We laugh at everything—short people laugh at tall people, tall people laugh at short people, fat people laugh at thin people, and thin people laugh at fat people. We laugh at long haired men and short haired women. We laugh at men if they do not have any hair, and what is funny about that? Just because a man has lost his hair that is not funny—the funny part of it is that he does not know why he lost it.

We laugh at everything. We laugh at our English cousins, and we have always laughed at them because we think their sense of humor is somewhat warped—they do not laugh at American jokes as quickly as we do.

It is just because they do not know much about America—they do not know the history of our great traditions; they do not understand our conventions; they do not understand our politicians—neither do we. And they do not laugh right away at our jokes because they do not understand them. They have to work backward to find out what it is about, and by that time somebody has told another one.

Last summer a friend of mine took an English lady to see a baseball game. She did not understand the game. As a matter of fact it was the first time she had ever been at a ball game. The New York Yankees and the Browns were playing, and the Browns scored one run in the first inning. It was put on the score board in the center field. The Yankees came to bat and they scored one run, and it was put on the score board in the center field; and then neither side scored a run for thirteen or fourteen innings. They stayed on and the hour was getting late, and the English lady said she had a dinner date and had to be excused. While riding back to the hotel someone asked her how she enjoyed the game. "Very much, indeed, but I had to leave before it was terminated." Then she was asked, "What was the score when you left?" "Oh, it was up in the millions somewhere."

You see, things happen because people simply do not know. You and I make just as foolish mistakes, because we do not know.

I have talked to teachers' associations throughout the country, and I have talked to them here in Sangamon County. I did not tell them that story. I talked to the teachers' association up in Pennsylvania, Erie County, and it was during the last war when most of the men teachers were in the Service. They were a bunch of fine looking girls and I wanted to make them happy so I told them some stories about golf. They did not understand the stories and I might just as well have stayed at home because they did not follow—they did not understand what was right and what was wrong, and they just sat there and looked. I told them one of my experiences with an overheated niblick, and all they did was look. One girl wrote it down on a piece of paper—she was going to look it up, she was interested.

I told them the best golf story I ever heard was told to me by a Presbyterian minister from Richmond, Virginia. This minister told me that he likes to play in a foursome every week, in which also a Baptist minister also plays. One day his game was slightly off, and he told his caddy, "Henry, I guess on this next hole we had better pray." He took his stand, got his grip, and came back with what he thought was a pretty good shot, but the ball only went twenty yards. He said, "Henry, I guess maybe our prayers did not do much good." Henry said, "In our church we prays with our heads down." But, the girls did not understand it.

So, I left there that day and on my way home I picked up two lovely school teachers, and one had no principal and the other had no class.

I love the fellow who is seldom wrong because he knows and he does not guess.

You and your business could do anything you wanted to if you knew how to do it. That is the big idea. You see, it goes on and on, and we do not understand.

The other day I heard the story about the traveling salesman—he had to go out of town and was gone a week, and the day before he returned home he wired his wife that he would be there on the following day. When he got home, walked into the living room, there sat his wife in the arms of another man. He was as mad as a hornet, rushed into the kitchen and got his shotgun, but when he returned the man had gone. He rushed out of the door with the shotgun in his hands, and down the street a little ways bumped into his old father. His father wanted to know what all the excitement was about, and the son told him. The old father then told him or rather reminded him, that he had brought him up to know there were two sides to every story. He told him then to go to his home while he went and got his wife's side of the story. Presently the old father came back and said, "Son, I told you every story had two sides. Your wife did not get your telegram."

I do not think there has been a time in American history when we have had to listen to so many guesses. I read in the paper and see that so and so, and that so and so thinks this or that—they do not think at all, they guess. Everybody is guessing these days. I go up in cultured New England, and I thought they would not guess up there, but they do. Up in New England there is a democratic institute called the Town Meetings—every little town has a Town Hall where the citizens gather and the municipal authorities render their accounts, and the citizens are allowed to rise and ask questions—sometimes very embarrassing questions.

At one Town Meeting in New England the Chairman of the Board of Health read his voluminous report in which he said the death rate in that town was 11.7, and when he finished his speech a fellow citizen got up and said, "We listened to your interesting and comprehensive report in which you said the death rate was 11.7, but some of us back here do not know what you mean by a death rate of 11.7—what does that mean? The Chairman did not know, but he did not say so. No person ever gets mad at you if you say, "I do not know." They are sorry, but they are not mad. He said, "Come to my office tomorrow morning, and

I will explain it to you." And, then, he had time to think about it. He said that he did not exactly know what a death rate of 11.7 percent meant—but, what he thought it meant was that 11 people had died and 7 were at the point of death. You know that he was guessing.

I was down in the great State of Kentucky, and they guess down there. Why? Because it is a great racing State, and they have to guess. You do not know who is going to win, you guess, and that is the fun of it.

Well, down in Kentucky I met a couple of moonshiners, and, like the Mining Institute, they were fifty-five years of age on the same day, and they wanted to celebrate by riding on the railroad train. Somebody told them to take a ride on the train because that was something they had never done. They hiked ten miles across the country to catch the train. When they got to the station somebody showed them how to buy their tickets, and with their tickets in their hands they got on the train. They held their tickets in their hands because they did not know what in the hell to do with them. They were standing there on the train—they did not sit down because they did not know they were allowed to sit down. Soon they saw a big burley fellow come through, with big brass buttons on his uniform. They did not know who he was because they had never met a conductor before in their lives. He took the tickets away from them, and that made them mad—they had not even read them; they had just bought them a minute ago. This fellow went to the end of the car and yelled out something that nobody could possibly understand, and people got up and left the train. They wondered what this man said that made these people get up and leave. They did not want to leave the train because they did not know where they were. Other people got on the train then, and they wondered where they came from—they did not know that anybody lived on the other side of the mountain.

A boy came through the train selling peanuts, popcorn, and soda pop. They had never heard of soda pop, and after a while a passenger said, "Boy, give me a bottle of soda pop." When this passenger said "bottle" they were interested, and they watched him take the top off of the bottle and slowly drink the contents. Then, they decided they would like to have a bottle, and they asked the boy for one. They took it and did what the other fellow did—they did not know. They decided to split the first bottle to see how they would like it. The first man drank his half of the bottle just as the train shot into a tunnel. The one man said, "How is it, Lem?" "Don't tuch the damned stuff, I've been struck blind!"

You see, you are laughing at him because he made a mistake—just the same as people laugh at you and me because we make mistakes on account of the things we do not know.

Everybody guesses, the government guesses, and the government does not mind the citizens guessing. They send out their income tax blanks, and nobody can fill those things without guessing. For years I have been trying to figure out how to answer some of the questions in those forms, and now, I do not care. There are only three questions necessary on any income tax—How much did you make last year? How much have you got left? How come?

Every year they seem to make it harder for us to fill those forms. One of the best thoughts on statesmanship I have ever heard was expressed by a man out in Red Oaks, Iowa, and he said this country needs a simplified form of government—I think he is right. And, I started with the income tax. I do not know how it is with you, but with me, the first thing they do that makes me angry is—they say that you have a choice of Form 1040 or 1040-A. How in hell do I know which one to use? Why do they not make out a form a fellow can use without getting all mixed up?

These income tax forms reminds me of a boy who was courting a girl, and the girl's father stopped him one day and said, "Son, are your intentions honorable?" The boy said, "Why, do I have a choice?"

To me, it is the same idea and they complicate the situation. They say, "Guess how much you are going to make next year?" They do not think, they guess.

But I have learned how to fool them, and if you do not tell anybody I will tell you. I fooled them last year. I took all the blanks they sent me and I answered every question they asked me, every question except my name and address. I sent them down to Washington, D. C.—let them guess who sent it!

You think I am giving you grand ideas, and that is what you need in the coal business—grand ideas. Of course you need ideas, nothing would have happened in the coal business unless somebody had an idea. You do not have ideas unless you think nothing ever happened.

Forty years ago, the girls never thought of doing the things the girls do today; and, the only reason they did not do it was because they did not think. Forty years ago if the girls dressed like the girls do today they would have been called immoral. If the girls of today dressed like the girls did forty years ago, they would be called crazy. Which would you rather be, immoral or crazy?—So would I.

Read the papers—they are arguing about whether or not we are going to have a depression. I was talking to a banker the other day who had just been down to Washington; and he told me a story how he called on two big department heads down there—they told opposite stories. One was sure that we were going to have a depression in 1948; and, the other person told him there was not a chance of having a depression in 1948—so, you see, they are only guessing; they do not know.

I remember the last depression, and you probably do too. We had a depression and we had a recession—one was Democratic and the other was Republican, that is all. No one seems to know the difference between the two, except me. I figured it out. If you have to pull in your belt, that is a recession; but if you have no belt to pull in, that is a depression.

I was at one of the Senate hearings in Washington and sat beside a distinguished gentleman, an economist. He told me that the depression cost us 133 billion dollars during those seven years of the depression. That is a lot of money. After a while I asked him what caused depressions. He said that he did not know; that nobody knew—bankers did not know, college presidents did not know, and financiers did not know.

Then, he told me that they asked the college boys to guess as to what caused depressions.

At Northwestern University in Evanston, Illinois, they ask that question every year in their examinations—what causes depressions? Last year, in December, one boy wrote on his paper, "God knows, I do not—Merry Christmas!" And, when his paper came back the Professor wrote on it, "God gets one hundred, you get zero—Happy New Year!"

All we know is that the depression cost us 133 billion dollars. Those who have the opportunity to go out and buy a new automobile can drive it around the block to another dealer, and can get five hundred more than was paid for it—land of opportunity! Little do we know about what is going on.

I was down in Charleston, South Carolina, the night that President Roosevelt made his first fireside speech about national defense—that was one of the most wonderful speeches President Roosevelt ever made. I sat there thrilled when he finished. The radio was turned off and I arose to go to my room; and just then, the southern gentleman sitting alongside of me, put his hand on me and said, "Just sounds like deflation to me." I said, "Well, friend, I do not know what deflation is." He said, "Deflation means instead of you not having the money you do not have now, you will not have twice as much, and it only will be worth one-third of what you do not have now." I did not understand that, and I do not understand it now.

I met a fellow in New York the other night who had on a new suit of clothes. I admired the suit and he said, "This suit is remarkable." I said, "What is remarkable about it?" He said, "The wool was grown in Australia, the cloth was made in Scotland, the thread was made in New England, the suit was tailored in Rochester, New York, and I bought it in Mobile, Alabama. Now, how could so many people make a living out of something that I have not even paid for?"

I think the one thing that most business men in America know so little about is economics. We do not understand economics. The politicians try to be economists. Our world, something is wrong with it—we do not seem to be getting along so well. We are doing all right here in America, and the rest of the world is starving to death—they want us to loan them billions of dollars. I hope they do not loan that money until they fix up the towns in this country—I am getting to that age where I want the comforts that we do not always get in these towns of ours.

However, when we do not understand something we try to figure it out, and that is what we have got to do with this money situation.

One of the greatest economists said several years ago that only eighteen men in the world understood money—think that over, only eighteen men in the world who understood money. This economist was not one of those men, and nobody in Illinois. Think of it! You think you understand money! Do you?

Down in the little State of Delaware a traveling man went into a hotel, registered, and took out of his pocket a wallet in which he had a hundred dollar bill; he gave it to the hotel manager and said, "I am going out into the country where I will not need a hundred dollars; so, will you put it in the safe for me until I get back tonight.'' The manager said, ''Certainly,'' and wrote him out a receipt for it. The traveling man went on his way, and the hotel manager took the hundred dollar bill and put it in the safe.

It was Monday morning and a holiday, the banks were closed. There was a lawyer in that small town who wanted to go away, and did not have cash on hand to do so. He called his grocer and said, ''Bill, you owe me a hundred dollars. I have never asked you for it, but I need it and if you can get it for me I would appreciate it.'' The grocer said, ''Certainly, I can get it for you.'' The grocer went right down to the hotel where he served them groceries—they had a running account, and whenever he needed money he went down to the hotel and got it. He told the hotel manager that he needed the money to pay a bill. The hotel manager told him that he would give him the hundred dollars, and opened his cash box to count out the money. He did not have a hundred dollars in the cash box; so he put the money back and closed the cash box, and then opened the safe, took out the hundred dollar bill, and gave it to the grocer—that paid the first man. The grocer took the hundred dollars, went up to the Lawyer's office and paid him. The lawyer, at the time, was in a conference so the grocer yelled at him, ''John, here is the hundred dollars. I will put it here on the desk with this weight on it.'' After a while, the lawyer came out and saw the hundred dollar bill and said, ''Well, he paid me, but I wish he had not brought me a hundred dollar bill because I am going duck hunting, and what will I do with it?'' He had no place to put a hundred dollar bill for safe keeping. Suddenly he thought of the hundred dollars he owed his doctor, so he took the hundred dollar bill over to him and paid him—that was three people paid, the grocer, lawyer and doctor. The doctor went right over to the dentist and paid him the hundred dollars that he owed him—that is four people. The dentist never saw a hundred dollar bill before and he was scared; so, he put on his hat went over to the funeral parlor and paid the undertaker the hundred dollars that he owed him—that was the fifth person paid. The undertaker's daughter was married a couple of weeks before, and he had a huge reception for her at the hotel, and he still owed a hundred dollars on the bill; he took the hundred dollar bill, went over to the hotel and finished paying his bill—six people paid. The hotel manager took the hundred dollars and put it back in the safe, and everybody was paid.

Do you understand it? Do you want me to go over it? That is not all of the story.

The traveling man came back to the hotel that night, presented his receipt to the hotel manager; the hotel manager opened the safe, took out the hundred dollar bill and gave it to the traveling man because it belonged to him—did it or did it not? He took it, looked at it and laughed and asked the hotel manager if he had any trouble with it. The manager told him that it had caused him no trouble. The traveling man said, ''Well, I was just wondering because I was playing a joke on you. This hundred dollar bill is a counterfeit.''

Little do we know. Do not think I am standing here trying to make you think I know everything, because I do not know very much.

In the summer time when nobody listens to me talk, and I do not have a good winter, I have got to do something—I may be out in Illinois for a job, who knows? I took a job once—selling pool tables. Did you ever try to sell pool tables? Well, people must buy them. They have pool halls everywhere, and many people have them in their homes, the pool tables, and, so, people must buy them.

They gave me a prospect, a millionaire who wanted to buy a pool table. They told me he was slightly eccentric.

"Do you want a pool table?"

He said, "Yes."

"Do you want the regulation size?"

"No, I want a pool table fifteen feet long, and two feet wide."

"You want a pool table fifteen feet long, and two feet wide? How high do you want it?"

"I do not want it high; I want it right on the floor."

"You want a pool table fifteen feet long, two feet wide, and with no legs? How about the pockets? Do you want three on each side?"

"I want one pocket, right in the center."

"You want a pool table fifteen feet long, two feet wide, no legs, and a pocket—just one pocket, in the center of the table?"

"Yes, that is just what I want."

"How about the cue balls and pool balls? Do you want them in different colors with little numbers on them?"

"No, I want thirteen balls, all pink, and no numbers."

"You want a pool table fifteen feet long, two feet wide, no legs, one pocket in the center of the table, thirteen balls, all pink, and no numbers on them?"

"That is exactly what I want."

"How about the sticks to shoot the balls with; shall I send you a couple of dozen?"

"No, I do not want any sticks. We are going to use match sticks."

He was only slightly eccentric. I said, "You are going to use match sticks for these thirteen pink balls on a pool table fifteen feet long, two feet wide, no legs, and with one pocket in the center?"

"That is what I am going to do."

"Do you really want a pool table such as you just ordered?"

"That is what I want, and nothing else."

So, I wrote up the order and sent it into the company. The table was delivered to me on Wednesday, and the millionaire died the night before. As you travel around, if you find anybody who can use a good pool table, let me know.

You see, I am still an optimist. There is a lot wrong with this world today, but everything will work out o.k. in the end; the law of supply and demand will take care of that.

Well, I have been talking to you for an hour about the mistakes other people make, and the moral of the whole thing is—let us not make mistakes so the world will not laugh at us.

This party is a lot different than some I have attended. The other night I spoke at a dinner party at a night club, and everybody was drunk. The toastmaster had a goblet in each hand—a two-fisted drinker. When he got up to introduce the speaker he said, "I am glad to see so many more people than are really here." One fellow did not like the party and decided to go home. He went out the front door, and there was a man standing there in a blue uniform with brass buttons and a lot of gold braid. He walked up to him and said, "Get me a cab." The fellow told him that he was not a doorman; that he was a United States Naval officer. "Well" he said, "Call me a boat, I have got to get home."

You know, there are a lot of business men who do not know what they want to do, and knowing what you want to do is the first law of success. And you as an individual, must know exactly what you want to do. You must then work hard enough to do it and make whatever sacrifices are necessary in order to do it. Do not be stumped.

When I lived in Albany, New York, I knew a fellow who lived in Troy, New York. One morning he heard a knock on his back door; he got up, went to the closet to get his bathrobe and by mistake got his wife's kimono. He put it on and went downstairs and opened the back door. There was the ice man, and he threw his arms around him and kissed him. He went back upstairs trying to figure out why the ice man kissed him. And he figured the ice man's wife must have had a kimono just like the one he had on. The sorry part of this story is, to this day the old fellow does not know that he was wrong.

I thank you. (Applause.)

* * *

Toastmaster Browning: Thank you Mr. Gheen. You certainly have told this evening how "Little Do We Know." I know that every man in this room realizes that he has heard one hell of a good speech.

We want to thank each and every one of you for your kind attention.

We have a few more things here, and then we will adjourn.

We had an election today, and you elected as your President for the coming year, Mr. Harry M. Moses. At this time, I take great pleasure in turning this microphone and this meeting over to your new President, Mr. Harry M. Moses. (Applause.)

President Moses: I will not take too much of your time, and I know I can not compete with Mr. Gheen or Mr. Browning.

But, Gentlemen of the Illinois Mining Institute, it is a lot of fun to come back home. It is a lot of fun to come back home as the Prodigal Son, and have you killed the fatted calf for me. You have given me one of the finest honors that could be given to any person, and I appreciate it more than I will ever be able to tell you. I will endeavor with all my might to be completely worthy of the honor you have bestowed upon me.

I have long recognized the wonderful friendships I have here in Illinois with you gentlemen, and I am proud of my association with you. I am proud of my background in the State, and I talk about it and tell everybody about it that I can.

I want to be a part of this Institute. I served in this Institute for many years as a member of your Board until I left the State. I helped revise the organization back in 1929 when it was falling apart. And, now, I am very happy to be the head of your Institute.

Perhaps the ambition to become your President was inspired by the fact that my father was, at one time, the President of the Illinois Mining Institute, and that he might be proud if I should ever merit this honor.

I am looking forward to serving you. I am glad to be back with you.

This meeting today has the largest crowd ever assembled at our Mining Institute meetings. This reminds me of a story. Again, I say that I will not try to compete with Mr. Gheen in telling it, but it is a true story.

In 1932, in West Virginia, we were opposed to the organization of our employees by the United Mine Workers of America—that was before it got to be a crime to say that we opposed unionism. We were making speeches every time we had a chance. We told them they would be much better off without the union, and that we would continue doing for them what we had done in the past, and that we would get along much better if we did not have the union.

We had a colored gentleman of some distinction in our community down there. Jim had been a character there for a great many years. The colored people there celebrated Emancipation Day there in the colored school, and they invited me to make a speech at one of the celebrations. I was delighted to do so. Jim took charge of the meeting and introduced me. I talked for about fifteen or twenty minutes about the union, and when I finished there was a burst of applause. Old Jim came strutting up to me and then he said, "That reminds me of a story. When the children of Israel were being driven out of Egypt, they rushed along the hot sands, and right on their tail was the Pharaoh and his army. They reached the bank of the Red Sea, and looked back and again the Pharaoh's army was right on their tail. Then they looked at the angry water of the Red Sea and said, 'Oh, Lord, what are we going to do?' What happened! What happened! The voice of an Angel comes back to them. What did that Angel say? The Angel says, 'Stand back, you angry sea, so I can lead these children to Moses.' "

I want to say in closing, thanks again, for my many years of fine association with all of you. I want again to thank you for the honor you bestowed upon me today. Good luck and God bless all of you. (Applause.)

I understand it is my official duty to tell you the meeting stands adjourned.

(The meeting adjourned at nine-ten o'clock.)

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Coal as a Fuel for the Gas Turbine

By John I. Yellott*

(Chicago Meeting, February 1946)

Since the days of Newcomen and Watt, when men first sought to turn the energy of fuels to useful purposes, coal-generated steam has supplied most of the power needed for both stationary and mobile applications. The low efficiency and large water requirements of the nineteenth century steam-power plant caused many engineers to turn their thoughts toward more direct means of converting heat into power. As far back as 1791, John Barber secured an English patent on a combination[1] which he might well have called a "gas turbine." He proposed to generate producer gas from coal or charcoal, to burn it under pressure in air obtained from a reciprocating compressor, and to drive a turbine wheel with the resultant hot combustion products. With the optimism characteristic of the inventor, he hoped that the turbine would not only operate his compressor but also perform useful work. There is no record that Barber ever built his machine, but if he had done so he would have learned that useful power can result from such a combination only when both turbine and compressor are highly efficient and when the temperature of the gas entering the turbine is not far below 1000°F.

Hot-air prime movers continued to attract attention, and both Stirling in England and Ericsson in America[2] built reciprocating engines that operated with some success upon coal-heated air. The internal-combustion engine, burning liquid fuels, supplanted the hot-air type, and, for the first time, challenged the supremacy of both the steam cycle and its familiar fuel, coal.

Liquid Fuels Compete with Coal

As the increasing use of the automobile multiplied the demand for gasoline, the supply of residual fuel increased rapidly, and heavy oil declined in price to the point where it became competitive with coal. First in the marine field and later in stationary plants in areas adjacent to refineries, oil began to be widely used. Oil's greater convenience and higher heating value per pound of weight or per cubic foot of bunker space have caused it to take over much of the marine field.

The introduction of the highly efficient diesel engine, capable of burning a fuel that is cheaper than gasoline, again threatened the position of coal, for the operating costs of the diesel became directly competitive with those of coal-burning equipment. In isolated power plants and smaller marine installations, the diesel provided the medium by which oil again successfully invaded fields formerly dominated by coal.

The diesel engine, provided with an electrical transmission, found an excellent application in railroad service. The high availability of diesel-electric locomotives, resulting in part from freedom from water

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[1] References are at the end of the paper.

troubles and in part from the absence of ash-disposal problems, offset their higher first cost. Their high thermal efficiency has made the use of light fuel oil* three to four times as expensive as coal per million British thermal units, so economical that American railroads are turning increasingly toward the diesel in their purchases of new motive power. Virtually no new steam switchers are being built, and most of the road locomotives now on order are to be fueled with light oil rather than with coal.

In summary, oil, refined to diesel grade or in the form of a low-priced heavy residue of the gasoline refinery, is in wide and increasing use as a fuel in both internal combustion and steam-powered prime movers. In forecasting the trends that will become apparent in the fuel situation during the next few years, it is essential to consider the relative importance of the nation's fuel resources, and their place in the over-all economy of the nation as a whole.

Future Fuel Resources

An accurate audit of the reserves of liquid and gaseous fuels in the United States is a physical impossibility, for new fields are constantly being discovered. A reasonable estimate,[3] however, anticipates the exhaustion within 15 to 30 years of presently known supplies of petroleum and natural gas. Oil shale and tar sands undoubtedly will produce large additional quantities of liquid fuels, but at a cost considerably higher than that now in force.

The United States, more than any other nation, is tied to the automobile and to liquid fuel. For reasons of national security as well, vast quantities of gasoline are a necessity for both military and commercial aviation, while the Navy needs adequate supplies of diesel and fuel oil. The technical availability of two synthetic processes for producing liquid fuels from coal is well established, but it is equally well known that the cost of gasoline thus synthesized would be much higher than for motor fuel derived from petroleum or natural gas. Incidentally, if all of the *proven* reserves of natural gas were diverted to gasoline production, they would yield, at the 1940 rate of consumption, only a 20-year supply of motor fuel.[3]

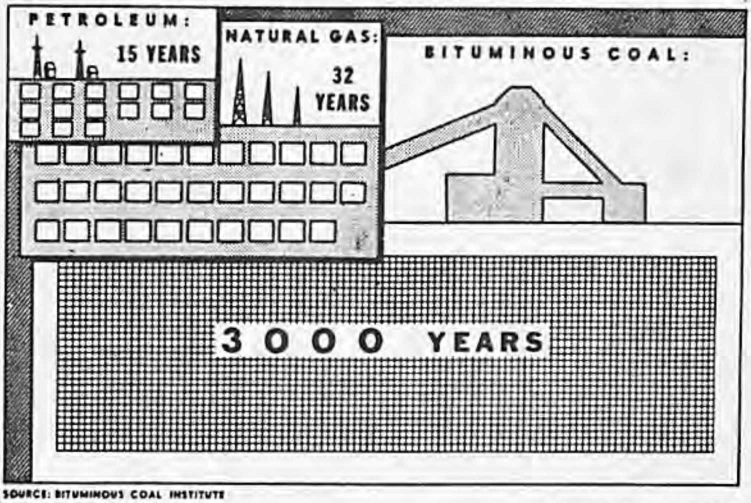
It is of the utmost importance to realize that these synthetic processes are designed to yield as much higher priced gasoline or diesel fuel as possible, with the minimum attainable yield of heavy residues.* This fact indicates that the availability and hence the price of heavy oil will be very different in the era of synthetic gasoline, not far distant in the nation's life, than they are now. Long-range fuel planning must take into account as well the fact that the refining of crude oil will be increasingly directed within the next few years to high-value motor fuels. The importation of crude oil from foreign sources also will tend to raise the cost of refinery products. Most of the recent developments in petroleum refining, including the Thermofor and the fluid catalyst processes, yield higher percentages of gasoline, and smaller residues of fuel oil.

The coal reserves of the United States, for all practical purposes, are inexhaustible. High-grade bituminous coal is available in known fields in quantities sufficient to supply all of the nation's fuel needs for almost 3000 years (Fig. 1). Vast quanti-

* Diesel fuel in 1945 averaged 40 cents per million Btu; coal at $3.00 per ton cost 12 cents per million Btu.

* The *New York Herald-Tribune* for January 17, 1946, stated that plans are being perfected to build at a cost of $14,000,000 a plant that will utilize 60,000,000 cu. ft. of natural gas per day and produce 5900 bbl of high-octane gasoline and 1100 bbl of diesel fuel and other oils.

ties of lignite are not even included in this estimate. From the conservationist's point of view, the use of coal evidently is desirable to preserve the diminishing supplies of oil and gas.



Graphic by Pick-S.N.Y.

FIG. 1.—UNITED STATES FUEL RESERVES.

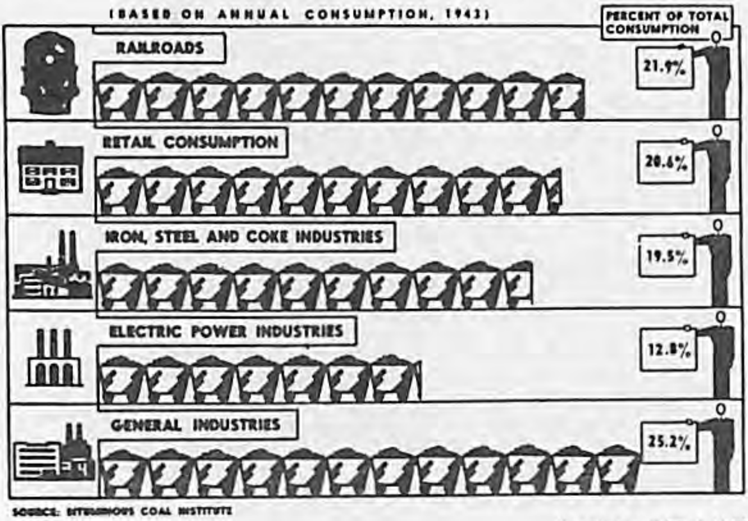
If the 1940 rate of gasoline consumption in the United States is taken for comparison, there is enough high-grade coal available for the Fischer-Tropsch process to yield 3750 years' supply of motor fuel.[3] In addition, there is an equivalent amount of lower grade coal. As a matter of fact, viewing the economics of liquid-fuel production and transportation, the vast deposits of lignite in Texas alone can replace all the world's oil wells for hundreds of years at the present rate of consumption.

PROSPECTS FOR ATOMIC POWER

Atomic energy must be considered in any forecast of fuel uses and economics, because the heat that can be released by nuclear fission makes all other sources of energy minute by comparison. The first successful controlled "chain reaction"[4] performed at the University of Chicago in a laboratory improvised under the stands of Stagg Field on Dec. 2, 1942, was perhaps the most significant scientific achievement in history. By controlling the rate of heat release, the destructive power of atomic energy, so alarmingly demonstrated at Hiroshimo and Nagasaki, can be turned toward useful purposes. The type of equipment might be not greatly different[5] from that used in the closed-cycle gas turbine (Fig. 6).

The principal drawbacks to the use of atomic energy for industrial purposes are radioactivity and cost. The intense gamma radiations that emerge from the "pile"[4] require protective measures similar in character but far more effective than those used in industrial or medical X-ray practice. The operation of the "pile" must be accomplished by remote control, since a thick shield must be interposed between the pile and the operators. Maintenance in the usual sense is impossible because an unprotected worker cannot approach the pile for many years after it has started to operate.

These staggering difficulties were overcome in the Oak Ridge and Hanford plants, but the initial cost of the necessary equipment was extremely high. It is interesting to note that vast quantities of coal[6] are required to supply the steam and power used in the production of the atomic bomb.



Graphic by Pick-S N Y.

FIG. 2.—UTILIZATION OF BITUMINOUS COAL.

The economics of power generation for most applications require that fixed charges on the equipment be considered at least as important as the fuel costs. For this reason, atomic energy, even with greatly reduced prices for the fissionable materials, will not be widely competitive for many years to come.

COAL AND THE RAILROADS

The particular importance of coal to the railroads, and of the railroads to the coal industry, is shown in Fig. 2. In normal times, the railroads consume more than 20 per cent of the coal mined in the United States, and, conversely, the hauling of coal is one of the most important sources of railroad revenue. There can be no doubt that the welfare of the railroads and of the nation as a whole is closely associated with the continued use of coal as the dominating railroad fuel.

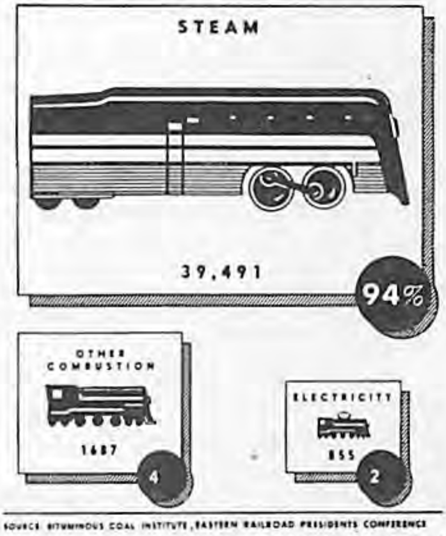
At least half of the locomotives in the United States are 30 years old or more, and most of them will have to be replaced during the next decade. The necessity for greatly improved coal-burning motive power is facing most American railroads today (Fig. 3). For many practical reasons, not the least of which is the danger of radioactivity, atomic power is not likely to be important in the railroad field for many years to come. Also, synthetic liquid fuels, while they are technically available, will certainly cost considerably more than the natural products that are in use today. The economic importance of developing a greatly improved method of generating power from coal is most apparent in the railroad field, but both the marine and the stationary-power fields will in time be faced with similar problems.

THE GAS TURBINE

The combustion gas turbine, old in conception but relatively new in practical application, has come into prominence just at the time when a simple and reasonably efficient prime mover for low-cost fuels is required. With the development during the 1930's of efficient compressors, and the concurrent improvement in heat-resistant alloys, the gas turbine has taken its place with steam and the internal-combustion engine as a practical source of power. The gas turbine already has demonstrated its ability to burn liquid and gaseous fuels. In aircraft applications, jet planes powered by gas turbines have taken over completely the high-speed field. Apparently most large aircraft of the future will use gas-turbine power, applied through a propeller or a jet, or a combination of the two.

Two major types of combustion gas turbines, the open cycle and the closed cycle, have already been developed. The simplest form is the open cycle, shown in Fig. 4. Air at the prevailing atmospheric condition is taken into a compressor, where its pressure is raised by an appropriate ratio, usually between four and six to one. The resulting air, partially heated by compression, can then go directly into the combustor, but a very marked increase in efficiency is accomplished by using a heat exchanger, usually called a "regenerator," to transfer heat from the turbine exhaust to the compressed air. The fuel is burned directly in this preheated compressed air, raising its temperature to whatever value the designer has selected. The hot combustion products then pass through the turbine, where enough work is done to operate the compressor and to drive the generator, which is geared to the turbine shaft. The cycle efficiency of the turbine-compressor-regenerator combination depends upon pressure ratio, turbine-inlet temperature, and the effectiveness of the regenerator. An excellent presentation of this relationship was made by Smith and Soderberg,[7] and Fig. 5 is reproduced from their publication. Using a maximum temperature of 1350°F., with a regenerator effectiveness between 50 and 75 per cent, it is shown on Fig. 5 that an optimum thermal efficiency of about 28 per cent is attained at a pressure ratio of five to one.

A summary of the open cycle indicates that it offers admirable simplicity, but



Graphic by Pick-S.N.Y.

FIG. 3.—LOCOMOTIVES IN SERVICE IN 1942.

it is subject to marked changes in performance with changes in the ambient temperature and barometric pressure. Also, the burning of the fuel in the working fluid necessitates the use of ash-free fuel or the provision of ash-removal means in the hot gas stream between the combustor and the turbine. The net output of the machine is restricted under present design limitations to about 10,000 kw., because of the large amount of compressor work that must be supplied by the turbine in addition to the net power. A 2400-hp. unit, for example, has a 6400-hp. turbine, but 4000 hp. is used by the compressor. The low absolute pressure and high temperature of the air mean that large volumes must be handled. Simplicity, with probable moderate first cost and low maintenance charges, lightness, flexibility, and good thermal efficiency are the outstanding assets of the open-cycle gas turbine.

The closed-cycle gas turbine, shown in Fig. 6 and described by Keller,[8] uses a heater, which may be fired by any kind of fuel, to raise the temperature of a gas coming from the regenerator at about 700° to about 1400°F., at which it enters the turbine. Expanding through a pressure ratio that may be as high as ten to one, the gas is discharged from the turbine at 750° to 950°F. after having done enough work to run the compressor and to deliver as shaft work about 35 per cent of the heating value of the fuel. A precooler reduces the gas temperature to 70°F., at which it enters the compressor. The gas, which may be air or any other suitable substance such as helium or nitrogen, is under a maximum pressure of 400 to 600 lb. per sq. in. and a minimum pressure of 40 to 60 lb. per sq. in. abs. Control can be accomplished by varying the quantity, and hence the pressure level, of the gas in the closed circuit.

Since the working gas is always relatively dense, the compressor and turbines are relatively small, and maximum outputs up to 50,000 kw. are anticipated. The air heater must be large, however, and water must be used to precool the working gas after it leaves the turbine. Test results show that thermal efficiencies above 30 per cent can be obtained with relatively small plants, and for locations where even solid fuel is expensive, the closed-cycle system will be useful. For locomotives, however, the size of the necessary heat exchanger is excessive, and the closed cycle seems to be limited to marine or stationary plants.

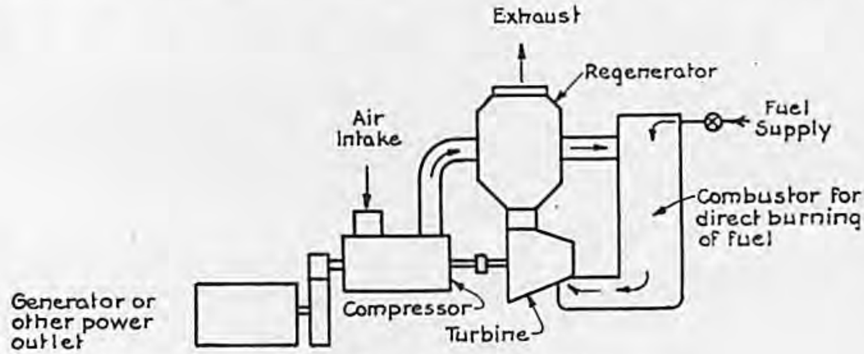


FIG. 4.—OPEN-CYCLE GAS TURBINE.

ANALYSIS OF THE OPEN CYCLE

The open cycle is so well adapted to both locomotives and isolated, waterless locations that a careful analysis of its possibilities is justified. The thermodynamics of the cycle are simple and the necessary calculations are readily made with the assistance of the Keenan and Kaye[10] tables, the Navy gas charts,[11] or the Allis-Chalmers[12] Mollier chart. The operating conditions for a locomotive gas turbine of 4000 rail horsepower (5000 hp. at the turbine shaft) can be taken from Fig. 5; at a full-load turbine-inlet temperature of 1350°F., with 60 per cent regenerator effectiveness, the optimum pressure ratio is approximately five to one. A shaft thermal efficiency approaching 29 per cent would be attained if pressure losses were neglected. The turbine efficiency probably will exceed 86 per cent, while 84 per cent is a conservative value for the efficiency of a large axial-flow compressor.

The cycle shown in Fig. 7 utilizes the assumptions given in the preceding paragraph and the condition prevailing at

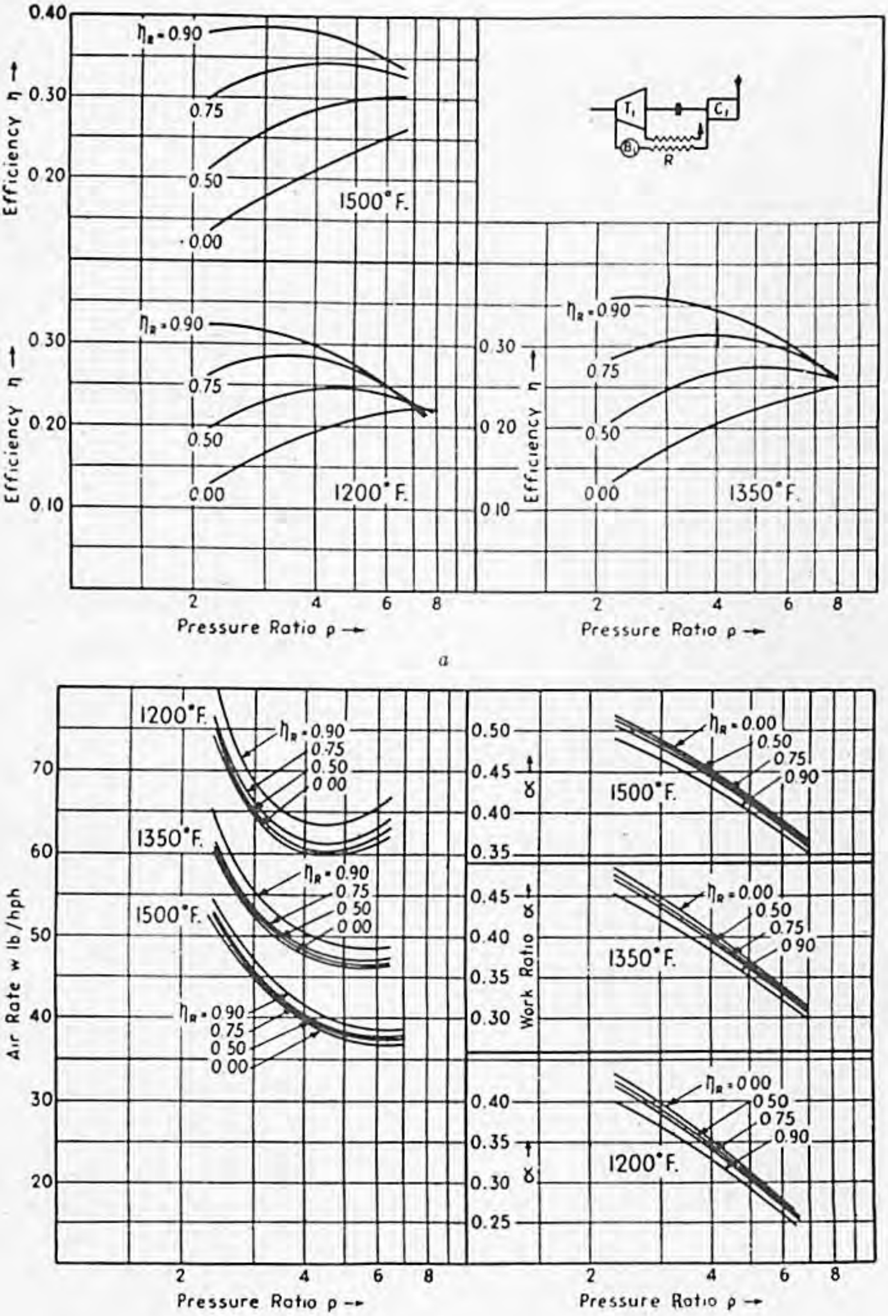


FIG. 5.—OPEN-CYCLE PERFORMANCE.

a. Efficiencies at various temperatures for cycle 1-0-η_R (1 combustion chamber, 0 intercoolers, various regenerator efficiencies as shown, denoted by η_R)

b. Air rate and work ratios for cycle 1-0-η_R shown in *a*.

each point is given. Tables 1 and 2 give the detailed computations for the cycle of Fig. 7. Without the regenerator, an efficiency of 21.4 per cent would be anticipated. If a 60 per cent regenerator is utilized, the top efficiency rises to 29.0 per cent, but pressure losses and imperfect combustion will reduce this to about 26 per cent. The quantities of air and fuel needed for a shaft power of 5000 hp. are given in Table 3.

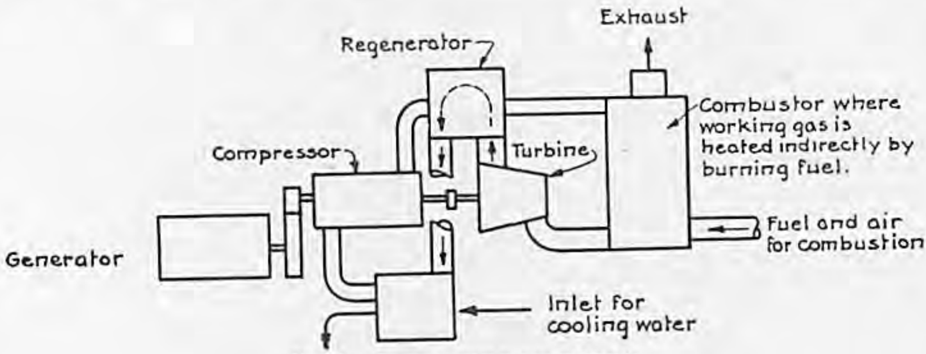


Fig. 6.—Closed-cycle gas turbine.

Table 1.—*Computations for Open-cycle Gas Turbine without Regenerator*[a]

1. Initial conditions: $t_1 = 70°$F.; $T_1 = 529.6°R$; $P_1 = 14.7$ lb. per sq. in. abs.; $P_{r1} = 2.676$; $h_1 = 31.1 \frac{\text{B.t.u.}}{\text{lb.}}$; $V_1 = 13.35 \frac{\text{cu. ft.}}{\text{lb.}}$
2. After isentropic compression to $P^* = 5.0$, $P_{r2} = 5 \times 2.676 = 13.38$; $P_2 = 5 \times 14.7 = 73.5$ lb. per sq. in abs.; $h_2 = 105.3 \frac{\text{B.t.u.}}{\text{lb.}}$; $T_2 = 836.5°R$; ideal work $= 105.3 - 31.1 = 74.2 \frac{\text{B.t.u.}}{\text{lb.}}$
3. With 84 per cent compressor efficiency, ${}_1\Delta_2 h = 74.2/0.84 = 88.2 \frac{\text{B.t.u.}}{\text{lb.}}$; h'_2 (at compressor outlet) $= 31.1 + 88.2 = 119.3 \frac{\text{B.t.u.}}{\text{lb.}}$; $T'_2 = 893.6°R$, $t'_2 = 434°$F.; $V_2 = 4.5 \frac{\text{cu. ft.}}{\text{lb.}}$
4. After heating to $t_4 = 1350°$F., $T_4 = 1809.6°R$; $P_{r4} = 241.36$; $h_4 = 357.1 \frac{\text{B.t.u.}}{\text{lb.}}$; $V_4 = 9.1 \frac{\text{cu. ft.}}{\text{lb.}}$
   q_c = heat added in combustor $= 357.1 - 119.3 = 237.8 \frac{\text{B.t.u.}}{\text{lb.}}$
5. After isentropic expansion to $P_5 = 14.7$ lb. per sq. in. abs.; $P_{r5} = 48.27$; $T_5 = 1190.7°R$; $t_5 = 731.1°$F.; $h_5 = 193.6 \frac{\text{B.t.u.}}{\text{lb.}}$
6. With 86 per cent turbine efficiency, ${}_4\Delta_5 h = 0.86 \times 163.5 = 140.6 \frac{\text{B.t.u.}}{\text{lb.}}$; $T'_5 = 1280.2°R$, $t'_5 = 820.6°$F.; $V'_5 = 32.3 \frac{\text{cu. ft.}}{\text{lb.}}$
7. Net energy available $= 140.6 - 88.2 = 52.4 \frac{\text{B.t.u.}}{\text{lb.}}$
   Air rate $= \frac{2545}{52.4} = 48.7 \frac{\text{lb.}}{\text{hp-hr.}}$
8. Cycle efficiency $= 2545/(48.7 \times 237.8) = 0.221$.
   With 97 per cent combustion efficiency, $E_c = 0.97 \times 0.221 = 21.4$ per cent.

P_r = "relative pressure" (See references 10 and 11).
h = enthalpy, B.t.u. per lb.
V = specific volume, cu. ft. per lb.

[a] Dry air data from Gas Turbine Gas Charts.[11]

Table 2.—*Efficiency of Open Cycle with 60 Per Cent Regenerator Effectiveness*

1. Maximum possible temperature rise $= t'_5 - t'_2 = 820.6 - 434.0 = 386.6°$F.
2. Actual temperature rise $= 0.60 \times 386.6° = 231.9°$F.
3. Temperature of air leaving regenerator $= t_3 = 665.9°$F.; $T_3 = 1125.5°R$; $h_3 = 177.1 \frac{\text{B.t.u.}}{\text{lb.}}$; $V_3 = 5.68 \frac{\text{cu. ft.}}{\text{lb.}}$
4. Heat added in combustor, $q_c = 357.1 - 177.1 = 180.0 \frac{\text{B.t.u.}}{\text{lb.}}$
5. Cycle efficiency $= 2545/(48.7 \times 180) = 29.0$ per cent.
   With 97 per cent combustor efficiency, $E_c = 28.1$ per cent.
   Pressure losses in the regenerator, combustor, and fly-ash separator will reduce this to about 26 per cent.

The variation of intake-air temperature with altitude and with seasonal changes will cause marked variations in the performance of the unit, the outstanding beneficial effect being the 50 per cent increase in shaft power that occurs when the temperature falls to zero.

The applicability of the gas turbine to locomotive service is demonstrated by the success of the Brown-Boveri unit, which was built for the Swiss Federal Railways. This unit has been adequately described in the technical press,[13] and its efficiency of 14 per cent at the rails, with a maximum temperature of only 1040°F., demonstrated that, in 1939, the open cycle could attain an efficiency far higher than the best steam locomotive.

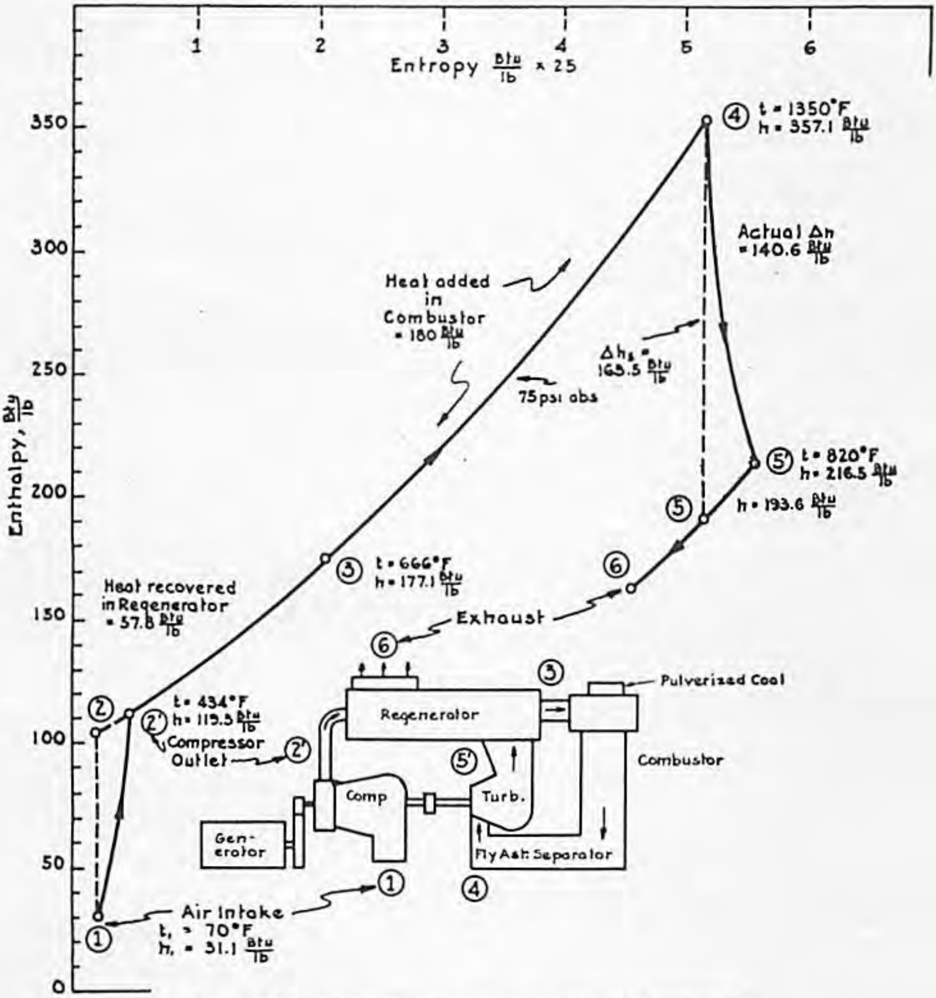


FIG. 7.—MOLLIER DIAGRAM FOR OPEN-CYCLE GAS TURBINE.
B.T.U. PER POUND

Turbine work.......	140.6	Cycle efficiency....... $\frac{52.4}{180.0} \times 100 = 29.0\%$
Compressor work....	−88.2	(Neglecting losses)
Net power..........	52.4	

ECONOMICS OF THE COAL-BURNING TURBO-MOTIVE

The economics of the open-cycle gas turbine for locomotive service may be investigated with the aid of operating data from a large eastern railroad. For the first eleven months of 1945, the diesel passenger locomotives of this road covered 3,363,132 miles, with the consumption of 10,317,262 gal. of diesel oil, costing 6.38 cents per gallon. Thus the average mile required 3.07 gal. and the necessary oil cost about 19.6 cents. The lubricating oil required per locomotive mile was 0.0586 gal., at 45.6 cents per gallon, so this cost of 2.67 cents per mile must be added to

TABLE 3.—*Air and Fuel Requirements*

Quantities required for 5000 shaft horsepower or 4000 rail horsepower, assuming 20 per cent of the shaft power for electrical transmission losses, auxiliary power, brake air compressors, and other purposes.

1. Air required per hour $= 5000 \times 48.7 \frac{\text{lb.}}{\text{hp-hr.}} = 243{,}500 \frac{\text{lb.}}{\text{hr.}}$
2. Compressor displacement $= \frac{243{,}500}{60} \times 13.35 \frac{\text{cu. ft.}}{\text{lb.}} = 54{,}300$ cu. ft. per min.
3. Required heat release $= 243{,}500 \times 180.0 \frac{\text{B.t.u.}}{\text{lb.}} = 43.8 \times 10^6 \frac{\text{B.t.u.}}{\text{hr.}}$
4. Necessary fuel input $= \frac{43.8 \times 10^6}{0.97} = 45.2 \times 10^6 \frac{\text{B.t.u.}}{\text{hr.}}$ (97 per cent combustor efficiency).
5. Weight of coal per hr. $= \frac{45.2 \times 10^6}{13{,}000} = 3480 \frac{\text{lb.}}{\text{hr.}}$ (13,000 B.t.u. per lb.).
6. Correction for lowered efficiency due to pressure losses, etc.
   Probable full load fuel consumption $= 3480 \times \frac{29\ \%}{26\ \%} = 3900 \frac{\text{lb.}}{\text{hr.}}$
7. Specific fuel consumption at full load $= \frac{3900}{4000} = 0.98 \frac{\text{lb. coal}}{\text{rail hp-hr.}}$

the fuel cost, to give a total of 22.27 cents per locomotive mile. If 260,000 miles are taken[9] as a reasonable year's work, the fuel bill would be $51,000 and the lubricating oil would add $6,950, making a total cost of $57,950.

The fuel used by the diesel cost about 42 cents per million B.t.u., and the average mile required 462,000 B.t.u. The electrical transmission efficiency may be taken as 82 per cent, while the average efficiency of the diesel engine can be taken as 30 per cent. If a gas turbine were to replace the diesel, and an average shaft thermal efficiency of 20 per cent could be attained, the average mile would require

$$462{,}000 \times \frac{30}{20} = 692{,}000 \text{ B.t.u.}$$

Coal with a heating value of 13,000 B.t.u. per pound, or 26,000,000 B.t.u. per ton, would cost about $3 per ton, or 11.5 cents per million B.t.u. The average mile would cost 7.96 cents, and the year's fuel bill for 260,000 miles would be $20,700, instead of $51,000. The lubricating bill for the gas turbine would not exceed $300, since the oil is not consumed.

If the gas-turbine locomotive costs no more than the diesel, the saving in fuel costs should be directly reflected in annual operating economy. The third man on the diesel will not be required aboard the coal-burning turbo-motive, and the maintenance cost of the turbine-compressor-combustor is not likely to exceed that of the diesel. The same electrical maintenance can be expected for both, although the turbo-motive can look forward to mechanical transmission with higher efficiency, lower first cost, and less upkeep.

LOCOMOTIVE DEVELOPMENT COMMITTEE'S RESEARCH PROGRAM

The economic desirability of putting the coal-burning gas turbine on the rails is evident. The Locomotive Development Committee* is sponsoring a comprehensive

* R. B. White, President, Baltimore & Ohio R.R.
C. E. Newton, President, Chesapeake & Ohio Rwy.
J. B. Hill, President, Louisville & Nashville R.R.
G. Metzman, President, New York Central System.
W. J. Jenks, President, Norfolk & Western Rwy.
W. S. Franklin, Vice President, Pennsylvania R.R.
G. M. Humphrey, President, M. A. Hanna Co.
J. D. Francis, President, Island Creek Coal Co.
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Howard N. Eavenson, President, Bituminous Coal Research, Inc.
Harold J. Rose, Vice President and Director of Research, Bituminous Coal Research, Inc.

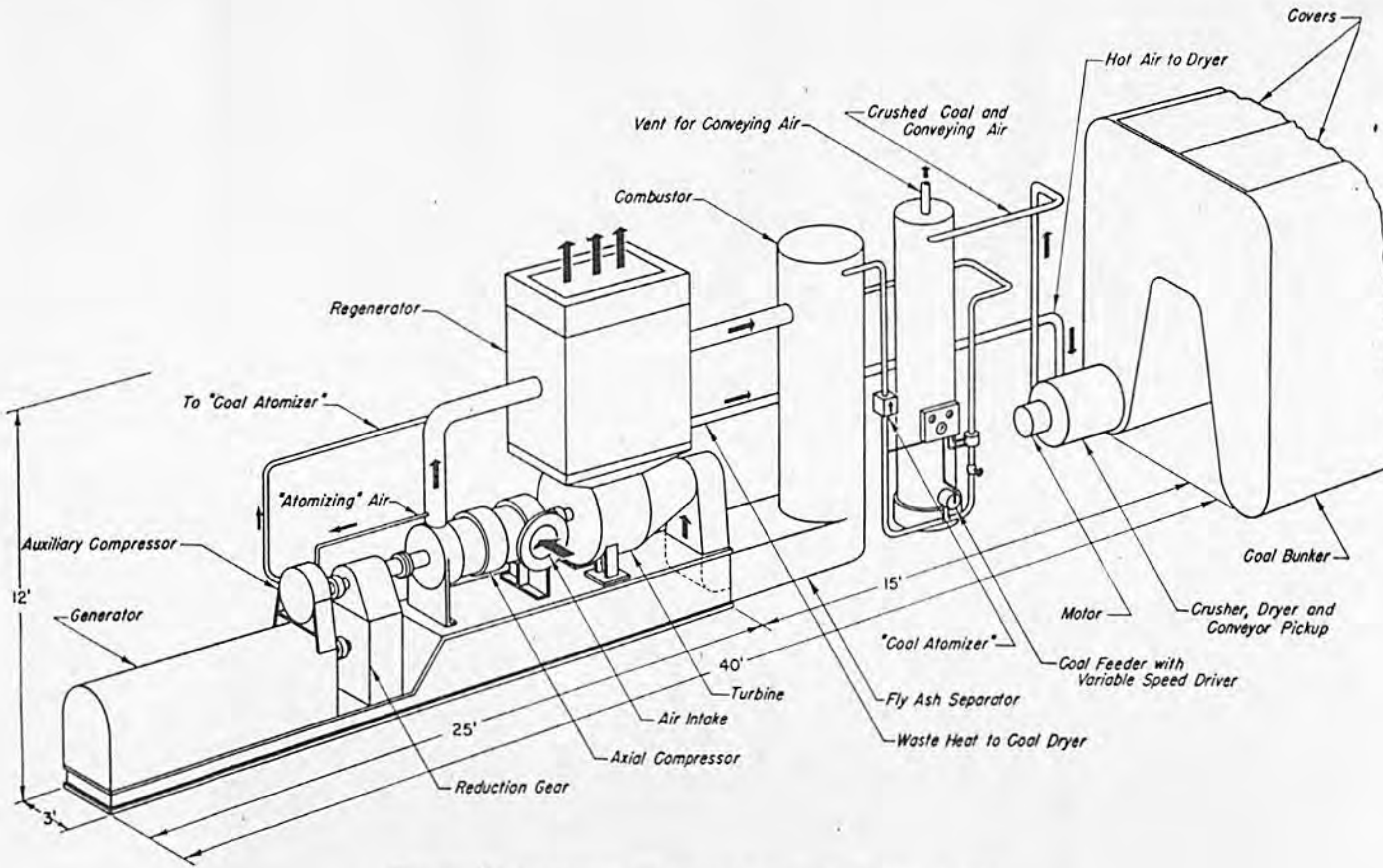

FIG. 8.—COAL-BURNING GAS TURBINE FOR LOCOMOTIVE SERVICE.
Locomotive Development Committee, Bituminous Coal Research, Inc.

program of research and development directed toward solving the three major problems that must be faced in applying a solid fuel to the combustion turbine:

1. Preparation of the fuel.

2. Combustion within the space limitations imposed by the locomotive.

3. Removal of the fly-ash to the extent necessary to give adequate life to the turbine blades.

The turbine itself is quite impartial as to the source of the hot air on which it operates, provided only that it contain no harmful solid matter. The compressor is equally adaptable, and the regenerator, like the turbine, needs only to be supplied with reasonably clean air.

In analyzing the three major problems, the operating conditions of the open cycle must be considered. The preparation of the fuel must accomplish the following:

1. Transportation from the coal bunker to the combustor.

2. Crushing and drying the coal to permit reliable feeding.

3. Pressurizing of the crushed, dried coal.

4. Feeding at a controlled rate to the pulverizer.

5. Pulverizing to the smallest practical particle size.

6. Transporting to the combustor.

Fig. 8 shows the general arrangement of the proposed coal-handling system.

The quantity of coal that must be carried depends primarily upon the range the locomotive must have. For full load, the probable performance is approximately that shown in Table 3. Assuming that the locomotive must run without stopping for 10 hr., 39,000 lb. of coal, or 19.5 tons, would be needed. Since coal weighs about 50 lb. per cubic foot, the bunker must contain at least 780 cu. ft. If a divided bunker, like that shown in Fig. 9, is used, with a useful cross section of about 75 sq. ft., a length of 12 ft. will be adequate. The passageway through the bunker will permit the train crew to pass freely from end to end of the locomotive, and it will also make possible the use of all of the coal by giving steep sides to the hopper.

The coal will be conveyed from the bunker by a special type of screw feeder that takes coal from a number of points along the length of the bunker. This is made possible by a number of spaced, fixed horizontal steel plates with openings through which the coal is delivered to the screw by reciprocating feeders. In this manner the bunker level is lowered uniformly, and virtually all of the coal can be used, since the only "dead" spots are the small areas included within the angle of repose above the fixed plates.

Drying of the coal will be started in the feeder, through the introduction of waste hot air into the trough along which the coal is being moved by the screw feeder. Control of the rate of coal flow is accomplished simply and reliably by varying the speed of the driving device, which may well be a small air-operated turbine.

Tramp iron is rejected by the screw feeder through a cleanout plate. There will be no advantage in using specially sized coal for the gas turbine, although the preliminary removal of excess ash and scrap iron will be helpful. The smaller and cheaper sizes of coal actually will be more desirable than the more expensive sized coal.

Crushing is a necessary first step in the coal-preparation system. The size to which the coal is crushed will depend upon the subsequent steps in the process. The "coal atomizer" that is being used by the Locomotive Development Committee requires that the coal be reduced to minus 10-mesh, a size that is readily attained by the use of a simple hammer mill.

Drying of the coal is necessary in order to ensure proper feeding in the later stages of the preparation process. Attempts will be made to utilize waste hot air as a drying medium in the crusher, and to employ the same hot air as a conveying medium to transport the crushed, dried coal up to the top of the pressure tank from which it is fed to the coal atomizer. An internal cyclone will separate the coal from the air, which will be vented to the atmosphere.

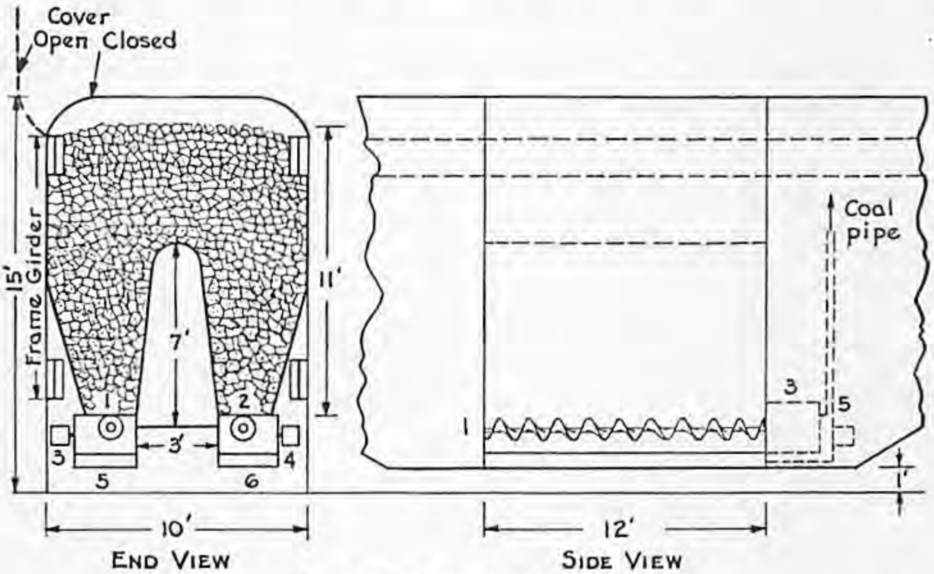

FIG. 9.—THE DIVIDED COAL BUNKER.
Suggested Coal-handling System

Screw conveyors 1 and 2 feed coal from bunker to crushers 3 and 4. Screened coal goes into pneumatic conveyor pickups 5 and 6. Air conveys crushed coal to tanks.

Pneumatic conveyor could be replaced by inclined or vertical screws to lift coal to pressure-tank inlet.

The use of an air conveying system means that the coal bunker can be in any convenient place on the locomotive or on a tender. The conveying air will be under virtually atmospheric pressure, and flexible connections, or relatively thin pipe, can be used. A draw-through system, with a high-speed suction fan at the cyclone outlet, will prevent the leakage of coal into the cab, and will minimize abrasion of the fan blades.

Whatever may be the means of pulverization, the coal must at some stage in the process be put under pressure. The least complicated method of pressurizing the crushed coal is a lock-hopper system, such as one used for many years by the sandblasting art. By the use of rubber-seated, air-operated cone valves, an intermediate chamber, between the upper and lower sections of the pulverizer-feed tank, is vented at intervals to the atmosphere and filled from the upper section; then, by closing the upper cone valve and applying full pressure, the coal is discharged by gravity into the lower section and the cycle is repeated. This system will require a minimum of energy, since gravity does most of the work, and its successful application in the abrasive blasting industry, where large quantities of sand are handled, indicates that such an arrangement is applicable to other granular materials.

An investigation is currently under way to determine the limitations of feeding coal against pressure with a screw feeder. By inclining the worm upward, it can be made to run full, and the elimination of a few flights at the discharge end of the screw causes the formation of a plug, continuously replaced, which acts effectively as a seal. Compressed air, of course, will permeate through such a porous seal, but if the coal is caused to move upward at about the same speed as the air tends to move downward, there is no serious leakage. At the Institute of Gas Technology, it has been found possible in this manner to force 28 lb. of coal per minute up a 20-ft pipe against a pressure of 65 lb. per sq. in. gauge, with a power consumption of about one horsepower. Because of its lowered weight and improved controllability, this method of pressurizing will be given careful study to see how it is affected by coal wetness, screw size and speed, and other factors.

The feeding of the crushed coal from the pressure tank to the pulverizer must be accomplished by another screw feeder. Within limitations, control of feed rate, and hence of turbine power, can be accomplished by varying the rotative speed of the screw. At very low speeds, however, the screw tends to feed in slugs. Two improvements have been incorporated into the coal-handling system to obviate this difficulty. It has been found that the addition of a rotating screen of proper proportions tends to smooth out the uneven feed of the worm, and to give a uniform rate of coal flow. Also, a recirculating system has been devised which permits any proportion of the coal to be returned to the pressure tank, thus giving a smooth variation from zero to maximum coal flow. This control method is currently under test at Johns Hopkins University.

Many attempts have been made to burn pulverized coal in conventional locomotives. The success of these attempts may be summarized by pointing out that no such locomotive is now in operation. Both in Europe and in the United States, systems have been tried in which the coal was pulverized in preparation stations and then carried in special dust-tight tenders. The disadvantages of this method are obvious, and in the current work the pulverization will be done on the locomotive. A mechanical pulverizer to handle one to two tons per hour, under pressure, does not yet exist, but an air-operated "coal atomizer" has been developed, which appears to be well suited to gas-turbine work.

The "coal atomizer," shown in Fig. 10, operates on the continuous explosion principle. The crushed coal in the pulverizer tank is subjected to an air pressure of 120 to 150 lb. per sq. in. gauge, and the pores of the coal particles become filled with the compressed air. By causing the coal to pass through a nozzle where the pressure falls instantaneously to 60 lb. per sq. in. gauge, the particles are shattered by the sudden release of the entrapped air. If the feed particles are smaller than one third of the throat diameter of the nozzle, clogging will not occur. About one pound of air per pound of coal is necessary for pulverization to such a fineness that 60 per cent of the product will pass a 200-mesh screen. By adding a simple attrition device, called a "cyclonizer," the fineness can be increased until 80 per cent passes a 325-mesh screen.

The air for the "coal atomizer" is provided by an auxiliary compressor, which draws its intake from the main compressor through a small intercooler and delivers the required amount of atomizing air at a pressure 60 to 80 lb. per sq. in. above that of the combustor. Transportation to the combustor is accomplished almost instantly by allowing the atomizing air to carry the pulverized coal to the combustor.

The actual ignition and burning of the coal is the subject of intensive research at the present time. The problems involved can be discussed best with the aid of a specific example: To give 5000 shaft horsepower, 3900 lb. of coal of 13,000 B.t.u. must be fired, and 97 per cent of this amount must be burned (Table 3). Solid and liquid fuels all require about 765 lb. of air for theoretical combustion to liberate 1,000,000 B.t.u. Hence, the theoretical air requirement for the fuel in question would be 765 × 45.2 = 34,600 lb. per hour. The compressor of the unit, however, will supply 243,500 lb. of air per hour to the combustor, representing about 700 per cent of the theoretical air requirements.

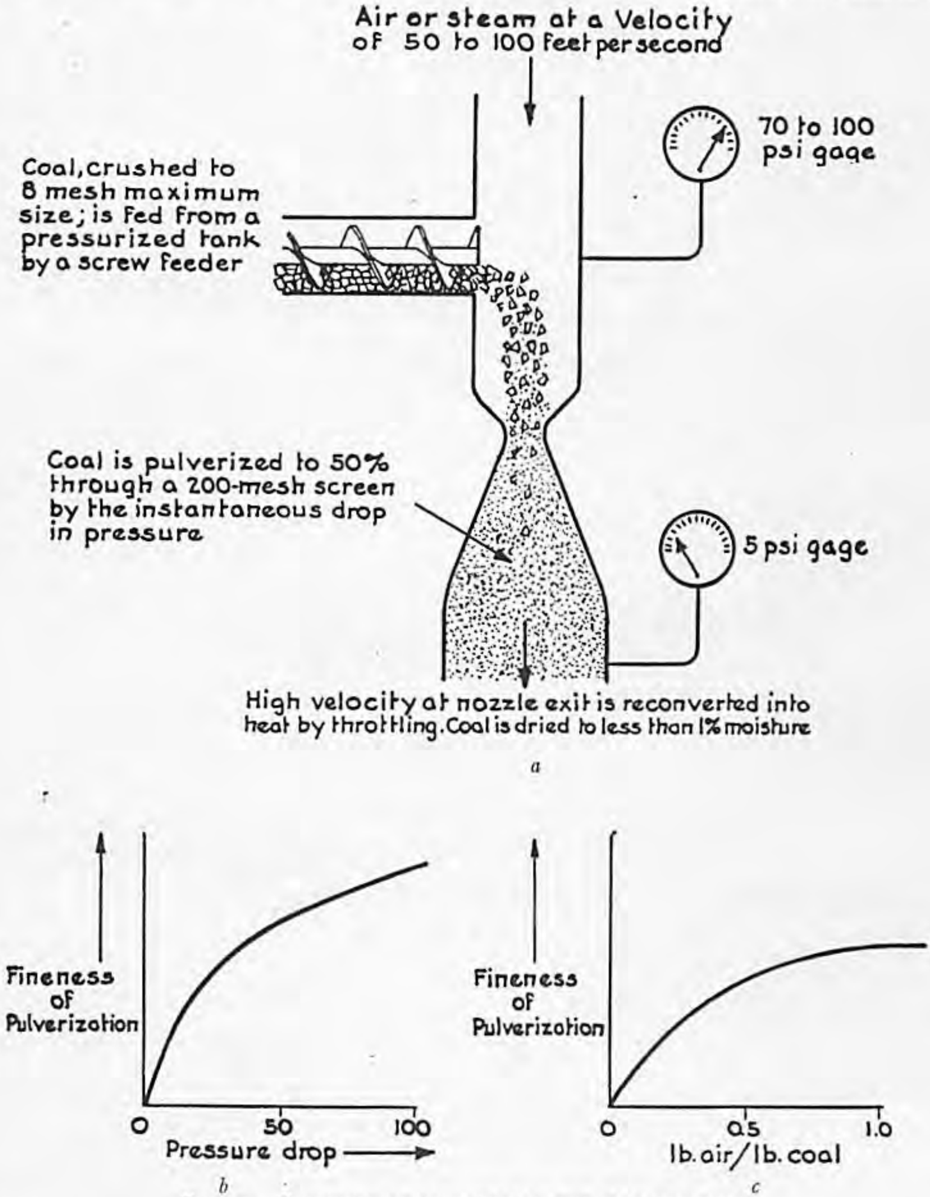

FIG. 10.—PRINCIPLE OF OPERATION OF THE COAL ATOMIZER.

A two-stage combustion process evi-

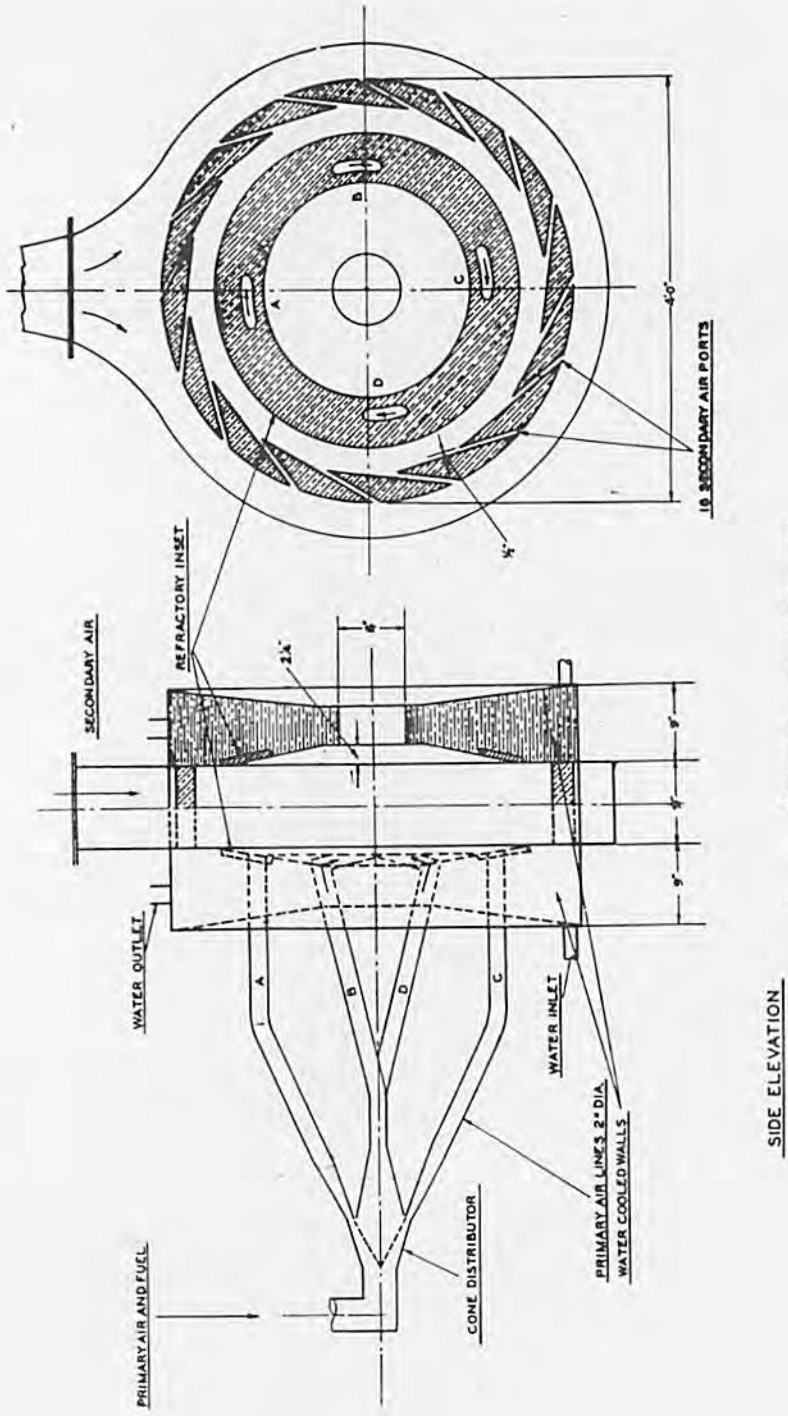

FIG. 11.—VORTEX COMBUSTION CHAMBER.

dently is needed, because the use of such a large amount of excess air would reduce the temperature in the combustion zone so drastically that burning would be very slow and incomplete. All liquid-fuel gas-turbine combustors use some form of inner chamber where the fuel is burned with a slight amount of excess air, while the remainder of the air circulates around the combustor, keeping it cool and mixing with the products of the primary combustion to reduce their temperature to the desired value.

The attainable heat release in pressurized combustion is still a matter of conjecture, although the very high partial pressure of the oxygen in the atmosphere of 75 lb. per sq. in. abs. will certainly be conducive to rates far higher than those reached in stationary plants. The presence of 600 per cent excess air means that the droplets of molten fly-ash will be instantly chilled, and no slag will be found.

The general philosophy of the current investigations is based upon the acknowledged necessity of producing a maximum of relative motion between the burning coal particle and the surrounding air. Investigations by the Fuel Research Board in England have revealed that heat releases in excess of 500,000 B.t.u. per hour per cubic foot of combustion space can be obtained in the "Vortex" combustor shown in Fig. 11. The principle of this design is the maintenance of a rotating ring of pulverized coal, through which the air passes on its way from the tangential inlets to the central outlet. The coal particles tend by centrifugal force to fly outward, while the inward drag of the air resists the centrifugal force and ultimately, when they are burned down to a sufficiently small size, carries the burned-out particles through the central outlet.

While investigation of several different types of combustors is under way, fundamental studies of the burning of pulverized coal under pressure are being conducted at Battelle Memorial Institute on behalf of the Locomotive Development Committee. Systematic tests of this equipment are just beginning, but indications have already been obtained that the application of pressure shortens the pulverized-coal flame very materially.

It is expected that combustion rates for very finely pulverized coal may approach those of the oil now being burned in jet-propelled aircraft. The practice of using a number of small "tin-can" combustors is not likely to be followed, however, because of the probable greater difficulty of igniting coal.

The third major problem that must be overcome in applying a solid fuel to the open-cycle gas turbine is the removal of the fly-ash, or at least the portion of it that is likely to damage the turbine buckets. Fly-ash from ordinary pulverized-coal combustion is in the form of very small spheres, as Fig. 12 indicates. This micrograph, taken at a magnification of 2600 times with the electronmicroscope at the Illinois Institute of Technology, shows that most of the particles are nearly perfect spheres, with diameters in the vicinity of 10 microns. Examination of other samples of the same coal revealed an occasional particle as large as 40 microns, but Fig. 12 is representative. Abrasion tests made at Battelle Institute on behalf of the Allis-Chalmers Co., and graciously made available by that company to the Locomotive Development Committee, indicate that particles smaller than 5 microns are relatively harmless to turbine-blade material, and the rate of abrasion for such small particles appears to decrease rapidly with temperature. This latter important fact is probably related to the twofold increase in viscosity that occurs as the temperature of air is raised from 70° to 1000°F. The problem

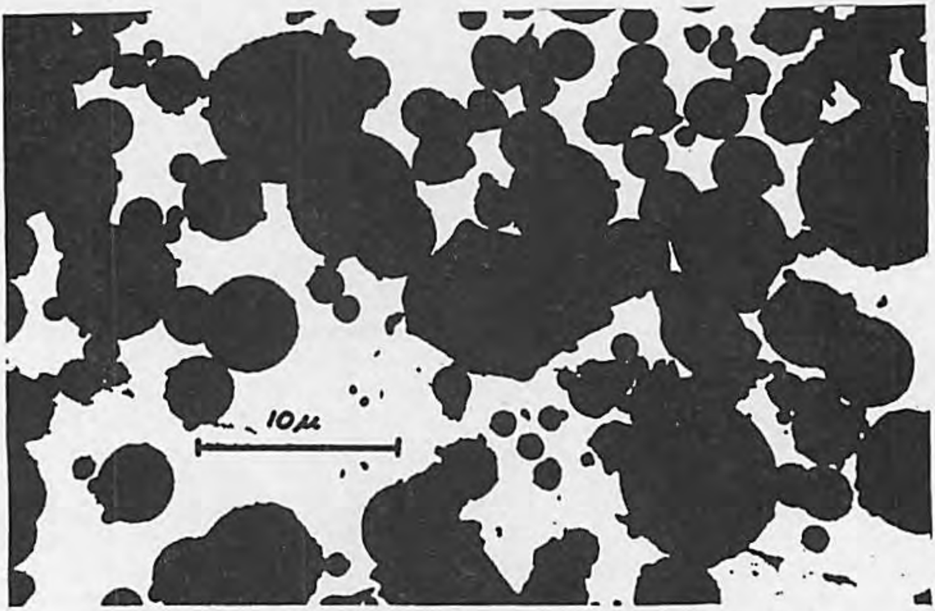

FIG. 12.—ELECTRONMICROGRAPH OF FLY-ASH FROM PULVERIZED COAL. × 2600.

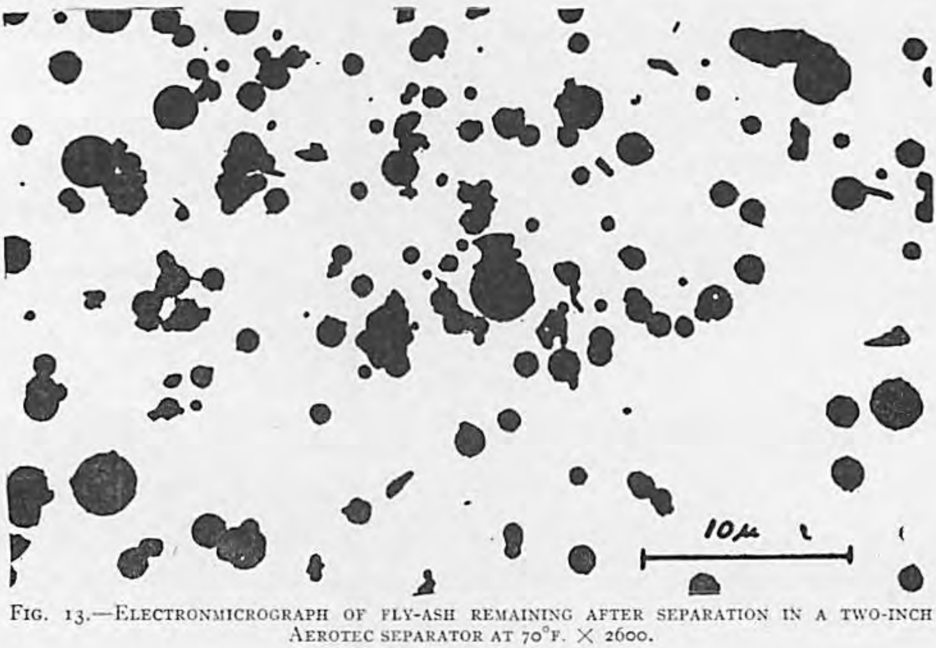

FIG. 13.—ELECTRONMICROGRAPH OF FLY-ASH REMAINING AFTER SEPARATION IN A TWO-INCH AEROTEC SEPARATOR AT 70°F. × 2600.

of burning pulverized coal in the gas turbine, therefore, appears to be the removal of all ash particles larger than 5 microns, and the elimination as well of any smaller particles that can be caught.

In studying the art of dust collection, it became apparent that the ordinary type of filter was impractical, and electrical precipitation was not feasible because of the high temperature and the necessary high velocity. Inertia-type separators appeared to offer some hope, and the Institute of Gas Technology was authorized to investigate the use of very small cyclone separators. The attention of the Committee was directed to a type developed by the Aerotec Company for use as an intake-air filter on airplanes and tanks for desert service. At 70°F., this 2-in. cyclone had demonstrated its ability to remove virtually all particles larger than 10 microns, and to eliminate about 80 per cent in the 5-micron size range. Tests at atmospheric pressure and room temperature on the fly-ash shown in Fig. 12 confirmed this performance, since at least 95 per cent of the dust was removed, with a pressure drop of about 4 in. of water and a free air flow of around 50 cu. ft. per min. Fig. 13 shows an electronmicrograph of the fly-ash that passes through this type of separator. No particle in the sample larger than 5 microns has escaped, and most of the remaining dust is in the 1 to 4-micron range. The theory of cyclone separation indicates that the size of the minimum removable particle varies as the square root of the viscosity of the gas, and so tests were run on the small cyclone at 1100°F. These tests indicate that the collection efficiency was still at least 85 per cent, and that no particle larger than 5 microns could escape.

Repeated tests on this type of equipment at atmospheric temperature have indicated that a battery of tubes behaves in the same manner as an individual tube. Plans are now going forward for testing a 60-tube installation with fly-ash at 1100°F., using the atmospheric-pressure combustor now installed at Johns Hopkins University. Preliminary calculations indicate that the space requirement for the necessary number of tubes is not excessive, and a particular advantage of the small tube is its low headroom. It is to be expected that the amount of fly-ash collected per hour will be from 8 to 15 lb. per hour per million B.t.u. of heat input. Thus, a 5000-hp. installation would produce from 360 to 720 lb. of fly-ash per hour. Methods of disposing of this quantity of ash have not yet been perfected, but tests will shortly be conducted at Purdue University to determine whether fly-ash is a suitable medium for sanding rails.

Among the unsolved problems at this stage of the research program is the matter of control. It is believed that the recirculating type of control previously mentioned will give the necessary accuracy that is difficult to attain with a screw feeder alone. The simplest method of governing a gas turbine is by constant-speed, variable-temperature operation. This method has the drawback of decreased efficiency at partial loads, and a combination of variable speed down to about 60 per cent of full load speed and variable temperature below that speed seems to be an acceptable compromise.

In summary, the necessity for the continued use of coal as the primary fuel for American railroads has been demonstrated. It appears that the gas turbine has a better possibility of guaranteeing this continuation than any other type of prime mover. The research program of the Locomotive Development Committee is intended to provide the necessary fundamental information from which the manufacturers can proceed to design and construct the required equipment.

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MODERN TRENDS IN DEEP BITUMINOUS COAL STRIPPING

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General

It might be well at the outset to dispel possible thoughts that deep stripping involves anything mysterious or any problems fundamentally different from those encountered in shallow stripping. The same general obstacles are met in trying to remove 25′ of overburden as are present in removing 90′, but obviously the emphasis may be much different. Difficulties of insignificant importance in the shallower overburden operations may bulk much more ominously in deeper ones.

If the basic nature of the problems does not differ in going from shallow to deep overburden, it follows that deep overburden operations are susceptible of the same common-sense analysis as those in shallow stripping. Basic to such analysis is the banishing of the thought almost universally present among coal strippers that somewhere, somehow, someone will produce an ideal stripping machine for deep overburden. The consensus seems to be that this machine will be of the continuous flow type, will excavate any overburden it may encounter with little or no bank preparation, will not interfere with other operations in the pit, will transport the spoil any required distance within reasonable limits. will deposit the spoil in a permanently stable condition, will perhaps level the irregular crests of the spoil piles, will operate cheaply, and will require only moderate capital expenditure. Such a machine does not exist, and it is improbable that it will be developed in the foreseeable future. Deep overburden will no doubt continue to be removed for many years by stripping machines of the same general types now being used.

Feeling reasonably convinced that we are familiar with the nature of the available tools, it is possible to evaluate their application either singly or in any combination which would best adapt them to the particular deep stripping operation under consideration.

Pit Conditions in Deep Stripping

It is a matter of observation that overburden dumped freely on spoil piles consistently assumes an angle of repose of about 1¼ on 1. This is generally true regardless of the nature of the material and its degree of comminution. An exception, of course, is water-saturated sand or clay, which may behave as a liquid when freely dumped. The length of time during which the spoil will remain stable at this angle of repose is extremely variable; it will depend on moisture content, mechanical coherence of the material, stability of the base upon which deposited, height of the spoil piles, the physical nature of the spoil constituents, frost pry, and certain other factors not well understood.

Highwalls will range for different materials and under different conditions from a condition of long-time stability with a steep face to short-time stability even with a gently-sloping face. Air slaking, frost action, chemical and physical hydration, mechanical expansion through relief of pressure, mechanical weakening by removal of material through ground water flowage, erosion by surface run-off, sloughing along incipient slippage surfaces aided by removal of toe support, and other causes may lead to unexpected collapse of the highwall with highly undesirable effects on the pit operation.

Generally a broad relationship exists between highwall and spoil pile stability: material in stable highwalls usually produces stable spoil piles; unstable highwall materials usually lead to unstable spoil piles. The exception would be that the substances of stable highwalls may at times become unstable in the spoil piles, never that unstable highwall materials form stable spoil piles. Of course, if the foundation for the spoil pile, which often is thick greasy fireclay, is unable to support the load, the spoil will lack stability despite the nature of its individual constituents and otherwise favorable internal and external factors.

Briefly, in deep stripping, both highwall and spoil may be stable for all practical purposes; the highwall may be stable and the spoil unstable; or, both highwall and spoil may be unstable. These considerations are basic to selection of the most suitable stripping equipment in order to arrive at the lowest cost per ton of coal through the tipple. An unstable highwall must be worked so as to give it maximum stability; unstable spoils developed from free dumping must be reworked to impart maximum stability.

In deep stripping the haulage berm exerts a much greater effect on overall costs than in shallow stripping. Wherever a berm is used, from the excavating standpoint it means extra distance over which spoil must be transported on each cycle of the excavator. In shallow overburden this may not be extremely significant because the excavator usually has excess range for the particular job. In deep overburden the building into the machine of the additional range needed to transport material over the berm increases its size and cost to a startling degree. There are probably very few pits which cannot be operated without a haulage berm, either by double-ended pits with coal loading retreating toward each end from the center, or by a central haulage road through the spoil piles and loading from each end toward the center. In either case the entire width of the coal cut is loaded out. Some irregular, rolling coal surfaces would not lend themselves well to these methods, but these are in the minority. It could well be axiomatic that in deep stripping the berm must be eliminated unless it can be proven to be essential.

The subject of bank preparation in deep overburden is worthy of extended separate consideration, but will not be dealt with here other than to note that all strip operators are fully aware of the necessity of keeping its cost at the lowest possible figure consistent with suitable fragmentation.

As to overall costs, in shallow stripping there is usually a definite tie-up between cost per cubic yard of stripping and cost per ton of coal through the tipple. This relationship may be much less definite in deep stripping. Machines capable of giving the lowest stripping cost per cubic yard could be responsible for pit conditions that would give a relatively high cost per ton of coal through the tipple. Machines might be selected which, although removing the overburden at a somewhat higher direct cost per cubic yard, would lead under proper usage to more continuous movement of coal to the tipple and a correspondingly lower unit cost. In deep stripping it is logical that appraisal of the economic merits of one method as compared to another should be based on cost per ton of coal through the tipple for the fiscal year rather than the direct cost of stripping each cubic yard of overburden.

The Large Stripping Shovel

The stripping shovel has been for so many years the basic implement of coal stripping that it merits first consideration in examining machinery application in deep overburden.

The shovel, if it is to operate alone in the pit, must have sufficient capacity and range to combine high output with suitable transporting ability. Given such a combination, the practicability of shovel usage becomes largely dependent on the nature of the overburden. Both highwall and spoil must be reasonably stable. If so, whether the shovel should be employed is simply a matter of economics and general mining considerations. If not, it is powerless to cope successfully with the conditions, since it is limited in maneuverability. Except in a restricted fashion it is unable to extricate itself from the difficulties produced by sliding highwalls and spoil piles.

The use of progressively larger stripping shovels may lead to certain operating difficulties; greater range and larger dippers necessarily impart to the machine greater bulk and weight. Wider pits will be required to accommodate such shovels; the labor and expense of making repairs will doubtless be increased; and the bearing pressures of such shovels on the coal will probably be considerably higher than those on present-day machines.

Another consideration affecting shovel operation in deep stripping is that the shovel works most effectively and at lowest cost at or below the height of its shipper shaft. Above this elevation the hoist and crowd are usually opposed, with resulting high maintenance costs on the machine.

Care must be taken in deep shovel stripping to minimize overhang of the highwall. Overhang is produced by the normal digging arc of the shovel dipper, and is potentially dangerous in many types of banks, being likely to slide into the pit when least expected. Overhang can be reduced by proper use of the shovel, ahd study of the problem should be routine in deep overburden.

Given proper working conditions, the stripping shovel operating alone is perhaps as efficient an excavating machine as is available. Such ideal conditions appear to become more rare with the passing years.

The Large Dragline

Large draglines, either with caterpillar or walking mountings, are widely used in deep stripping, singly or in combination with other machines.

The caterpillar-mounted large dragline usually operates from the coal surface in conjunction with a stripping shovel, and benches the upper part of the overburden ahead of the shovel. This arrangement requires less range of the dragline than if it were operated from the highwall, but entails difficulties in that the machine operates less efficiently digging well above its base than below its base. This loss of efficiency frequently more than offsets the advantages gained by being able to place the machine close to the toe of the spoil. Such draglines may also be operated from the highwall or spoil piles as the occasion arises, but usually only in emergencies because of the cost of providing mats for adequate footing in soft ground.

Singly, the large walking dragline has proven highly successful in deep stripping where the highwall is sufficiently firm to provide good footing and the spoil piles are adequately stable. In tackling deeper overburden than has heretofore been done, the machine suffers from the disadvantages inherent in any excavator which is required not only to dig but to act as a transporting agent. Simply constructing larger basic machines as an answer to this problem may prove to be unsatisfactory because of the rapidly-mounting initial cost with increasing size and the attendant difficulties of making field repairs on enormous units.

The large walking dragline is sufficiently adaptable to be used in a variety of ways in conjunction with other excavators. It has worked with stripping shovels in benching the upper part of the overburden ahead of the shovels, leaving for these machines burden low enough so that they can handle it successfully.

Large walking draglines have been used in pairs, both machines operating from a bench; one removes the upper part of the burden and the other the lower part.

Within the next two years a method will be employed in southern Indiana for handling deep overburden with a large dragline and a large shovel. The overburden being firm, both machines will operate from the same bench. The shovel will remove the upper part ahead of the dragline, and the latter will strip the lower part of the overburden as left by the shovel. This is a reversal of the normal tandem operation of shovel and dragline, but appears to be feasible because of the good footing provided in this instance for both machines. No difficulties are expected because of instability of either highwall or spoil.

This method has been in successful use for several months on a smaller scale at a property in southern Illinois. Here the coal is relatively thin and was being stripped by a shovel on the coal and a dragline on the highwall, both caterpillar-mounted. Loss of coal through crushing by the shovel caterpillars amounted to an important percentage. To eliminate this a bench was developed on the upper surface of a limestone bed some ten feet above the coal, and both machines operate from this surface, the shovel removing the material above this elevation with the dragline following it and taking the remainder of the overburden.

In cases where two coal seams are separated by a suitable vertical interval, it seems likely that combinations of excavators will be worked out to strip both seams. For instance, a large shovel or dragline would be used to uncover the upper seam, the upper coal be loaded out, and a large dragline with proper operating range would follow the upper loader and strip the lower seam so that its coal could subsequently be loaded.

Certain operations in the northern Appalachian fields will make use of large walking draglines working with smaller stripping shovels constructed by putting long-range shovel front ends on what are basically close-coupled quarry machines. The terrain is rugged, and the hill slopes ordinarily about 30 degrees. The initial cut is to be made following the hillside contour by the shovel, which is above to develop a suitable width of cut because the hill slope below the coal seam gives ample spoil room. When the first cut has reached adequate length, the shovel's next job is to ramp up to a desired elevation above the succeeding stripping cut, where it makes a bench into the hillside and places its spoil in the space provided by loading the coal out of the preceding cut. The width of the second cut is established mainly by the dumping range of the shovel. The large dragline is then located on this bench, follows the shovel, and strips the balance of the overburden in the second cut, spoiling as much as possible on the spoil pile produced by the initial cut in the hillside. The method has, among other advantages, the merit of getting the property into maximum production rapidly at a relatively low initial capital expenditure. Under the prevailing topographic conditions and with the rocky nature of the overburden usually present in the area the large dragline would unaided meet major difficulties in establishing its own bench from which to work.

For some years walking draglines up to 7 cu. yds. in capacity have been located on the spoil and have pulled back material dumped by the stripping shovel in deep overburden, so providing shovel spoil room where badly needed. The conviction seems to be growing among coal strippers that basically this method contains the elements necessary to solve many of the problems of deep stripping, especially where spoil piles tend to be unstable. It divides the operation into two basic parts—that having to do primarily with excavation and that having to do primarily with transportation. Mention has previously been made that in the large excavator which combines excavation with transportation, if one of these features gains the other necessarily loses, and for deep stripping a machine combining high output with long-range transportation reaches gigantic size with a correspondingly somewhat astronomical price. If the excavation is handled by a high-capacity, relatively short-range unit, either shovel or dragline, working with a walking dragline of suitable capacity located on the spoil and acting as a transportation unit by pulling back the shovel spoil as it is dumped, a combination results which has both high output and excellent transportation ability. Neither machine is excessively large, and it is probable that the capital cost of both would not be as great as that of a single machine which could do no more work than the two. The dragline on the spoil would minimize the danger of slides by mechanically imparting to the spoil a flatter slope than could be obtained by free dumping from shovel dipper or dragline bucket. The dragline could also do whatever levelling of the spoil might be required, and in addition would be available for box-cutting work at times when the shovel might be able to handle the existing overburden alone. Whether such a method should be used depends again upon the final cost per ton of coal through the tipple, rather than direct cost per cubic yard of overburden stripped, taking full cognizance of the necessity for maintaining a continuous flow of coal from the pit.

The Wheel Excavator

The wheel excavator, as so far developed in this country, is confined to one machine, although another is expected to be placed in operation in the near future. It is a large, caterpillar-mounted unit operating from the coal surface with a stripping shovel, and takes the upper overburden ahead of the shovel. Basically it consists of an electrically-driven rotating wheel about the periphery of which are equidistant digging buckets, and mounted on a digging ladder which is retractable and bears a conveyor belt. This belt discharges into a hopper at the end of the ladder away from the wheel, the hopper being attached to the ladder and free to move on a track over a stacker belt conveyor which receives the spoil from the hopper and takes it across the pit to beyond the crest of the last-deposited shovel spoil pile. All the digging and conveying mechanism is located above the cab roof to enable the machine to dig at the desired height above the coal. Digging is accomplished by retracting and elevating the wheel to a point where it will intersect the highwall at its upper edge; the wheel rotates so that its buckets dig upward through the bank and discharge onto the ladder conveyor during the normal wheel rotation. After the wheel is placed in motion, the entire machine is swung through the bank in a sort of milling cut, each bucket successively shaving the bank during the combined operation of rotating the wheel and swinging the machine. When the arc of swing is complete in one direction, the wheel is advanced a suitable distance and swung back through the bank. After the wheel has been advanced to its maximum distance through a sequence of swings, it is completely retracted, lowered suitably, and the entire operation repeated. In this manner a bench is developed in the overburden, its width controlled by the amount of extension and retract built into the digging ladder and its depth delimited by the maximum angle above and below the horizontal at which the conveyor belt can carry the material, ordinarily from 19-20 degrees each way.

As now constructed, the wheel excavator is restricted to tandem operation with another excavator and operates most successfully in the softer types of overburden. Its vertical range is limited by the vertical arc through which the wheel can be elevated or depressed, and its horizontal range by the dimensions of the conveyor system. In conditions to which it is adapted it has given a good account of itself, and the future may see major improvements in design and performance. In general, its employment is linked to stable conditions in both highwall and spoil pile.

The Tower Excavator

The tower excavator is essentially a self-propelling slack-line scraper. Machines most recently constructed have an electrically-powered head tower and gasoline engine-powered tail tower, the propel and steering of either tower being handled independently. They are equipped with caterpillar mountings and in the largest size can handle as much as a 13 cu. yd. scraper type bucket on an operating span between towers of 700 to 800 feet. For longer spans the bucket size is usually reduced, and where the operation requires lifting and carrying a loaded bucket rather than dragging it over the surface the bucket size is cut very materially. This type of machine was originally developed for levee building and in consequence would probably undergo considerable design changes if constructed specifically for application to coal stripping.

It appears that the first application of the tower excavator to coal stripping was in a lignite operation in North Dakota, where it has been working successfully for some five years. The head tower is located on the spoil piles and the tail tower on the highwall, the machine spanning the pit. A scraper bucket removes the upper part of the overburden, in this instance reaching 70′ thick, ahead of the stripping shovel and drags it to the spoil, usually making a bench some five shovel cuts wide.

Within the next few months it is proposed to install a tower excavator at a strip mine in central Illinois. In this property a sloughing highwall has proven very troublesome, and it is anticipated that the tower excavator will not only reduce the overburden to a depth suitable for the stripping shovel, but will also, by removing the upper part of the burden, minimize highwall slides. It should further be capable of imparting flat slopes to the spoil piles, so lessening the probabilities of spoil slides into the pit. The tail tower will be placed well back from the highwall so as not to be in danger if the highwall fails locally.

Where both highwall and spoil piles are unstable in deep stripping, the tower excavator would appear to be a suitable machinery application. About the only alternative is placing a caterpillar-mounted dragline in the pit to bench ahead of the shovel; the relative inefficiency of such operation has been pointed out, and in addition a dragline working in this way is powerless to improve a sliding spoil condition.

Summary

Faced in many localities with handling deeper overburden as a steady condition, coal strippers now have available to them machines or combinations of machines which can work successfully from a mechanical standpoint most of the stripping likely to be encountered. The selection of the proper equipment must be made with a cautious eye to the pertinent economics and, emphatically, to the highwall and spoil pile conditions which may be expected to prevail. The machinery trend in deep stripping seems to be in the direction of combinations of units with resulting operating flexibility, rather than toward the use of ever-larger single units. Examination of costs accruing to employment of excavators measurably larger than those now in existence indicates the possibility that the point of diminishing returns will soon be reached if excavator sizes are increased materially over those now existing.

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THE PREPARATION OF HIGH-REJECT COAL FOR DISCRIMINATING MARKETS BY USE OF JIGS, TABLING PLANTS, HEAT AND CENTRIFUGAL DRYERS

By JAMES D. REILLY
Hanna Coal Co., St. Clairsville, Ohio

The discussion paper which I propose to present with regard to the subject assigned to me will have to do generally with the Pittsburgh No. 8 seam of coal as it is found in Eastern Ohio and in particular with the Piney Fork No. 1 Mine of our Company, located in Jefferson County, Ohio.

The Pittsburgh No. 8 seam at this mine averages 4′-6″ in height. Immediately above the coal, there is a stratum of clay or shale locally known as "draw slate," ranging from 12 to 18 inches in thickness. When the coal is shot, this draw slate, due to its weak structure, often comes down on the coal. In years past, we attempted to hold the draw slate in place until the coal had been loaded out and then to dispose of it by hand along the ribs of the working places. This, of course, was quite a costly handling proposition, and it was done in order to keep as much draw slate out of the coal as possible. However, since it was impossible to hold the draw slate in a majority of cases, we adopted the practice of shooting the draw slate with the coal and loading the run-of-seam product together into the mine cars. The large slabs of this extraneous material are removed in the preparation plant by scalping screens ahead of the main classifiers, and the smaller pieces are removed during the washing process. This method of mining contributes substantially to a preparation plant reject of 38%. While not closely relevant to the subject of my paper, it might be interesting to note that we encounter very poor roof conditions in Eastern Ohio. In most cases, it is necessary to place 70 lb. steel cross bars on 3-foot centers in our room work. It is necessary to carry these cross bars right to the working face, and this, of course, interferes quite a lot with loading machine performance. Thus, in our field in Eastern Ohio, we are faced with the multiple handicaps of a relatively thin seam of coal, poor roof conditions with which to contend, contributing to a high mining cost, a stratum of draw slate to be handled underground with the coal and to contaminate it and to be separated and handled outside, together with the problem of preparing a coal which of itself is relatively poor in quality, but which is further degraded by admixture of the draw slate. On the basis of these factors and considering realizations for this field in years past, a mine with a worker efficiency of 14 tons of run-of-seam material per man on the payroll does not make a very outstanding mine income-wise.

Considering our necessary practice of run-of-seam loading and the impurities inherent in the coal seam itself, it is apparent that a very complete and efficient washing job is required. In order to stay on the market with our fine sizes, it was necessary to produce a 7.5% ash slack coal, at 13,000 B.T.U. Our raw slack contains some 18 to 20% ash and only 11,200 B.T.U. Competitive mines in the Pittsburgh area were mining raw slack with 12% ash and 13,200 B.T.U. This coal, when washed to an 8% ash, was increased to 14,000 B.T.U. Northern West Virginia mines were able to ship a 3/8″x0″ *raw* slack to power plants at 8.4% ash and 14,000 B.T.U. on an "as-received" basis.

In washing our slack, or 3/4″x0″, in jigs to the required 7.5% ash, we found that washing efficiency on the 3/16″x0″ was extremely poor, causing a considerable loss of coal in the refuse. In order to improve this efficiency and still maintain this low ash requirement, we installed Deister concentrating tables for washing the 3/16″x0″. Our present washing set-up is that we hand pick our plus 7″ coal, wash the 7″x1-1/4″ in one Link-Belt jib, the 1-1/4″x3/16″ in another Link-Belt jig, and the 3/16″x0″ on the Deister tables.

These tables were manufactured by The Deister Concentrator Company, and consist of nine Super-Duty diagonal deck No. 7 coal tables. This type of table is frequently called the "Deister-Overstrom." The principles of operation for practically all tables for wet cleaning of fine coal are the same. A reciprocating motion imparts relatively slow forward to backward movement and by this action, plus differences in elevation, water currents, shape of table and riffling, advantage is taken of the size and shape of coal versus impurities, as well as their differences in specific gravity. As coal-bone-refuse separate along the table, it is easily possible to cut into clean coal or reject at any point desired.

The Deister table employs a variation of the pitman and toggle head motion design called "concenco" anti-friction-bearing head motion. Stroke length can be varied, and will usually be from 5/8″ to 1″. Speed is 270 R.P.M., and each table is driven by a 3 H.P. motor.

65 tons per hour of raw 3/16″x0″ is wet-screened ahead of these tables and settled into a drag-type settling tank, where it is carried to a 30-ton surge bin. The coal is fed from this bin to a distributor of Deister design and distributed to 8 tables. The ninth table is used as a spare.

The overflow from the above-mentioned settling tank contains a certain amount of fine solids which pass out with the water. Since a considerable loss would occur to both water and tons of fine coal, it is necessary to find some means of recovery. Thickeners, vacuum filters, and other devices may conceivably be applied. We have been experimenting, however, with an apparatus, unique in the coal industry, but applied successfully elsewhere, especially in paper pulp plants.

This apparatus is called a Vortrap, and is manufactured by the Nicols Engineering and Research Corporation. It is a device designed to classify and separate materials in liquid suspension by means of centrifugal force. It is in a sense a water cyclone where "dust" is separated from water, rather than air. The principles of such a separation are so ably described by M. G. Driessen as a result of their research at the Netherlands State Mines at Limburg (The Use of Hydraulic Cyclones as Thickeners and Washers in Modern Coal Preparation" by M. G. Driessen, A.I.M.E., T.P. No. 2135, Aug. 1947), that there is no point in going into fine detail here.

The particular equipment as made by the Nichols Engineering and Research Corporation has no connection, except in principle, with Driessen's wet cyclone. The Nichols Vortrap is nothing more than an 8″ diameter rubber-lined pipe about 10 feet in length, with an especially designed head piece wherein the water-solid solution is pumped in tangentially, imparting a swirling and centrifugal action which gradually forces the solid particles to the outer edge and working down to the bottom, passes through a rubber diaphragm, or orifice, and out to discharge.

This same diaphragm starts an upward motion to the clarified water in the center of the pipe, which then keeps running upward and passes out a center hole in the head piece. The advantage of such an apparatus is quite apparent over a large settling basin or thickener, in its simplicity and lack of space requirement.

One Vortrap 8 inches in diameter will handle 800 G.P.M. of water to be clarified, containing 8 to 18% solids, producing a thickened discharge at 50% solids, amounting to 4 tons per hour solids on a dry basis.

Although this apparently holds much promise, it is a little early to predict its ultimate success. Our preparation and research engineers are continuing with their experimental work, and I would rather wait until a later time before drawing up definite conclusions as to its permanent value. As it stands now, we propose to place the thickened discharge from the Vortrap back into the table feed and re-use the effluent in whole or in part in our plant water re-circulation system.

When we washed our slack to the required 7.5% ash, however, only part of our problem had been solved, inasmuch as the washing process left the coal with a moisture content of 8%. While our washing beneficiated the product by some 12.5% to 13% in ash, we added back the equivalent of some 5% in moisture (on the basis that 1% of moisture is equal to 1% of ash when considering B.T.U. value), leaving us a net gain in ash content of only 8%, or a 12% ash product, so far as fuel value was concerned. Therefore, in order to produce a slack product containing only 7.5% ash and at least 13,000 B.T.U., we had to face the problem of a very complete drying job on our fine sizes of coal.

To thermally dry fine coal in any type of dryer as it comes from a settling or dewatering tank is generally considered economically impossible, due to the excessive amount of water necessary to be evaporated. Usual drainage from such tanks on 3/16″x0″ produces in the neighborhood of 30% moisture still in the coal. Vibrating screens on the same material may cut it down to 16% moisture, which is still too high.

It became necessary for us to use some form of mechanical drying of the centrifugal type ahead of heat drying. For this purpose, we have two C.M.I. dryers. The C.M.I. dryer is of the vertical type, and consists of two rotating units—an outside conical screen frame and an inside solid cone carrying special flights, or wiper blades. Both units rotate at high speed, but the screen unit moves slightly faster than the solid cone. Screen perforations are usually 1/16″ in diameter.

These centrifuges reduce 30% moisture 3/16″x0″ coal to 7.5% moisture. I am, of course, referring to "surface moisture" and not to "inherent moisture." These C.M.I. dryers make an ideal, uniform feed for the flash dryer. Of the two C.M.I. dryers installed, only one is operated at a time, handling 50 T.P.H.

The flash dryer is a heating system devised by the Raymond Pulverizer Division of the Combustion Engineering Company. It consists essentially of a stoker-fired combustion furnace, a vertical tube drying stack, cyclone collector, and suction fan.

Wet feed, in our case centrifugally dried 3/16″x0″, is fed from a surge bin by means of a variable-speed screw conveyor, into the bottom of the vertical drying stack, where it is immediately swept upward along with the combustion gases from the furnace, and carried into the cyclone. There the dried coal particles are collected and dropped through a rotary air lock device onto a conveyor which takes it to the main plant, where it combines with the 3/4″x3/16″ coal previously washed and dried by other methods. The moisture and gases from the cyclone pass through a straight-bladed fan, and escape to the atmosphere.

The heating gases from the furnace are tempered with atmospheric air before entering the drying stack by means of louvres, which are controlled automatically from a Brown Electronic instrument connected to a thermocouple placed in the cyclone outlet. In other words, the cyclone outlet temperature set manually to be at a certain temperature, in our case, 115 to 125°F., governs the amount of tempering air required to dilute the heating gases from the furnace automatically through an air valve operated electrically by the Brown Potentiometer. An indicating pyrometer also tells the temperature of this heating gas-air mixture, which is usually in the neighborhood of 600-700°F.

Fan speed is 900 R.P.M., driven by a 150 H.P. motor. About 30,000 cubic feet per minute of gases are handled. The drying stack, made of stainless steel, is 30″ in diameter, and has a 30-foot vertical height. The cyclone is 12 feet in diameter and lined with 2 inches of Gunite cement. The dryer handles the product of the C.M.I., or on an average of 50 T.P.H. The dried product will contain 2.0 to 3.0% surface moisture, but moistures below 1% can be attained, if necessary, and at the same feed rate. If this is done, however, we would be required to install a secondary dust collector after the cyclone, which is a definite possibility, as competitive B.T.U. requirements make lower moistures necessary.

This, gentlemen, describes briefly the manner in which we have met the severe coal preparation problems which confronted us in Eastern Ohio. In my estimation, it behooves us as a Company to be constantly on the alert for better and more efficient methods of preparing our coals for acceptance in an increasingly discriminating market, facing as we do, competition from other types of fuel, as well as from other coals which come out of the ground much better in their raw state than ours. We believe that the industry as a whole must start giving more recognition to the science of beneficiating coals by surface preparation as, with many of the higher quality seams becoming depleted rapidly, we shall be faced with the problem of preparing relatively high-quality fuels from some of the sub-standard seams in which many of us will be working in the future.

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POWER DUCKBILLS

By LOU AHLEN and MORRIS CUNNINGHAM
Goodman Manufacturing Co., Terre Haute, Indiana

We are deeply appreciative of the opportunity to come here to discuss with you and illustrate to you a new form of power loading through the Power Duckbill.

Duckbill loading of itself, is not new, being an adaptation of the European system of hand loading conveyors plus a self-loading head. Heretofore, however, due to the necessary manual work connected with extending the Duckbill and swinging it across the face, it has generally been regarded as a device for thin seam mining where only comparatively low capacities were possible. Now with the advent of the Power Duckbill which transforms the shaker conveyor into a powerful, maneuverable, loading machine, with a rear conveyor as long as the room is deep, the application has broadened so as to take in almost the entire mining field. It has, in effect, brought appreciably nearer the coal operator's dream of a constant flow of coal from the face to the tipple without interruption and without degradation of the product.

The Power Duckbill itself consists of three main parts—

1. The Duckbill proper, which is very similar to those which have been in use for the last several years.
2. A swivel trough so constructed as to swing laterally through 90 degrees and yet maintain full motion of the conveyor at all times, regardless of the degree at which it is operating. It is also provided with automatic limit switches to prevent overswing.
3. A hoist mechanism, including motor and control, which furnishes power not only for a lateral swing of the Duckbill, but for pulling it forward to the next cut.

At the present time two types of these machines are in operation, the 277, which is 31 inches high, and the 477, which is a lateral model and which has been reduced to an overall height of 21 inches and a coal line of only 13 inches.

Development of the low vein model, which made its debut early this year, comes as a result of an increasing need in the eastern coal fields, particularly the Appalachian, for a loading machine which would efficiently operate in the lower coal measures. Rapid depletion of the higher seams of quality coal becoming more apparent in the past war years, focuses attention on the development of the high quality seams 48″ and under. As an example of this situation, a recent survey by engineers for one of the largest coal bearing railroads in the east reveals that the average seam thickness of all coal reserves in the territory served by this system in three states averages less than 48 inches in thickness. Many coal operators served by this system, originally mining 5 to 7 foot coal, are now working or contemplate working measures in the three-foot class or under.

Keen observers of production and labor efficiency state that at a certain point labor efficiency falls off at an alarming rate in restricted working heights. For example, take a four foot seam as par. A reduction of one foot or 25% in height results in a production decrease of 40%, while a reduction of 1½ feet or 37½% results in a production decrease of 60%.

Because of this situation, the greatest demand for cost reduction has so far channeled the major applications of the Power Duckbill in the east into seam heights under 48″.

The Duckbill itself advances and retracts in accordance with the latest design of non-Power Duckbills, that is, when the operating lever is put in the forward position the shovel advances into the coal, and when in the rear position it is retracted from the face. The swing of the Duckbill across the face is accomplished by push button control located on either side of the Duckbill immediately to the rear of the operating levers so that it is easily possible for the operator to both swing the Duckbill and extend or retract it at the same time. This permits him to load the face in a sweeping motion and keep the conveyor full of coal at all times during the loading process, thus greatly increasing the loading ability of the Duckbill.

Naturally, the true value of this type of loading is obtained when an overlapping cycle of cutting, drilling and loading is provided, thus enabling the Duckbill to be in coal at all times and a constantly full pan line discharging onto a belt conveyor on the entry. A typical operating cycle is as follows:

Immediately after the coal is prepared and shot, loading is begun. The Power Duckbill starts to load at the right rib, working from right to left so as to allow resumption of cutting and drilling operations at the earliest possible moment. With the Duckbill in this extreme position, positive loading action and full capacity is maintained by the smoothly functioning 45 degree swivel trough. While this operation is in progress the machine man is preparing the shortwall for the next cut, and the face man is timbering. After the Power Duckbill has loaded a portion of the face the shortwall moves from its position into the right hand sump position. He is immediately followed by the driller, thus insuring a complete overlapping cycle.

Nowadays the shortwall machine is generally equipped with a Bugduster and as it completes its running cut the cuttings are piled in a window parallel to the face. In the meantime, the Duckbill will have loaded out the old face ahead of the short wall and will now further demonstrate its maneuverability by rapidly sweeping the face in loading out the cuttings. After this is accomplished the Duckbill is power swung into the center position ready for a move-up, and the drilling and cuttings operations are continued.

For the move-up of the Duckbill a jack and sheave are placed at the face directly ahead of the shovel trough by threading one of the power swing ropes through the sheave and hooking it onto the Duckbill frame. After the Duckbill has been disconnected at the swivel point, a touch of the push button control sees the Duckbill quickly pulled forward into position for loading out the next cut. The new trough is then installed and the Duckbill is in position to load as soon as the face has been shot.

Delivery of supplies to the face, which is generally much more of a problem in the lower seams than the higher, is accomplished by reversing the gathering belt during the off shift and delivering the supplies at the shaker conveyor discharge point. A false pan line is set up parallel to the operating pan line. This false pan line is pulled toward the face after each cut with the cutting machine rope as the room or entry advances. As pans and supplies are used at the face they are replaced by an equivalent amount at the discharge end, and when the room or entry setup is one-half completed the needed supplies for the remainder of the setup are to be found in the false pan line. From that point forward it is merely a matter of pulling the line forward after each cut.

Naturally, face cycles will vary as to conditions, but a well planned cycle which provides for as many overlapping operations as possible, is essential for high efficiency and will rapidly be shown in the cost sheets. Frequent time studies, prepared graphically, are a considerable aid in determining the efficiency of the cycle and eliminating delays and wasted effort.

All in all, we feel the development of this device has been revolutionary in that it has brought high capacity loading to low seams, and at the same time increased the efficiency of high seams with elimination of dust and preservation of the product.

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THE ADVANTAGE OF CONSISTENT PREPARATION OF MEDIUM QUALITY COALS FROM A UTILIZATION VIEWPOINT

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Coal preparation problems as related to utilization are becoming more common, due to the pronounced change in the usual methods of mining. This condition is aggravated by the present heavy overload demands of equipment in almost all fuel using plants. Improvements in the preparation technique, as applied in new tipples and the revamping of present facilities, are providing remedies for this situation. Further refinements of preparation both in production procedure such as selective mining, and in tipple performance, will undoubtedly be achievements of the future. The degree to which consistent preparation is carried, must compare favorably on a cost-wise basis, with advantages which will accrue to the consumer. A most gratifying feature of the preparation—utilization problem, is the versatility of fuel requirements, being engineered and designed into a very large percent of the fuel consuming units currently being installed. This is a most commendable procedure, bound to result in overall savings to the coal consumer.

Consistent preparation is not a choicy problem-child; it is an important factor in the utilization of high, medium, and low grade coals; for by-product, metallurgical, steam raising in utility, industrial, and mobile plants, for heating both domestic and on a large scale, and all the other various and sundry uses to which King Coal is applied. The evils of inconsistent preparation frequently produce similar effects, and involve the same corrective measures regardless of the use to which the coal is put, but since medium quality coals are being considered, our remarks will be confined to the application of coal for steam raising.

Activity in practically all industries is now at a high stage. Maximum production in many plants and railroads requires steam generation at rates never anticipated when the combustion equipment was installed, and even in excess of wartime demands. With equipment for boiler plant expansion and betterment subject to twelve to twenty-four months delivery after placement of formal orders, it becomes a matter of "sweating out" what in many cases amount to almost unbearable conditions. In such instances cooperation of the coal producer and his representative the sales company, with the coal consumer and his representative the boiler plant personnel, is most important, and if successful results are achieved both parties may feel a justifiable pride in the accomplishment. Such teamwork between producer and the handicapped boiler plant operator might right now be considered only as a temporary necessity. A continuation into the future of all reasonable cooperation, together with a keen appreciation of what can or cannot be legitimately accomplished in the way of coal preparation and fuel utilization and the costs involved, cannot help but lead to a sounder economic position for each of the interested parties.

That the consistency of preparation is being adversely affected by recent developments in mining procedure can hardly be questioned. With the hand loading method of mining which in the past was so widely used, the loading of each railroad car of coal involved many mine car loads, and would undoubtedly contain coal; from average, good, and faulty working conditions: loaded by careful, average, and indifferent miners, under the influence of the docking system. Thus, hand loading inherently tended to provide uniform preparation. The contrary will usually be true with mechanized deep and open pit mining, which in the immediate future at least, will undoubtedly provide an increasing percent of our nations coal production. The nonuniform preparation of these increasingly popular types of mining are apparent when we mention: production line methods, very large tonnages from a comparatively few highly concentrated areas, and absence of any docking arrangement.

Fortunately means are at hand to provide consistent preparation, thereby offsetting the adverse features of mechanized deep and open pit mining. There are today, modern preparation plants installed in coal tipples, which are turning out a uniform product of satisfactory quality, even though the raw material feed is extremely variable. These plants involve tremendous overhead charges, in addition to maintenance, power and labor costs. True, some of these costs particularly labor, might be even higher if the large investment in mechanical preparation equipment had not been made. It is equally true that loss in working time (the bugaboo of all coal operations) under competitive marketing conditions, might be avoided with the uniformity of product provided by the modern preparation plant. Before making any decision concerning the type, and extent of preparation facilities to be installed for a given operation, it is most important to make a careful analysis of market requirements, geographical location, transportation costs, competitive conditions, and production costs with various preparation possibilities.

We recall the experience of a large industrial plant, obtaining its coal supply from a dozen or more different operations producing coals with widely different qualities and characteristics. The wide diversity in source of supply was a policy of the purchasing department. All of the different coals were for a time indiscriminately mixed, and burned as a hodgepodge in their modern multiple retort underfeed stokers. When the various coals were segregated, so that those with similar burning characteristics and qualities could be fired consistently in individual combustion units, a fuel saving of over twelve percent was accomplished, and eight boilers successfully carried the load formerly requiring nine.

This is admittedly an example illustrating the effect of extreme variations in burning characteristics, analytical, and physical properties, and the results are naturally outstanding. It is not the intention to infer variations in shipments of coal of a given size, seam, and operation, would necessarily provide the conditions cited in the above example.

The size of the coal consuming plant is one of the important features when studying the effect of variable preparation on plant performance. While there are exceptions, it is apparent from the following discussion, that the small plant usually is most sensitive to inconsistent preparation. It is agreed the personnel of the large plant, particularly of the utility type is usually, better trained, and provided with the last word in maintenance, combustion control and standby equipment. By the same token however, service in the utility type plant is very often of a most exacting nature. The small plant, frequently with only one boiler or steam generating unit, is under a definite handicap with inconsistently prepared coal. Generally the coal must be burned about as received—a car load at a time. Often variations in quality of coal from one end of a car to the other, may carry on through to the actual point of consumption. There is usually little or no opportunity for the blending or mixing of coal, either from several cars, from a reserve in live storage, or from permanent storage. Such small plants are often undermanned, equipment is not too well maintained, and personnel are not too experienced in making the necessary adjustments to meet variable fuel properties. In addition, under strict competitive fuel conditions, small plants may be expected to most readily fall victims to gas and oil competition. For some or all of the above reasons, coal application to the small plant may well call for special handling, from the standpoint of suppling coal of consistent preparation.

In considering the advantages of consistent preparation of coal from the utilization viewpoint, its properties might be divided into three general groups:

1. Physical qualities. These would include sizing, and structure. Uniformity of top size in shipments is very important with certain types of mechanical feeding, especially for pulverized fuel and pneumatic spreader stokers. Coal handling equipment, such as conveyors and elevators, may be torn up by oversize coal. Many coal burning plants built in the twenties and thirties, did not follow the earlier custom of installing a crusher in their coal handling system to protect equipment against oversize coal, and also make available a wider range of coals, but we note crushers are again becoming more common in recent remodeling programs and new installations.

Perhaps the most important feature of sizing relates to the percentage of various sizes making up the consist of shipments to a given consumer. It must be realized that when the percentage of a certain size is changed, the weight per cubic foot almost always changes. Since the rate of feeding coal with most mechanical firing equipment, and inherently with hand firing, is based on volumetric displacement, the effect of variation in the size percentages is very critical. Complications multiply, when the fact is considered that resistance to the passage of air, through fuel beds on grates increases with an increase in the percentage of fines. This same increase in the percentage of fines, usually increases the coking and caking characteristics of any given coal. Flyash becomes an increasingly serious problem as the percentage of fines goes up. Couple with the above difficult features, the rather common possibility of an increase in ash and moisture content with an increased percentage of fines, and the lack of consistency in this respect presents a very drab outlook.

Segregation of sizes at the point of coal consumption is largely beyond the control of the coal producer. Yet, everything which has been indicated above with regard to the consistency or lack of consistency of size percentages, applies equally to segregation. In many plants it is exacting the same toll of low efficiency, unsatisfactory capacity, high maintenance, and objectionable smoke, and atmospheric pollution, and sponsoring in the mind of the plant owner, the thoughts of a change over to oil or gas. Providing coal shipments with the minimum practical variation between top and bottom size, and aiding in the installation of proven mechanical corrective measures for the reduction or prevention of segregation ills, are two services which the coal shipper cannot afford to overlook, for any of his customers plagued with segregation difficulties.

2. Burning qualities. The effect of size percentages on coking and caking, or conversly free-burning characteristics, has already been mentioned. With the highly concentrated loadings of mechanized mining, and also with certain selective mining operations, the coal loaded for shipment may carry an inconsistent percentage of certain bands or strata from the seam, such as bone, cannel, etc., which would change the free swelling index, grindability, ash fusion, or other characteristics. Any one or a combination of these items could wreak havoc with the uniform operation of a boiler plant.

3. Analytical qualities. It is quite apparent there is a distinct overlapping in the tabulation of the variables in production and preparation of coal, and the effect of their consistency upon its utilization. Analytical qualities of a variable nature, with respect to coal shipments from a given operation, might be thought of as including moisture, ash, sulphur, heating value, and ash fusion temperatures.

Consistency of heating value is of paramount importance in most plants, for it is the item which literally, "makes the wheels go 'round." A decrease in the heating value of the coal being used in a plant where boilers are operated at maximum capacity, will reflect a decrease in steam output of at least a proportionate amount, and usually more. This decrease in steam output. similarly effects the value of the coal to the consumer.

The ash fusion temperatures also play a decidedly important part with regard to capacity, efficiency, and maintenance, in any plant where design or load requirements make clinker, slag, or tube honeycombing a factor. It is not the desire to convey the idea that the fusion temperatures of the ash, such as initial deformation, softening point, or fluid temperature, tell the complete or accurate story of clinker or slag difficulty—but rather to consider them as perhaps the most reliable indicators in common use today.

The consistency of the ash and moisture content of shipments, from a given seam and operation, largely control the heating value, while the ash fusion temperatures are generally subject to change with variations in the sulphur and constituents in the ash. Hence, shipments of coal containing consistent heating value and ash fusion temperatures require uniform moisture, ash and sulphur contents.

Boiler plant performance is further penalized by inconsistencies in analytical qualities. Moisture content running on the high side results in mechanical handling difficulties, climaxed of course when in conjunction with an extraordinary amount of fireclay or freezing, during cold weather. Pulverized fuel grinding capacities are usually adversely affected by increased moisture content. Chain grate installations on the other hand, frequently suffer combustionwise, when the coal supplied to them is abnormally dry. Increased ash content in coal shipments frequently introduces ash handling and disposal problems, with plant labor as an important factor. A fickle sulphur content may attain a maximum value high enough to cause corrosion difficulties under certain critical boiler plant conditions.

A short period might be devoted to several matters of a very general nature, perhaps seldom encountered, but usually with serious results. Oxidized coal, loaded too close to the crop line in open pit mining, or from a storage pile, can cause no end of trouble with low boiler plant capacity and efficiency because of unfavorable physical, burning, and analytical qualities. Extraneous material in shipments, including that encountered because of failure to clean railroad cars before loading them with coal, is an inconsistency in preparation which should not be countenanced under any condition. Damage and power failures due to wood, metal, or oversized pieces of coal are inexcusable. Then we have the super-critical boiler plant personnel, whose favor must never-the-less be curried. This is the individual, usually small plant fireman, who climbs up on the car of coal and pronto reports his expert opinion to his superior. He might be dead wrong, but it may be easier for him to prove he's right than to retract his statement, so the tops of all loaded coal cars should obviously show a pleasing as well as consistent preparation.

Needless to say, the actual amount of increased value per ton for improved consistency, or conversely the decrease in value for less consistent preparation, will in almost every instance be different for each coal and every consumer. By the same token the cost of providing greater consistency in preparation as related to its various phases, swing over a wide range for the entire coal industry. These statements can be made because of the wide variation in coal handling equipment, combustion equipment, and operating conditions, of the many thousands of coal burning plants, and in production as it occurs in the same and different seams and in the mining methods of the hundreds of mining operations involved. In quite a few coal consuming plants the effect of change in such items as heating value, ash and moisture content, and clinkering tendency have undoubtedly been rather accurately determined on a dollar and cent basis. Many of the other items mentioned as being affected by preparation most certainly have an important bearing, on capacity and cost of plant operation. There is a dearth of reliable information on the cost of providing various degrees of consistency in preparation, as well as its dollar value to the consumer. In view of the large number of variables involved this is understandable, but studies should most certainly be encouraged to provide more facts about this very important subject.

Because of the generalities with which this subject is considered, it is not deemed feasible to attempt the assignment of actual values for different degrees of consistency in preparation.

Among the advantages accruing to the boiler plant assured of being supplied with coal of consistent preparation might be listed:

1. No need to adjust combustion equipment to suit varying fuel requirements—less labor, lower labor cost, more satisfied and cooperative personnel, and lower combustion control equipment costs.

2. Maximum capacity from units in service—less plant overhead.

3. Less combustion equipment outage—greater plant capacity, lower maintenance cost.

4. More uniform operating conditions—higher efficiency and lower fuel cost.

5. Less smoke and atmospheric pollution—better public relations, and more assurance of the continued use of coal.

Perhaps these features could best be summed up by saying the more consistent the coal preparation all other conditions remaining the same, the more reliable and the lower will be the overall cost of boiler plant operation, the greater will be the emergency capacity, and the more satisfactory will be the operation of the plant.

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RECENT DEVELOPMENTS CONVERT THE BAUM JIG INTO A HEAVY-MEDIUM PROCESS

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Introduction

The story that Dr. Cromwell tells in his famous lecture "Acres of Diamonds" came to the speaker as he was preparing this paper. The gist of that story is this: A young man took mining and geology in a university and then left his home village to seek his fortune in far distant lands. Finally as an old man, and broke, he returned to the village where he was raised. There he was amazed to see tremendous activity on the site of his old home. He asked someone what it was all about. "Oh," was the reply, "You must be a stranger here. That is the most famous diamond mine in the world. Some years ago they found literally acres of diamonds in the yard back of an old house that used to be there."

This story is certainly apropos to the Baum jig. Like the mining student of the story, coal companies and machinery manufacturers have been searching far and wide for some trick process with which to wash coal, while the best answer appears to lie in the commonest of all types of washers, the Baum jig. Why add sand or magnetite or some other material to a coal to form a heavy medium when a natural medium-forming material of fundamentally better characteristics is to be found in every coal?

Now jigging is inherently a "heavy-medium" process. For instance, in an Alabama jig, operated to make a separation at 1.60 specific gravity, the bed showed a 1.53 specific gravity, measured just above the opening leading to the refuse elevator. This measurement was the average of the solids and the water. And it was a true medium, with every particle helping to build medium for every other particle.* But it was .07 specific gravity below that of the actual separation being effected by the jig.

Since that time one or two instances have been found where the specific gravity of the natural jig bed was just right or very close to it. But such cases are unusual. Typically, a jig feed is deficient in particles of the right size and density to form a medium of high enough specific gravity. But the fact that the natural jig bed is so close to the desired specific gravity makes building it up artificially very attractive. Evidently the amount of medium to be added would be very small.

The development of a suitable medium has been investigated over a

*See Dr. B. D. Thomas' chapter "Principles of Gravity Concentration," "Coal Preparation," A.I.M.E. 1943, pp. 249.

period of years and a workable answer has been found, one that in all essential particulars changes the Baum-type jig into a float-and-sink machine capable of washing any size range simultaneously from 8″ to 200 mesh.

This development has come slowly. One reason for this will be evident at once. If an artificial medium is to be used, it must be kept out of the washed coal. This has meant development of the jigging process itself, for, obviously, if a conventional type of jig stroke is used, one in which a considerable part of the separation takes place on the up stroke, the high specific-gravity material necessary to form a suitable medium will be washed over into the washed coal. Then the work has progressed slowly for another reason. The investigators have been groping in the dark. Getting one's hands on the fundamentals, so that systematic experimentation is possible, has been a slow process.

In this paper the development of a heavy-medium jigging process will be reviewed and because the development of a "back-stroke" separation has preceded it and is a necessary part of removing the heavy medium from the washed coal, it will be reviewed first.

"Back-Stroke" Jigging

Fundamental Equation. A simplified form of the differential equation for a particle in *down* currents of water is to be seen in Fig. 1. The derivation of this equation may be found in Chapman & Mott, "The Cleaning of Coal," Chapter 3.* Now the point must be emphasized that this is not one of the conventional equations commonly appearing in text books on ore dressing; such equations usually deal with the separation in *up* currents. This equation deals with the separation in *down* currents.

The equation contains two terms, one involving specific gravity and the other size and shape of particle. The first thing to note is the expression (V-W) in the second term. Evidently, if someone can develop a process in which V = W, the entire second term, involving size and shape of particles, will vanish. Then the downward motion of any particle will depend solely on the first term involving only specific gravity. To anyone familiar with jiggling, with a down stroke following every up stroke, that process would seem to hold great promise, but all efforts failed in the earlier work owing to the fact that the average jig bed opens on the up stroke.

The investigation was started about 1930 but little was accomplished until about 1937. At that time the Jeffrey Manufacturing Company decided to have your speaker tune up new jigs as they were installed. This afforded him an opportunity to work on this problem, an opportunity to work with an air valve having probably one thousand significantly different workable combinations. He kept trying them, not always in an orderly way, for he was groping in the dark. Then one day he stumbled on to a combination that showed promise. All of a sudden, size and shape of particle seemed to make no difference. Refuse 48 mesh in size began

*Chapman & Hall Ltd., 11, Henrietta Street, W. C. 2, (1928) London, England. Incidentally, a recent letter from Dr. Chapman advises that he and Dr. Mott intend to revise this very valuable book on the cleaning of coal.

appearing in the refuse elevators along with 6″ pieces. At last he had a hand hold on the solution of an elusive problem.

Not only was this a workable jig stroke, but analysis showed it to have some fundamental logic behind it. With that start, back-stroke jigging has been making steady progress over a period of around 10 years. Each new discovery has speeded up the work. But its possibilities are still not exhausted. Even during the past six months significant progress has been made in applying the basic method.

The Jigging Cycle. As an aid to understanding some diagrams to follow, Fig. 2 is shown giving a cross section of a Baum jig. This shows in effect a U-tube filled with water. On the right leg is the jig bed, on the left, the air chamber. Above the air chamber is a receiver and an air valve. At the beginning of each stroke air is admitted rapidly through the valve for about 1 sec. It pushes down on the water at the left, producing a sharp upward acceleration on the right that lifts the bed in a mass. Then the incoming air is shut off and the air in the chamber at the left is allowed to expand for roughly 1 sec. During this stage the pressure drops and the upward acceleration of the water decreases rapidly, allowing the coal bed to open from the bottom upward. The result of these two steps is to suspend the particles of coal and refuse in the water ready for separation. Then the air is exhausted and the separation takes place with the water and the particles falling together.

The stages of the separation of the jig bed can be followed in Fig. 3, which should be entirely self-explanatory. The important thing to note is the fact that the entire separation takes place on the "back" or down stroke.

Now someone may object at this point that the particles and the water cannot continue to fall at the same rate, that the particles must inevitably gain on the water if any separation is to take place. If so, there must be some separation according to size and shape. This is a point that has bothered about everyone, including your speaker. And yet, as an experimental fact, the jig seemed to function as if no separation according to size or shape were taking place. Finally, Dr. B. T. Thomas of Battelle Memorial Institute pointed out the answer. The lack of sizing apparent on the down stroke lies in the fact that the bed comes to rest on the screen at the end of each stroke.

He pointed out that the down stroke may be roughly divided into three phases. In the initial phase the water and particles fall together; every student of jigging has recognized this phase. Then follows a phase in which the particles gain on the water; during this phase some separation according to size and shape occurs. But everyone heretofore has failed to grasp the importance of the particles coming to rest on the screen plate. Necessarily, just as the bed closes, the particles and the water pass through a stage in which they again fall at the same speed. That critical instant is of great fundamental importance in jigging unsized feeds.

Once some of the fundamentals of the down stroke were grasped, certain essential techniques became evident. These will now be discussed.

Rapid Acceleration. The upward acceleration of the water must be rapid enough to lift the bed in a mass. But for some reason that is not at present understood it must not be more rapid than necessary to accomplish this objective.

Intermediate Sizes Required. The screen analysis of the jig feed must be such that the bed can be lifted in a mass. To be lifted, the particles must lock together. In general this involves sufficient intermediate sizes. On coal this point is of almost no importance, but on hard ores a jig feed made by some special type of crusher is sometimes difficult to lift in a mass. If this occurs, some intermediate sizes must be recycled.

Low Water. The "net" upward water must be a minimum. If reference is made again to Fig. 2, this point will be clear. The rapidity of the down currents is determined by the difference in level between the water in the jig bed and that in the air chamber, as represented by "H."

Now the term "net" upward current water needs some explanation. It is the water added through the jig header. It represents the water that is added to replace what does not come back through the screen on the return stroke. Inasmuch as the down stroke should be as rapid as practicable, it follows that in an ideal jigging operation, the net water or added water should be zero. Enough water should be introduced with the feed to transport the coal along the jig and no other water should be needed.

Some day jigs will be built without headers. This construction will solve many a jigging problem, for the average jig operator has a mania for using water. He wants all the valves wide open. If there are no valves, he cannot get into trouble. Actually there is no surer way to throw off the cleaning on the small sizes than to use water indiscriminately.

An experience might be given to show the importance of limiting water. In one of Jeffrey's recent installations of a Baum jig handling 500 t.p.h. of 8″ x 0″ coal, the jig was run for a period with a preliminary adjustment involving quite a bit of water on the header. After the "bugs" were worked out of the plant, attention was given to tuning up the jig. The first step, naturally, was to cut water. The valve on No. 2 compartment was gradually closed entirely and the one on No. 1 compartment was closed in large measure. It was not shut off entirely because the water lines to the push water box ahead of the jig proved to be too small to supply the necessary transportation water. For this reason some water was supplied through No. 1 compartment.

After the plant had been running for an hour, the railroad inspector dropped up to see what had happened. He remarked that he had had no complaint on the quality of the cleaning but something had happened to the fine sizes. The cleaning was so much improved that it was obvious even to a casual inspection.

Now what of power consumption?

From the fact that less water is being circulated, one might reasonably think that the total power consumption on the jig would be reduced.

This does not follow. The power to jig coal does not vary greatly. As water has been cut down, the amount of air used has been increased, also, in some instances, the pressure at which it is used. But, of course, a matter of importance today when so much emphasis is being placed on the reduced volume of water is very advantageous either in reducing the size of the clarification system or in improving the clarification. This is running plants in closed circuit and wasting no water to the rivers.

Long Expansion Periods. The period during which the air is allowed to expand is of great importance in getting the bed adequately opened so that all of the water can return to the hutch compartment on the return stroke. As time has gone on, the trend has been to use more and more expansion. For instance, a typical jig stroke today is 100-120 degrees air admission, 100-80 degrees expansion and 160 degrees exhaust. The long expansion period has been very beneficial in getting a perfect opening of the jig bed on the up stroke.

A further contribution to the effectiveness of the expansion period is a very slow jig speed—commonly around 22 strokes per minute. This gives ample time for complete opening of the jig bed to the very topmost layers on every stroke.

Shallow Jig Bed. The depth of the jig bed i.e. the distance from the screen plate to the overflow lip should be a minimum. If it is too great, the bed acts as a valve interfering with the return of water through the screen plate. Experience shows that in handling even an 8″ x 0″ feed, the jig can be operated successfully with a bed as shallow as 22 inches.

Clean Circulating Water. To facilitate return of the water through the screen plate, the circulating water should be as clean as practicable. The jig action is distinctly dampened if the water gets over 25% solids. In this connection, the argument has often been advanced for running a jig with dirty water, that its higher specific gravity is an advantage. But a moments consideration will show that a specific gravity as low as 1.08 really could not enhance the jig operation in any significant way. Experience shows that the cleaner the circulating water is, the better the jigging.

Heavy-Medium Jigging

Now all of this preliminary discussion has been necessary to show a workable scheme for using a heavy medium without washing it over with the coal. Necessarily, the medium of high specific gravity must go out with the refuse or with the middling product so that it can be recovered and returned to the jig feed. The pure back-stroke separation takes care of this problem.

But someone objects at this point, why have the medium? If the entire size range can be separated efficiently, why complicate the circuit by introducing any medium? That question gave your speaker considerable trouble. Initially, he tried out the medium without analyzing carefully what he expected to get. The improvement in the jigging went beyond his fondest dreams. Then he wondered why. He recalled an experience in Alabama where he jigged Mary Lee Coal, 1″ x 0″, in a hand jig, effecting a separation at 1.38 specific gravity. The stroke used was very similar to that now used on the Baum jig and just described. If straight jigging will effect separations like that, why add the medium?

The answer, however, once one thinks carefully, is actually simple. True, back-stroke jigging of unsized materials in inherently a perfect gravity process, the only one thus far discovered, but it is subject to severe limitations as to capacity. For instance, in the Mary-Lee test just mentioned, the tonnage might be compared to that of running 25 t.p.h. on a 3-compartment, 7-ft. Baum, in other words, of running it at one-tenth its rated capacity. What the medium does, then, is to speed up the separation.

That this is the case may be readily seen from Fig. 4 in which some actual values are substituted in the first term of the fundamental equation in Fig. 1. The figures show the effective relative specific gravities of two particles of bone, one of 1.50 specific gravity and the other of 1.45 specific gravity. The ratios govern the rapidity of the separation. With different media they vary all the way from slightly above 1.0 to infinity as the specific gravity is increased. But the fact should be noted in particular that they gain most rapidly as the medium approaches closely the specific gravity of the separation, that is, 1.45. This is a clear demonstration of the fallacy of attempting to run a jig with very dirty water, for, as mentioned previously, water containing 25% solids, which is the upper safe operating limit, has about 1.08 specific gravity. Obviously the increase from 1.00 with clean water to 1.08 for dirty water would hardly change the ratios.

Now the gains in relative specific gravity are tremendous, but they cannot be realized fully in speeding up the separation because as the density of the medium increases, the particles settle more slowly. However, the overall gain is very great, as shown by greatly improved cleaning of the fine sizes with an artificial heavy medium present.

Medium Circuit. A basic medium circuit is shown in Fig. 5. The essentials are a screen to size the product of the last refuse elevator into three sizes. The coarsest size is crushed. This, together with the undersize of the bottom screen, is delivered back to the jig feed. The intermediate size is sent direct to refuse. The meshes of the top and bottom decks are chosen to suit the coal. Usually the top is about ¾″ and the bottom about 3/16″. As shown, the ¾″ x 3/16″ size is discarded. If the meshes are properly chosen the intermediate size will be essentially bone from which the coal cannot be liberated except by fine grinding. Actually, however, a number of instances have already been found in which there is laminated material in this intermediate size. In those cases, the entire product of the last elevator is run through the crusher and returned to the jig feed, nothing being discarded whatever. Whenever this practice is workable, it is obviously desirable, affording a maximum recovery of coal. The returns to the jig feed may either be conveyed or pumped.

Now this basic circuit should be carefully distinguished from one in which the crushed materials are jigged in a separate jig. That practice defeats the purpose, which is to build up a medium in the primary jig. This point leads naturally to the next section dealing with the medium band.

The Medium Band. When the experimental work in building a medium in the jig was first undertaken, a rather natural thing—from analogy with a Chance medium of sand of 2.65 specific gravity—was to recycle shale, but the ash content of the washed coal could not be maintained with an artificial shale medium. The medium density was obviously too high. It had to be narrowed down to bone of about 2.00 specific gravity. This observation was very proplexing at first, but it can probably be explained now, at least in part.

Remember that the medium being recycled is composed of mixed sizes, usually about 1/8″ x 0″. This being the case, the particles need not be of very high specific gravity relative to the specific gravity of the medium, in fact, cannot be. For instance, an unsized medium of 55% solids by volume will certainly be mobile. This means that bone of about 1.9 specific gravity can be used for a medium of 1.50 specific gravity and bone of about 1.8 specific gravity for a medium of 1.45 specific gravity.

The conclusion is inescapable that bone in this range constitutes the essential constituent of the medium. Materials of higher and lower specific gravities that may be returned from the middlings crusher become primarily coal and refuse, as distinguished from the artificial bone medium. Necessarily, all sizes in this specific-gravity range function as medium, each medium particle tending to support any coal or refuse particle coarser than itself. It follows, however, that the finer particles are of greatest value, for a 1/4″ particle of medium can support only pieces coarser than 1/4″ whereas a 150-mesh particle is effective on all coarser particles.

Amount of Meduim Required. The amount of medium required naturally varies greatly according to how much bone of the right specific gravity and size occurs in the jig feed. In an average case of a jig washing 500 t.p.h. the last elevator usually shows around 10 t.p.h. of fine bone. This is 2% by weight. Obviously, if the jig feed happened to contain such an amount, no medium would be necessary and, as mentioned earlier, at least two cases have been found where that condition has prevailed. Until the experimental work was done in connection with developing the heavy-medium circuit, these cases were very puzzling. One, for example, occurred on Pocahontas No. 3 coal. The jig feed presented a difficult washing problem, the coal containing a high percentage of near-gravity materials, up to 20% ± 0.10 specific gravity. And yet, the separation was extremely efficient.

This case is now easily explained. Ahead of the jig, the carbon sizes (7/16″ x 0″) were screened out and cleaned on air tables. Then the air-table refuse and middlings were added to the jig feed. This procedure gave something approaching the right amount and size of bone of around 1.9 specific gravity. Thus, the jig was being operated with a good heavy-medium circuit and this fact explains its sharp separation.

Control of Amount of Medium. When a heavy-medium circuit was first considered, the problem of how it should be controlled loomed large. But inasmuch as many companies with heavy-medium processes keep someone busy running float-and-sink tests to control the washing, it seemed reasonable to believe that coal companies in general would do so with the jig. With this idea in mind the first heavy-medium installation was observed carefully to see how much attention it required. But the jig ran along all day without any discernible change. What was happening? Obviously the jig feed had changed a lot during the shift and one would reason that the medium should have required some attention.

However, as soon as longitudinal section of the jig was examined, as shown in Fig. 6, at least a partial explanation was found. The "fish" float is a hydrometer measuring the specific gravity of the mixture of coal and water. If too much medium or a medium composed of particles of too high a specific gravity is formed, the specific gravity is increased and the float rises. As soon as this occurs the star gate begins to draw refuse, especially coarse refuse. As a result the refuse bed is thinned out. As this occurs, the jig hutches more rapidly and withdraws more fine refuse, and, with it, medium, through the screen plate. In this way the medium density is controlled by the float in No. 1 compartment.

As a result, about all the jig operator needs to do is to put back plenty of medium; the jig will do the rest. If any tendency develops for too much medium to be held in the circuit, which has occurred in one instance, larger perforations can be used in No. 1 compartment. For example, in this instance, they were changed from 1/4" to 3/8". This resulted in a greater hutching rate and enabled the float to control the medium circuit.

Now this explanation of the way the medium density is controlled may bother those listeners who are familiar with other heavy-medium processes in which the medium particles are supported in vertical currents of water. Their first thought is this: Medium specific gravity should not be affected by the amount of medium. That is correct for *up* currents, but does not hold for *down* currents. In up currents the interstitial spaces between particles are fixed, and, hence, the specific gravity of the medium for any given kind of particle. But not so in down currents in a jig. The interstitial spaces can vary with the amount of medium. Thus if too much medium is present, the specific gravity is high. As a result, if too much medium builds up in the circuit, the fact is reflected by the float in No. 1 compartment rising higher on each stroke and adjusting the amount of medium present.

In an initial adjustment of a jig, how can one tell when he has too much medium? Practically, the answer lies in the capacity of the last refuse elevator. If it shows peak loads beyond the elevator capacity, the air should be increased on No. 1 compartment to speed up the hutching rate. Once the right adjustment has been found, the experience has been that it requires no further attention; the float control does the rest.

Why has there been no difficulty with medium getting into the washed coal? As a practical operating matter, medium must come just high enough in the last compartment to cover the fish float, but no higher. What holds the level? The answer is the same as that given for the circuit as a whole. If too much medium accumulates in the last compartment, the medium specific gravity becomes high, the float rises, and thins out the coarse bone bed. Then the excess medium hutches through the screen.

One other point might be made in this connection. A jig never entirely stops hutching at any time as long as there are any fine materials in the feed. The hutching is merely reduced by holding a coarse bed of refuse on the screen, but not entirely stopped. For this reason a jig with an artificial medium circuit should never be idled with no feed. However, if, through carelessness, the medium is lost from the circuit, it is recovered very rapidly as soon as the normal jig operation is resumed.

Shale in Medium Circuit. Many coarse laminated pieces removed in the last compartment of a jig contain clay or shale. When they are crushed, these impurities show up in the medium. They are readily rejected by the hutching action of the jig, but are detrimental in dirtying up the circulating water system. This is unavoidable, but crushing of shale should be minimized. For that reason No. 1 (or No. 2 compartment in the case of a three-compartment jig) should be controlled carefully to throw no pure shale or clay particles that contain very little recoverable coal into the last compartment.

Type of Middling Crusher. The most satisfactory middling crusher is a slow-speed hammer mill. It is selective in its action, crushing coal in preference to refuse, but it does crush some bone and thus insures an adequate supply of medium of the required fine size.

Some Observations on the Artificial Medium

(1) The jig medium appears to act over the entire size range. For instance, the cleaning of the 48 mesh x 100 mesh sizes is greatly improved by its use. This observation is borne out by some data to be shown later. Probably the explanation lies in the complete absence of upward interstitial currents in the jig bed.

(2) All sizes of coal tend to be washed at one specific gravity. This observation means, fundamentally, that a falling medium has no sizing action. This is to be expected from the fundamental equation for falling particles given earlier. It gives this medium an important technical advantage over those where the medium rises, for they have a sizing action that limits the size range effectively cleaned.

If a coarse egg size must be washed at a lower gravity than the smaller sizes, the back stroke must be modified by the addition of some water to hold down the medium density. However, many companies, on account of the growing importance of the domestic-stoker market today, wish to clean all sizes at a relatively low specific gravity.

(3) The crushing circuit, then, becomes of great importance in liberating coal from laminated pieces so it can be recovered.

(4) Seemingly, any difficulty of separation can be handled. Some data showing very difficult separations are given later.

Results

In a general way washing results must be considered from the standpoint of the percentage of near-gravity materials, which is a measure of the difficulty of the separation, and of the size of materials. For instance, no one would expect to jig 1/4" x 0" coal at the same rate that he would jig 6" x 0" coal. The fine feed would require several times as much effective jigging capacity as the coarse feed. However, in the data to be given, the screen analyses are not widely different and so the results may be appraised on the basis of percentages of "near-gravity" materials.

Percentage of "Near Gravity." The best measure of the difficulty of a separation is the percentage of material within ± 0.10 specific gravity above and below the point of separation. For example, if a separation is to be made at 1.50 specific gravity, the important factor in measuring the difficulty of the separation is how much of the feed is between 1.40 and 1.60. This percentage, to make it comparative with percentages from other coals, is commonly reported as a percentage of the portion floating at 2.00 specific gravity. This procedure prevents large variations in the amount of pure rock in the jig feed from obscuring the real washing problem.* Fig. 7 contains data for interpreting washing difficulty.

Discussion of Results. In Fig. 8, overall results are given for several plants. In all of these the jigs are making at least the recovery shown possible by the float-and-sink data of the raw coal. For instance, if the float-and-sink tests of the raw coal show a possible recovery at 80% with 6% ash, the jig is recovering at least 80% of washed coal analyzing 6% ash. To whatever extent there is inefficiency in the separation—and there always is some—it is at least offset by coal recovered from crushing laminated pieces. The difficulty of the separations cove ra considerable range from simple to very difficult. The capacities given are actual, not contract tonnages. The figures are reported in this way because in one case the plant is being run below the contract capacity.

In all instances except the first, the data are sketchy, having been collected over short periods of time. For this reason some individual result may be in error, but the data taken collectively present a consistent picture. Moreover, several other plants on which the data are not considered good enough for presentation are probably doing equally good work.

Now the figures in Fig. 8 relate to the separation over the entire size range. How about the cleaning of the fine sizes? To answer this question

*Refer to "Interpretation of Float-and-Sink Data" by B. M. Bird. Proceedings of the Third International Conference on Bituminous Coal November 1931, Volume II.

a set of figures are given in Fig. 9 for the 1/8" x 0" sizes screened from washed 5" x 0" sizes. These figures, it should be said, were taken over one week's time in a plant in which a heavy-medium circuit was being used and in which the water circuit was entirely closed. Thus, they should be considered to be very reliable.

The data show that the ash and sulphur percentages do not begin to mount until 80 mesh is reached. Down to that size the fines are as well cleaned as the composite 5" x 0" size. The complete size range showed 6.35% ash and 1.7% sulphur. The composite to 80 mesh in Fig. 9 is 5.83% ash and 1.7% sulphur. A sharp rise in ash and sulphur contents will be noted in the size minus 80 plus 100 mesh. Below 100 mesh the jig was ineffective, the ashes given being essentially the same as those in the raw coal. For comparison with these ashes and sulphurs, the figures for the raw coal 1/8" x 0" were 12.27% ash and 1.55% sulphur.

Summary

A basically new method of operating a jig is described, one now in use in six washeries, the first installation having been made in 1942. Data on four of the plants show a recovery at least equalling that shown possible by the float-and-sink data on the raw coal.

The method involves two essential features: (1) The circulation of a bone medium about 1/8" x 0". This fills the interstitial spaces in the jig bed, in this way the jig is converted in effect into a float-and-sink machine. (2) The use of a type of jig stroke such that the entire separation takes place on the back, or suction, stroke. This type of stroke holds the medium in the bed and prevents the jig from washing it over with the coal.

Acknowledgments

Many men have contributed to the developments described in this paper. Of these the speaker wishes to mention particularly Drs. B. T. Thomas, E. M. Baroody and H. W. Russell, all of Battelle Memorial Institute, Columbus, Ohio.

Fig. 1: Fundamental Equation for a Separation in a Downward Current.

$$\text{Downward Motion} = \frac{K_1\ (S\text{-}M)_g}{S} - \frac{K_2\ (V\text{-}W)^2_g}{S}$$

Sp. Gr. — Size & Shape

In the above equation— K_1 & K_2 are constants
S = Specific Gravity of particle.
M = Specific Gravity of pulp.
V = Downward Velocity of the particles.
W = Downward Velocity of the water.
g = Acceleration of gravity.

NOTE: The equation in Chapman & Mott has been modified by the substitution of the specific gravity of the solids-and-water medium (M) for the specific gravity of water appearing in the original equation: Also the equation has been simplified somewhat, but the mathematical reader will realize that "downward motion" is $\frac{dv}{dt}$ and that K_1 is dimensionless while K_2 will have the dimensions $\frac{MT^3}{L^5}$

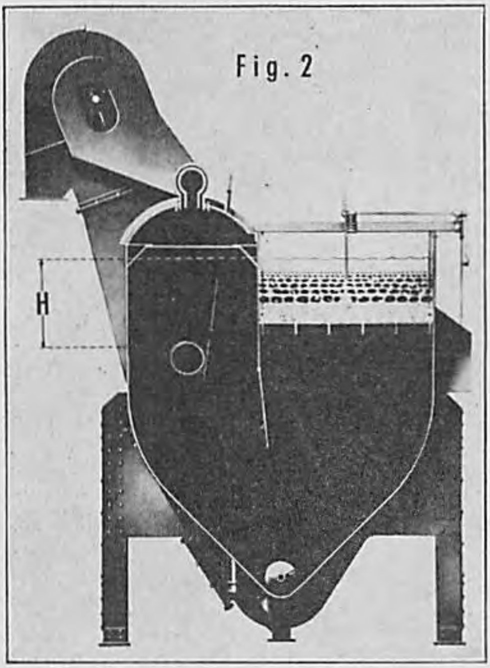


Fig. 3: Showing Opening of Jig Bed with Back-stroke Separation.

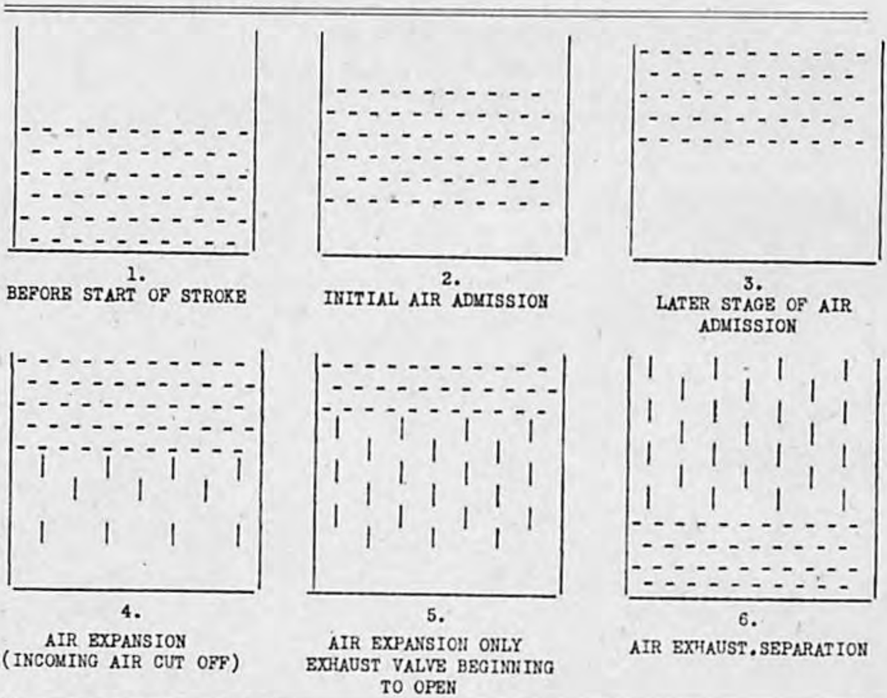
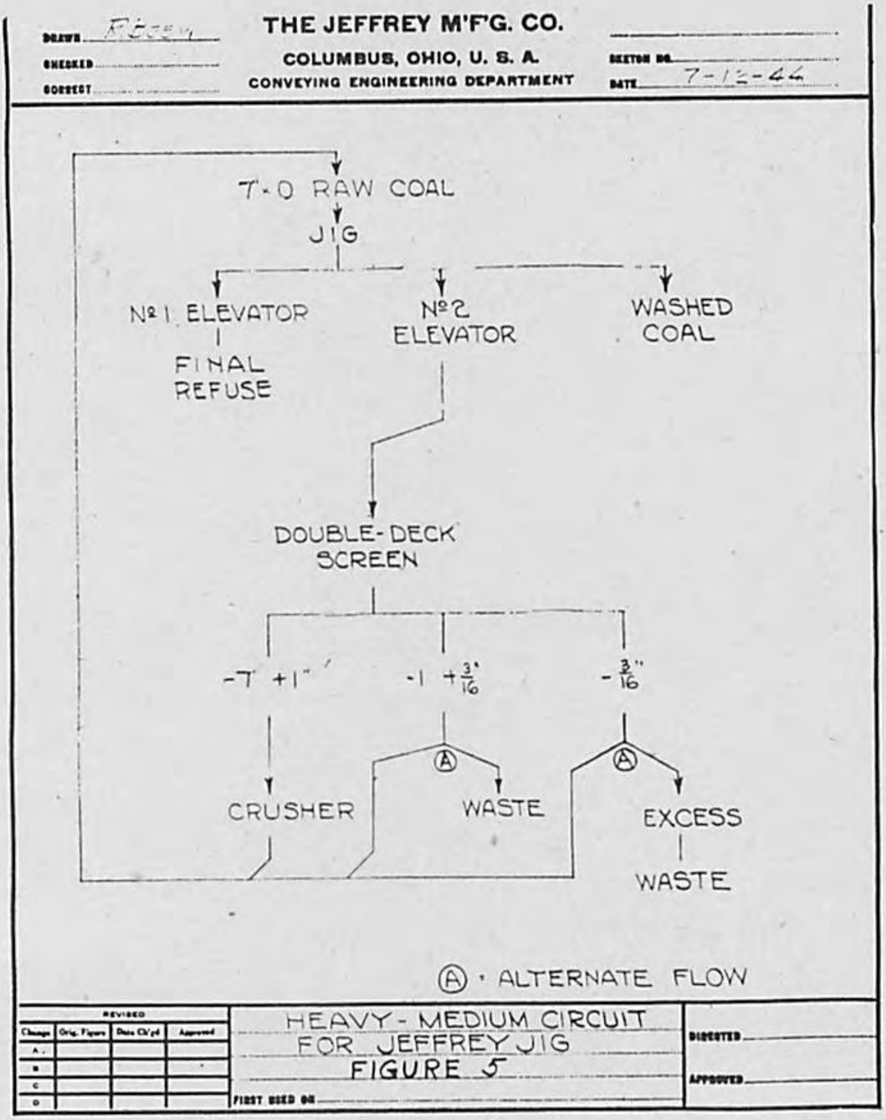


Fig. 4: Effective Specific-Gravity Ratios of Two Particles of Bone of 1.45 and 1.50 Specific Gravities, respectively, with Various Media.

Medium	*Medium Sp. Gr.*	*Ratio*	*Remarks*
Water	1.00	1.07	Typical of closely-sized feeds on jigs.
Natural jig bed	1.40	1.93	Good Baum jig practice on unsized feeds.
Artificial bone medium	1.42	3.38	New practice with bone medium.
Artificial bone medium	1.44	10.63	New practice with bone medium.
Artificial bone medium	1.45	Infinity	New practice with bone medium.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-T +1"
-1 +3/16"
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FIRST USED ON
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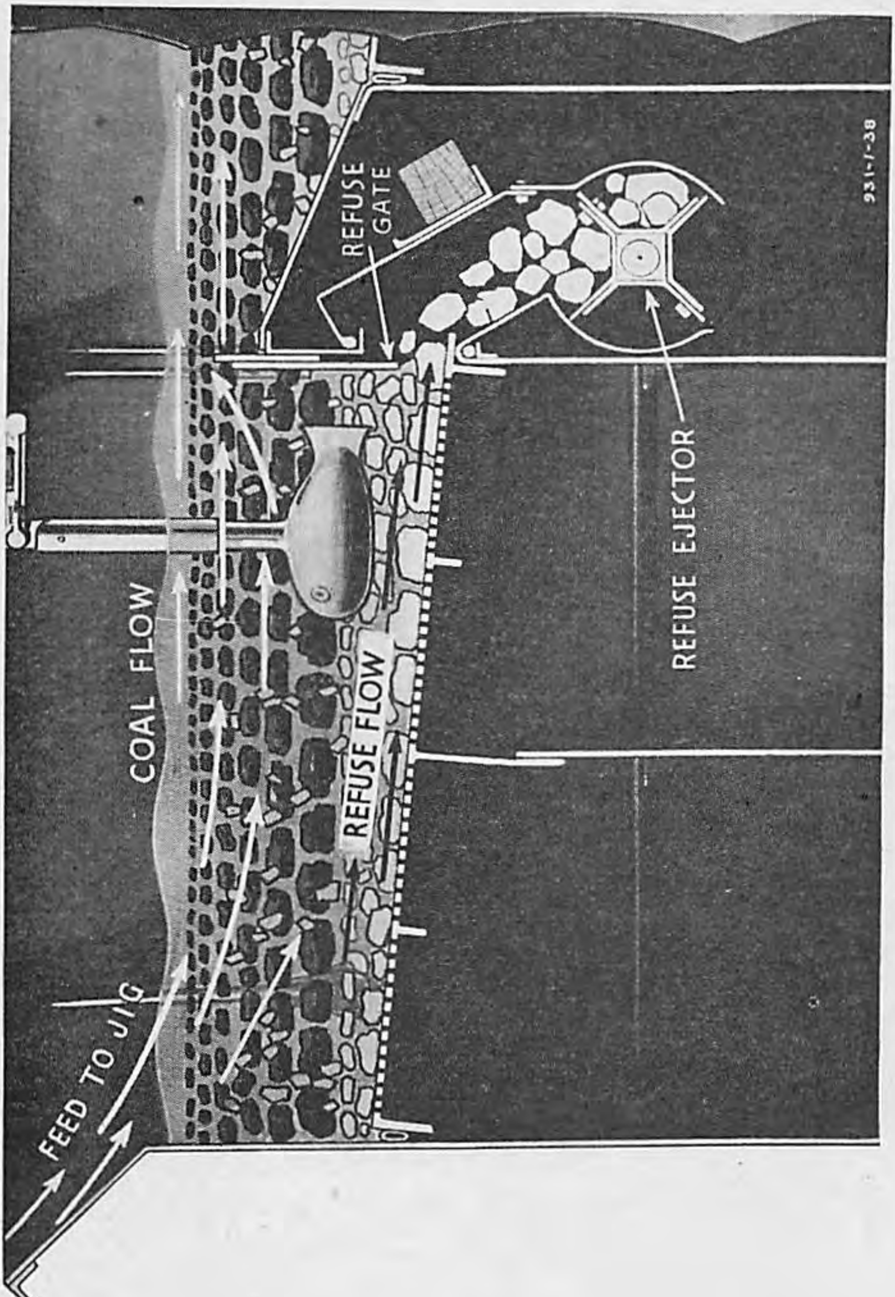
FEED TO JIG
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931-1-38

Fig. 6

Fig. 7: Interpretation of Near-Gravity Percentages.

± 0.10 Curve per cent	*Degree of Difficulty*	*Preparation*
0-7	Simple	Almost any process; high tonnages
7-10	Moderately difficult	Efficient processes; high tonnages
10-15	Difficult	Efficient process; medium tonnages; good operation
15-20	Very difficult	Efficient processes; low tonnages; expert operation
20-25	Exceedingly difficult	Very efficient processes; low tonnages; expert operation
Above 25	Formidable	Limited to a few exceptionally efficient processes; expert operation

Fig. 8: Results with Baum Jig Equipped with Heavy-Medium Circuit. All Plants Shown are Making the Yield Shown Possible by Float-and-Sink Tests of Raw Coal at Ash Contents Made in Washing.

Coal Seam & State	*Size Range Cleaned Effectively*	*± 0.10 Sp. Gr. %*	*Tons/Sq. Ft./Hour*
Pittsburgh, Pennsylvania	4″ x 80 M.	4	3.2
Koehler, New Mexico	3″ x 65 M.	22	2.4
No. 11 Kentucky	6″ x 65 M.	5	4.8
5 Block West Virginia	6″ x 65 M.[a]	12	2.8

[a] Raw coal screened and ⅜″ x 0″ air tabled; refuse added to jig feed.

NOTE: Plants 1 and 2 recover all fines with the washed coal.
Plants 3 and 4 lose part of the extreme fines to the river.

Fig. 9: Performance of Heavy-Medium Separation on Fne Sizes in a 5" x 0" Feed.

Mesh	Wt., %	Ash, %	S, %	Cumul. Wt., %	Cumul. Ash, %	Cumul. S, %
Screen Analysis						
+20	1.17	6.89	1.10	1.17	6.89	1.10
—20+30	5.49	4.87	1.04	6.66	5.22	1.05
—30+40	13.85	5.18	1.15	20.51	5.19	1.12
—40+50	10.67	5.66	1.18	31.18	5.35	1.14
—50+60	8.75	6.57	1.19	39.93	5.62	1.15
—60+70	3.88	6.43	1.21	43.81	5.69	1.15
—70+80	5.23	6.96	1.25	49.04	5.83	1.17
—80+100	18.60	10.70	1.44	67.64	7.17	1.24
—100+140	24.96	18.38	1.95	92.60	10.19	1.43
—140+200	4.57	20.97	1.98	97.17	10.70	1.46
—200	2.83	22.58	1.81	100.00	11.03	1.47

BRITISH vs. AMERICAN COAL MINING

By EUGENE McAULIFFE
Chairman, Board of Trustees, The Union Pacific Coal Co., Omaha, Neb.

With a definite shortage of coal for transportation, public service, manufacturing and heating processes now confronting Great Britain, and with the possibility of a repetition of the suffering endured by the British people in the winter of 1946-47, much is being said respecting the fact that the average production per man-shift of the British mine worker is not comparable with the daily output of the American mine worker.

It is axiomatic that no two coal mines are alike, whether compared physically or in output per man-shift, which, after all, represents the most comprehensive method of comparison. The criticism of the British coal operator and mine worker centers around the fact that the American mine produces about 5 1/16 times the weight of coal secured in Great Britain per man-shift worked. The British output is running at 1 ton per man-shift, while our record for all bituminous and lignite mines averages 5.78 tons per man-shift.

The first element in this comparison which the average writer ignores is that Britain uses the long ton (2,240 lb.) while our bituminous-coal figures are based on the short ton (2,000 lb.). Thus, the British ton is 12 percent heavier than ours. We would recommend that Britain hold onto the Tower of London, Westminster Abbey, St. Paul's Cathedral and a thousand more of its traditional landmarks, but that it should adopt the decimal system in its weights and currency.

This difference of 12 percent, however, is but a minor matter. The real handicap that Britain suffers lies in the marked spread in physical conditions, including the removal of much-thinner coal seams and more heavily pitching measures. Much of Britain's coal is taken from a series of coal seams, many of which lie at depths under the surface so far below our maximum present-day depths as to make any real comparison impossible.

In the absence of any British national average, we are compelled to depend upon the drilling records of a new Scottish property where sinking is now under way and which will approximate the average of all British mines. The U. S. Bureau of Mines released in July, 1947, its Mineral Market Report M.M.S. No. 1526, which covers the "Thickness of Bituminous-Coal and Lignite Seams Mined in the United States in 1945." A similar survey was made by the U. S. Bituminous Coal Commission for the year 1920, which checks very closely with the 1947 compilation, from which we abstract the following:

Mine	Tons Coal Mined	Avg. Thickness, Feet	Avg. Tons per Man-Shift
Strip	109,986,865	5.30	15.46
Underground	467,630,462	5.40	5.04
All Mines	577,617,327	5.40	5.78

The production of 15.46 tons per man-shift in the 19 percent of the total production stripped, as compared to 5.04 in the underground mines, presents conclusive evidence of the extent to which physical conditions enter into man-shift tonnage.

In June last, we were given the opportunity to review the physical conditions that attach to a mine now under construction in Fife, Scotland —the Rothes colliery, originally planned by the staff of The Fife Coal Co. and which is now being constructed by the National Coal Board of Great Britain, whose engineers and mining experts approved the plans of the Fife company.

The details of the Rothes colliery were worked up by the Fife company's staff after making an exhaustive inspection of the largest and most-modern collieries in America and on the Continent. Many of the details adopted were, in fact, taken from American and Continental properties. A total of 11 separate seams, ranging from 20 to a maximum of 84 in. in thickness, will be worked through two circular shafts 24 ft. in diameter. None of the seams are of uniform thickness nor are they continuous throughout the property. The area of the available field, 10 square miles or 6,400 acres, with a reserve of workable coal totalling 183,000,000 long tons (204,496,000 short tons) will be mined from 51,618 seam-acres, or approximately 73 percent of the total coal-bearing acreage. The details set forth below will prove informative:

Seam	Acres	Thickness, Seam, Inches	Total Calculated Reserves, Tons
Smithy Top	6,245	20-50	21,857,500
Smithy Lower	6,245	30-60	25,604,500
Little Splint	4,743	22-75	14,229,000
Seven Feet	4,991	32-57	14,973,000
Main	5,874	31-40	16,447,200
Jersey	2,514	20-40	7,793,400
Top Lochgelly	6,439	28-58	25,756,000
Lower Lochgelly	6,439	23-33	16,741,400
Glassee	646	20-30	1,679,600
Five Feet	6,439	28-84	35,414,500
Dunfermline Splint	1,043	20-36	2,503,200
Total and Average	51,618	40.66	182,999,300

It will be observed that the weighted-average thickness of the 11 seams under a varying acreage, taking the mean thickness of each seam for purposes of calculation, is but 40.66 in., and that the extraction per seam acre is 3,545 long or 3,970 short tons. Assuming that it costs more to develop and produce coal from seams that thin down to 20 in. and average but 40.66 in. in thickness than it does with seams averaging 64.8 in., this factor alone would tend to create a lower man-shift output than that obtained in our American mines.

There are, however, more serious handicaps applying to the British operation. Such include thickness of cover and weight of the overlying strata, the necessity of driving haulageways in the rock below the coal, added ventilation problems and protection of the surface against subsidence. Britain is very jealous of its tillable surface lands. The task of removing the negligible tonnage secured by stripping in Great Britain is made doubly hard by the fact that the surface soil is first removed and carefully stored and thereafter several inches of the subsoil is treated in the same manner. Then, when the spoil banks are carefully levelled, the subsoil and surface material are restored to the same position they occupied originally. Certainly, the British strip-coal producer does not get 15.46 short tons per man-shift worked by his employees. Britain goes out for the highest possible extraction also, which again costs man-shifts.

The Machinery Question

Much also has been said to the effect that the coal-loading machinery sent over to Britain has not pulled up production. Some of the promoters of this type of machinery have promised an immediate gain of 25 percent in production from machine over hand loading. This is not the experience of American coal operators. The cold facts are that while coal-loading machinery should and eventually will reach the proportions in Great Britain that exist here, those who pioneered this type of machine (as well as the now firmly established coal-cutting machine) found out early in their experience that it took some time to synchronize the efforts of the underground supervisors and the working force before they would make the best of the machines. There is nothing new in this situation. It is as old as machinery. America has a long way to go yet before all of its coal is loaded, or even partially loaded, by power-driven machines.

After attempting to clarify the difference in working conditions that govern in Great Britain and those that exist in America, there yet remains the more-important political situation that enters into the question of coal production. That the British mines are not producing enough coal to carry the nation's domestic load is an open secret. The Minister of Fuel and Power has said so repeatedly and posters that scream the National Coal Boards' slogan—"Work or Want!"—are to be seen in the various coal fields. Yet the daily and weekly production sinks. Some months ago, the Coal Board set 200,000,000 tons as the minimum-possible requirements for the year 1947. So far, the production is lagging and the mot-rigid economies are being practiced—and coal is being purchased at high prices from American mines to fill the need.

Something big must be done if Britain is to recover its old spirit. A new leader who can re-form the industrial front line, such as was done by Churchill after Dunkerque, is tragically needed. The Labor Government lacks the courage to confess its mistakes. There is a lack of discipline in the mines and, with a shortage of labor, the mine officials are in an even-worse position to deal with strikes, slowdowns and absenteeism than were the operators before the government took over. The Labor Party over-promised and, with pay day here, they are in default. It was an Englishman, Isaac Newton, who discovered the law of gravity, and that law holds as good today as it did in 1665 when Newton observed the falling of an apple in his garden. If Britain fails—and some of its friends are now becoming very fearful—its first shove down the incline will come from its coal mines which, since the beginning of the industrial age, have been the foundation and keystone of Britain's greatness.

Problem for America

There is a growing disposition on the part of British political leaders to lean on America, forgetful of the fact that this country cannot restore and support the greater part of Europe and a substantial portion of Asia. As of June last, the American people have subscribed $23,350,000 for relief and rehabilitation work overseas. As of mid-August, the American corn crop—the most-important of all our grain crops—has been sharply cut by drought and searing winds. This means less pork, beef and poultry and higher prices for consumers. We have been a giving government for 15 years—first at home and now world-wide. It is time to read the crossing sign: "Stop, look, listen."

Britain should abandon its further ventures along the road to socialism, want and suffering. It has failed in the operation of its coal mines and it will make the same failure with its railroads and its steel industry. Some man with a stentorian voice should call the nation to eight hours' work, six days a week, foregoing all strikes, voluntary absenteeism and slowdowns. "Produce! Produce! Produce!" should be the cry from the government, the press, the radio and the pulpit. If the food allowance is not sufficient for those engaged in hard labor, amplify it, tightening up on those who could but will not work.

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. Funds received from life members are to be invested and only the income from these funds may be used in the regular operation of the Institute.

ARTICLE III.

Officers.

Section 1. The officers shall consist of a President, Vice-President, Secretary-Treasurer and twelve Executive Board members. The services of all officers shall be without compensation.

Section 2. Nominations for officers and the executive board shall be made by nominating committee of three (3) appointed by the President at least thirty days before the annual November meeting, provided that anyone can be nominated on the floor of the meeting for any office for which an election is being held.

Section 3. The President, Vice-President and Secretary-Treasurer shall be elected by ballot, annually, at the regular November meeting and shall hold office for the ensuing year.

Four Executive Board members shall be elected by ballot, annually, at the regular November meeting and shall hold office for the ensuing three years.

To make effective this change, at the regular November meeting in 1938, in addition to the four Executive Board members who shall be elected for the three year term, there shall also be elected by ballot eight other Executive Board members, four for a two year term and four for a one year term.

Section 4. In case of death, resignation, or expulsion of any officer, the executive board may fill the vacancy by appointment until the next regular meeting, when the vacancy shall be filled by regular election. In case of a vacancy in the office of president, the duties shall devolve upon the vice-president.

Section 5. The executive board shall consist of the officers and twelve other board members.

ARTICLE IV.

Duties of Officers.

Section 1. The president shall perform the duties commonly performed by the presiding officer and chairman. He shall sign all orders for payment of money by the treasurer, and with the executive board shall exercise a general supervision over the affairs of the Institute between sessions.

Section 2. The vice-president shall preside in the absence of the president and perform all the duties of the president in his absence.

Section 3. The secretary-treasurer shall keep a record of each meeting, shall read and file all resolutions and papers that come before the Institute, countersign all orders for money which have been signed by the president, and shall purchase necessary supplies under the direction of the executive board.

He shall keep a true record of all money received by him and payments made on account of the Institute. He shall pay out no money except on an order signed by the president, and countersigned by himself, and shall retain these orders as vouchers. He shall give bond in such sum as the Institute may provide, the premium on said bond being paid by the Institute.

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

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

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

Section 5. The Executive Board shall perform the duties specifically prescribed by this constitution; it shall supervise the expenditures and disbursements of all money of the Institute, and no expenditure other than current expenses shall be authorized without first having the approval of the Executive Committee; it shall act as program committee for each meeting to determine what is to be published in the proceedings and shall perform such other duties as may be referred to them by regular or special meeting of the Institute.

ARTICLE V.

Meetings.

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

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

ARTICLE VI.

Amendments.

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

ARTICLE VII.

Order of Business.

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

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

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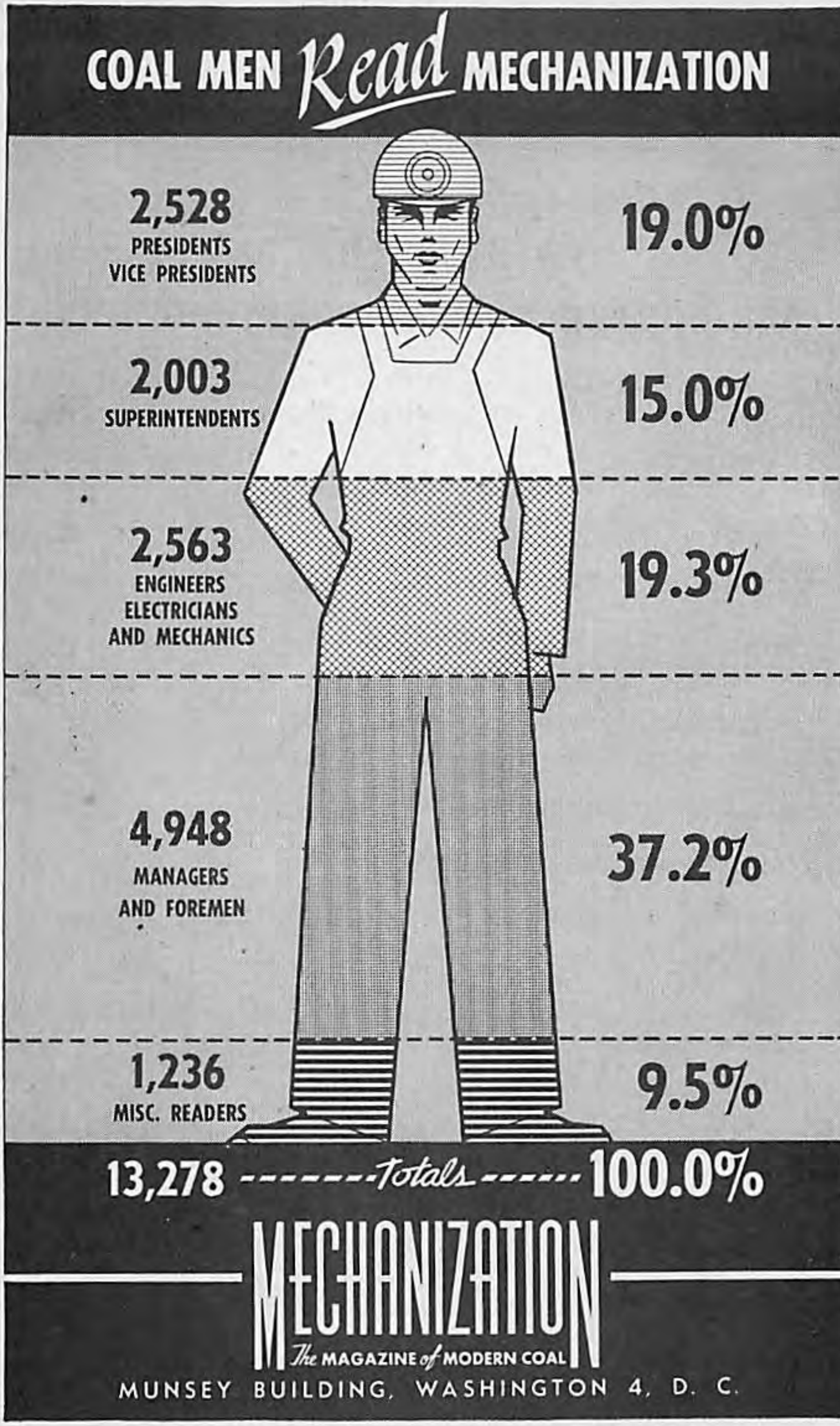
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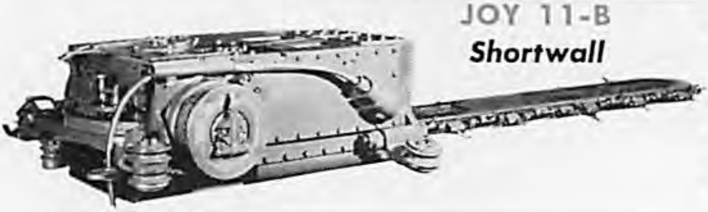

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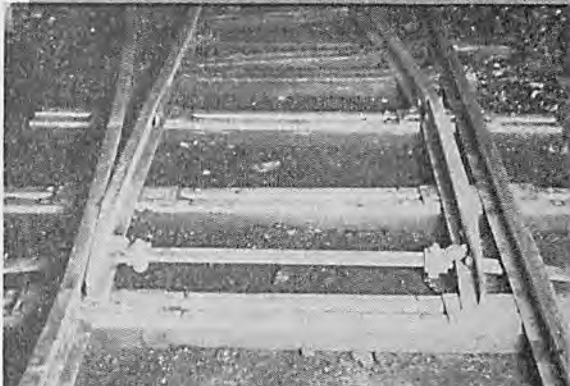

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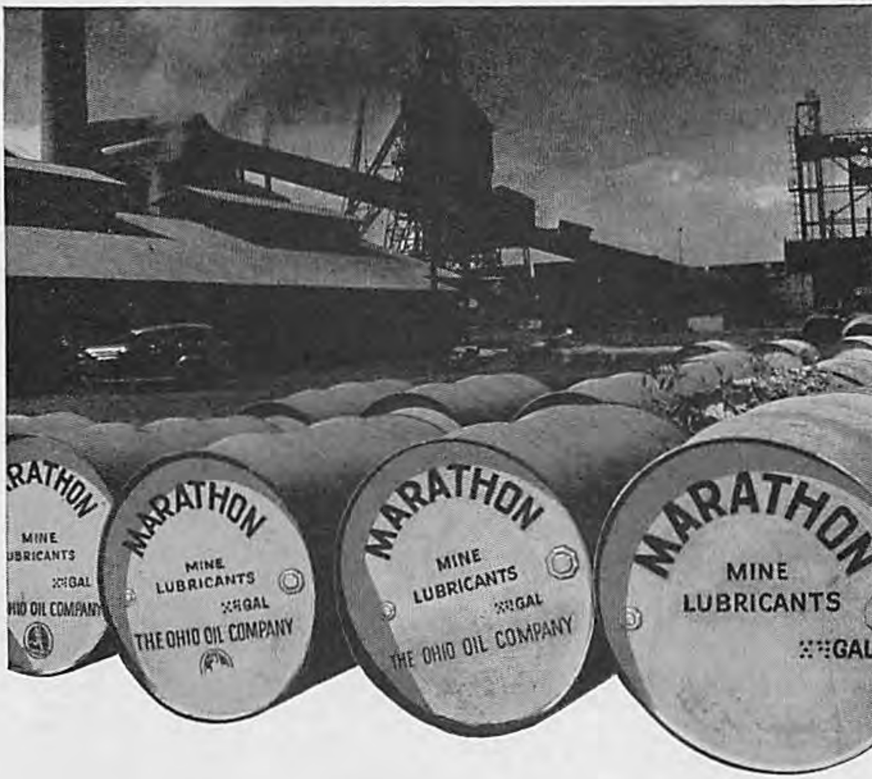

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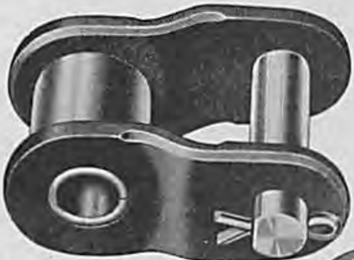

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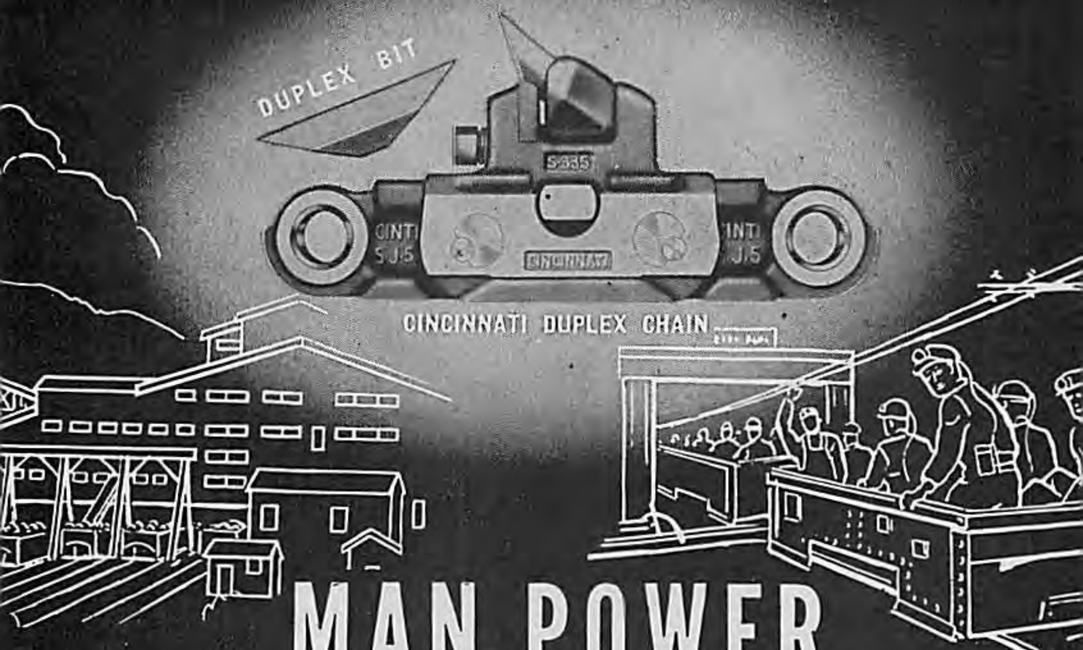

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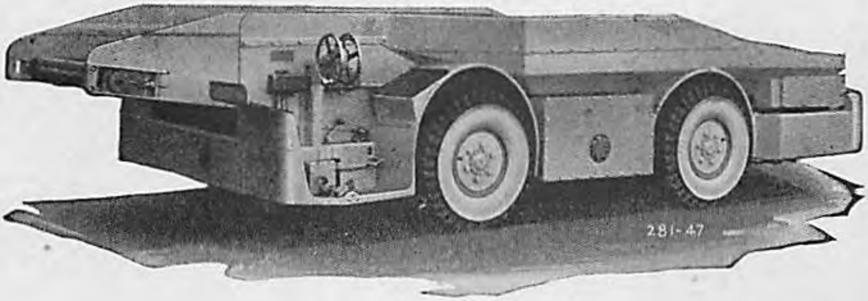

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- **Explosion Tested Equipment**
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— OTHER JEFFREY COAL MINE EQUIPMENT —

CUTTERS LOADERS CONVEYORS DRILLS
LOCOMOTIVES FANS BLOWERS
WASHERS CRUSHERS SCREENS FEEDERS
BUCKET ELEVATORS CHAINS TRANSMISSION MACHINERY

THE JEFFREY MANUFACTURING COMPANY
953 NORTH FOURTH STREET COLUMBUS 16, OHIO, U.S.A
Established in 1877

SEND A SALESMAN WITH EVERY TON OF COAL YOU SELL . . .

Your Trade mark, in your coal, is your best salesman. It goes right into the users' bins with every ton of coal. It stays right on the job . . . working for you night and day . . . and it tells and sells the quality of your coal with every shovelful.

Trademarking is the surest way to build user confidence and a steady repeat demand for YOUR coal. Your trade mark SELLS your coal and enables the user to re-order . . . and be sure of getting your coal . . . every time.

Dustlix Labels stay put—cannot roll.

U. S. PAT. NOS. 2,169,228—2,209,768

Of what value is your trade name, or trade mark, if it does not appear on the product it represents?

The cost of trademarking, the DUSTLIX way, is so extremely low . . . you make no investment in expensive equipment and buy only the trade marks you require, at from 40% to 60% less than the regular price of ordinary printed trade marks.

Decide NOW to build a steady repeat demand for your coal under its own trade name. Uniform coal insures uniform comfort, and that's what the user expects to get when he buys coal. Remember too . . . trademarking insures uniformity.

Write us for complete information.

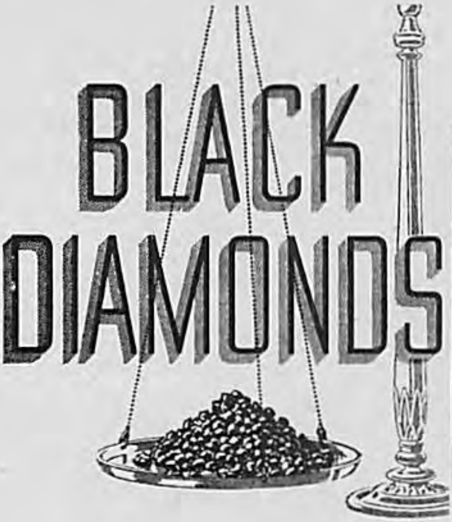
DUSTLIX CORPORATION

MILWAUKEE 2 — **345 NORTH WATER STREET** — **WISCONSIN**

DUSTLIX SCIENTIFICALLY PROCESSED DUSTPROOFING FLUIDS

DUSTLIX AUTOMATIC COAL • TRADEMARKING SYSTEMS

BLACK DIAMONDS



MINE MORE WITH WHEAT THE *productive* CAP LAMP

It is a proven fact that light and productivity go hand in hand. Especially is this true underground where more and better light always means *more and better production—with a far greater margin of safety.*

Wheat, the *approved* cap lamp can actually *reduce fatigue, lower the accident rate and raise the output level as much as 20% per man day!* Even at the end of the shift Wheat remains bright and maintains more than 80% of its initial efficiency.

Because these are dollar-producing facts that no mine owner or operator can afford to ignore, it will pay you to investigate Wheat—the *productive* cap lamp—now.

WHEAT GIVES YOU THESE EXCLUSIVE BENEFITS

1. 20% Brighter light at working face.
2. Compact, lightweight, balanced, streamlined.
3. Steady, dependable light; 80% efficient at *the end* of shift.
4. Emergency bulb means miner is never in the dark.
5. Simple, fool-proof, self-service charging system—battery charged through headpiece and cord of lamp.

KOEHLER — THE FIRST LAMP APPROVED BY THE U. S. BUREAU OF MINES

NATIONAL MINE SERVICE COMPANY

BEMECO DIVISION — BECKLEY, W. VA.
ALL-STATE DIVISION — LOGAN, W. VA.

EXCLUSIVE U. S. DISTRIBUTOR FOR WHEAT ELECTRIC CAP LAMPS AND KOEHLER FLAME SAFETY LAMPS

This ideal permissible helps get out more coal—faster

Today, "Monobel" AA is the largest-selling permissible in the country. And for good reason. It's an economical coal-getter that produces big lump coal by the carload.

"Monobel" AA is a strong, low-velocity ammonia permissible. It has a slow, heaving action that doesn't shatter the coal but puts it where mechanical loaders can get at it—quickly.

Excellent water-resisting qualities permit using this permissible in extremely wet mines. It is also widely used for high, hard-shooting seams and in rock or slate work. Class A fumes of "Monobel" AA allow speedy return to the face.

Ask any Du Pont Explosives representative for complete information about this popular permissible.

E. I. du Pont de Nemours & Co. (Inc.)
Explosives Department
Wilmington 98, Delaware

DU PONT "MONOBEL" AA

A Product of Du Pont Explosives Research

BETTER THINGS FOR BETTER LIVING
. . *THROUGH CHEMISTRY*

DU PONT
REG. U. S. PAT. OFF.

Use the wire rope that's cut out for today's jobs

There's no place for slack in the coal industry's program—or in a vital mining cable. To accelerate production, to strengthen your defense against equipment shutdowns, you need the workability and durability of Preformed Yellow Strand. With this time-tested wire rope handling the load, giant stripping and loading shovels can take the full bite. Main hoists can utilize their high speeds with safety. Above and below ground, cable-using machines can move closer to capacity operations and put off replacements.

These gains result from pointing up Yellow Strand's stout, drawn-to-order steel wires with the limberness of preforming. The rope reeves easily . . . runs freely around small sheaves . . . spools evenly despite overloads. Still every length is as tough as ever—highly resistant to shock, abrasion and drum crushing. Today time-and-labor-saving cable counts *double* in production. Install Preformed Yellow Strand and help your men and machines deliver to the limit.

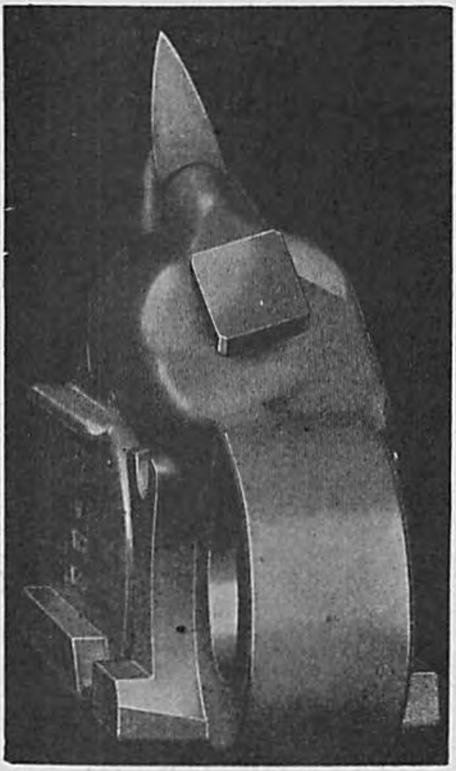
Broderick & Bascom Rope Co., St. Louis

Branches: **New York, Chicago, Houston, Portland, Seattle.** ***Factories:*** **St. Louis, Seattle, Peoria**

YELLOW STRAND

PREFORMED **WIRE ROPE**

A MAINSTAY OF WAR PRODUCTION



MODERN MINE VENTILATION

demands

FLOCKER'S MODERN BRATTICE CLOTH

MOROPA

DRY TREATED

better 5 ways

• **SUPERIOR FIRE-RESISTANCE**—Chemicals are impregnated in the Moropa cloth by an exclusive process for lasting protection.

• **SUPERIOR MILDEW-REPELLANCE**—The chemical treatment wards off excessive moisture . . . the fabric remains relatively dry and free of mildew.

• **LONGER SERVICE**—Moropa can be used and re-used many times . . . brattice men willingly reclaim and re-hang it.

• **SAFER STORAGE**—Moropa can be stored with the confidence that it will remain dry and ready for use at all times.

• **GREATER ECONOMY**—Moropa's longer life and service cut your costs.

For your next brattice requirements—specify MOROPA.

Samples and quotations on request.

JOHN FLOCKER & COMPANY

ESTABLISHED 1822

644 GRANT STREET, PITTSBURGH 30, PA.

WHY
The BIG Demand is for Tiger Brand-

● Made of high tensile steel wire . . . to close tolerances and unvarying quality standards, U·S·S American Tiger Brand Excellay Wire Rope has the stamina to stand up *tirelessly* under long, continuous service. Strength, toughness and flexibility are combined to your greatest advantage. Installation is simplified through its ease of handling. Once on the job your trouble factor is reduced to a minimum because it operates smoothly over sheaves and drums. It's safer, too, because broken wires lie flat and in place — do not porcupine out to injure workmen. All of which reduces maintenance and rope replacement costs . . . and helps you do a more efficient, more profitable job all the way through. That's why the Big Demand is for Tiger Brand.

IMMEDIATE DELIVERY
ALL TYPES AND SIZES

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York

UNITED STATES STEEL

Beating Nature's Restrictions

With RANGE, SPEED, OUTPUT, ECONOMY

Many stripping operations now being successfully worked once lay undeveloped because conditions imposed prohibitive costs. Extremely deep overburden, necessity for spoiling far from the digging point, hard-to-dig materials, soft footing — these and other factors made stripping costs excessive.

Today such workings have been converted into profitable mining operations by machines like the Bucyrus-Erie 1150-B walking dragline, which is able to perform economically in the face of extreme conditions. This long-range machine — with maximum boom length of 250 feet — easily peels off deep overburden and deposits it well out of the way. Its great strength, capacity, and power are more than a match for the toughest stripping job. Its sure-footed walking traction mounting and large area base permit traveling over and working on ground too soft for other machines. Fast action and highly responsive electrical control give it a fast overall working cycle that is easy to maintain for a continued high production pace.

Design and construction of the 1150-B are a direct result of Bucyrus-Erie's thorough knowledge of stripping problems and of 67 years' experience building excavating equipment of all sizes that is "years ahead" in range, speed, output, and economy.

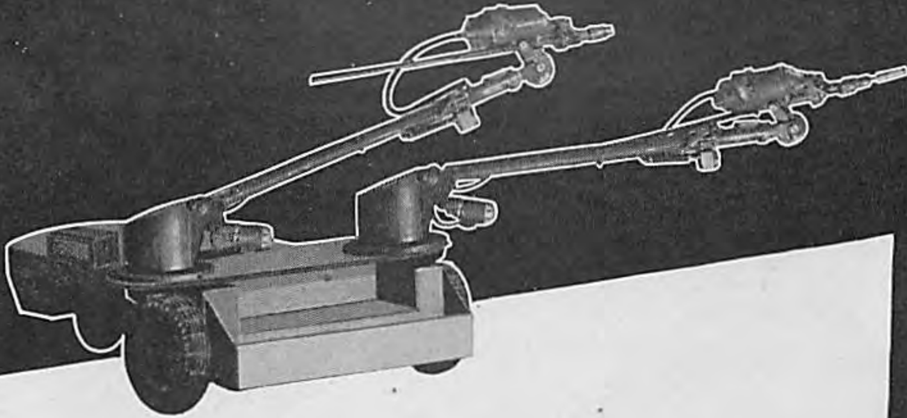
WALKING DRAGLINES

Booms to 250 feet; Buckets to 25 cubic yards

BUCYRUS ERIE

SOUTH MILWAUKEE, WISCONSIN

50L47



BIG YARDAGE - MORE PAYLOADS = REAL PAYDIRT!

Thirteen of these mighty Mack LR tractors haul 35-ton payloads for the Sunlight Coal Company of Boonville, Indiana. Performance counts with this company.

That's the sure-fire formula for transforming overburden and coal into real pay dirt.

And that's the way Mack super-duty trucks are built to operate. On the toughest off-highway dump work Macks have consistently demonstrated their ability to move high yardage per load and more loads per hour.

They've got power in abundance! Extra margins of strength and stamina! Assured traction through Mack's exclusive Power Divider for both four and six-wheel trucks. And throughout their design special stress has been placed on ease of control, maneuverability and clear vision—thus reducing shovel delays to a minimum.

Mack trucks for off-highway service range up to the largest capacities built—gasoline or diesel—four or six wheels. Each is individually engineered for its specific job and each takes to its job only after thorough study of the proposed operation.

Our engineers will gladly advise you on the most efficient use of trucks on your particular haulage job.

Write or call your nearest Mack branch or dealer.

Mack

MACK-INTERNATIONAL MOTOR TRUCK CORP.

33RD STREET & WENTWORTH AVENUE • CHICAGO 16, ILLINOIS

POWER

EXIDE-IRONCLAD POWER Assures

"Full Shift Availability in Mine Haulage Units"

Numerous records show that in mines where Exide-powered locomotives and shuttle cars are used, coal handling is speeded up all the way from face to cage. Loaders are kept busier, car change time is reduced, and main line haulage sets a faster pace.

Exide Power is sustained power, equal to every demand made upon it. You can be sure of *full shift availability* hour after hour, day after day. This is the main reason why more mine operators use Exide-Ironclads for locomotives and shuttle cars than all other makes of batteries combined.

You can always count on Exide-Ironclads for safety and dependability. Their rugged construction keeps maintenance costs at practically nothing. *These characteristics of Exide-Ironclad Batteries add up to lower haulage costs per ton.*

Exide
IRONCLAD
BATTERIES

THE ELECTRIC STORAGE BATTERY CO., Philadelphia

CHICAGO BRANCH:
5335 SOUTH WESTERN BLVD.

ST. LOUIS BRANCH:
1218 OLIVE STREET

SERVING THE MINING INDUSTRY IN SOUTHERN ILLINOIS

In southern Illinois, Fabick Service brings to the mining industry famous "Caterpillar" Diesel power and matched equipment — backed by the finest in service by Fabick.

At Salem and Marion, Illinois—in the heart of the coal fields—Fabick Service centers bring "Caterpillar" equipment parts and shop facilities close to the mines. Each center is equipped to tackle any job that calls for skill and speed.

FABICK AT SALEM

FABICK AT MARION

MO. ILL.

FABICK SERVICE

ST. LOUIS-SIKESTON, MO. **SALEM-MARION, ILL.**

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