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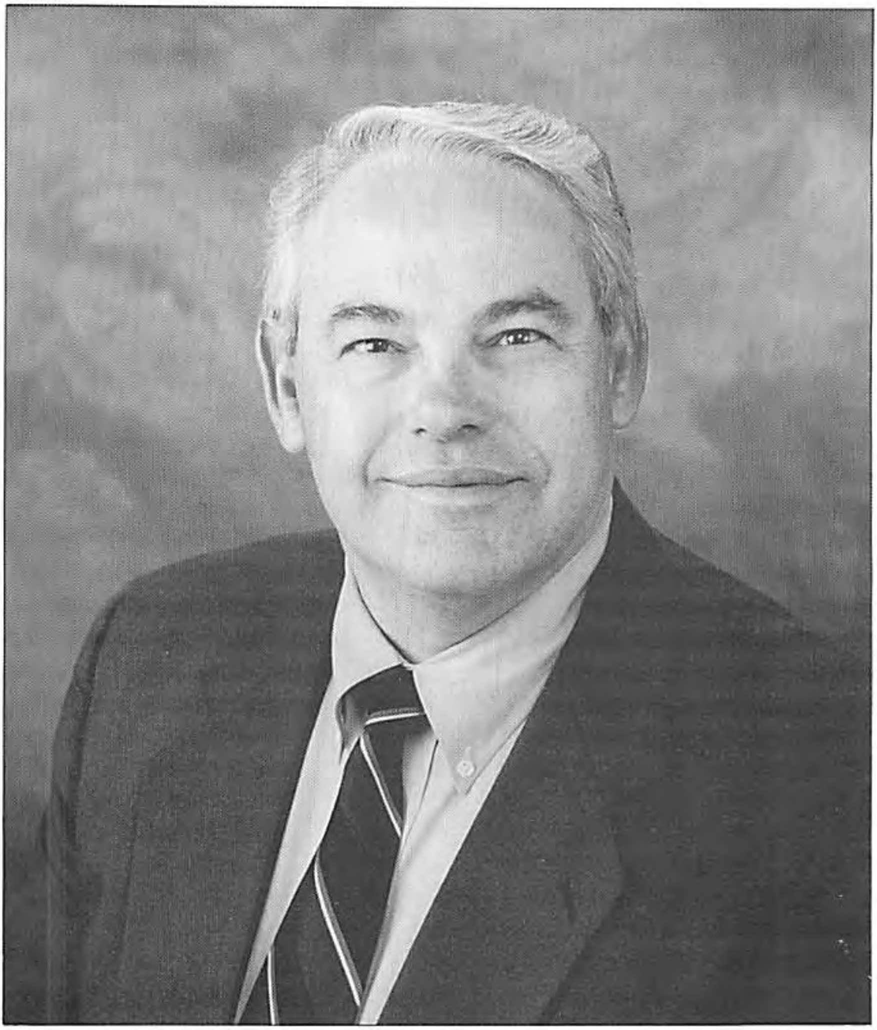

J. Robert Danko

PRESIDENT 1992-93

THE COAL MINER

TRUE – he plays no grandstand role in life
But his importance is vital, great and just:
For without his toil in earth's caverns deep,
Civilization would soon crumble into the dust.
AD 1964 From his poem – Vachel Davis

(Dedicated on State Capitol Lawn, Springfield, Illinois, October 16, 1964)

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of

All Deceased Members

of the

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1919-20	WILLIAM HALL, Miners Examining Board, Springfield, IL
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1938-39	PAUL WEIR, Consulting Mining Engineer, Chicago, IL
1939-40	ROY L. ADAMS, Old Ben Coal Corp., West Frankfort, IL
1940-41	M. M. LEIGHTON, State Geological Survey, Urbana, IL
1941-42	J. A. JEFFERIS, Illinois Terminal Railroad Co., St. Louis, MO
1942-43	CARL T. HAYDEN, Sahara Coal Co., Chicago, IL
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1944-45	GEORGE F. CAMPBELL, Old Ben Coal Corp., Chicago, IL
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1946-47	ROBERT M. MEDILL, Dept. Mines & Minerals, Springfield, IL
1947-48	HARRY M. MOSES, H. C. Frick Coal Co., Pittsburgh, PA
1948-49	J. ROY BROWNING, Illinois Coal Operators Assn., Chicago, IL
1949-50	T. G. GEROW, Truax-Traer Coal Co., Chicago, IL
1950-51	G. S. JENKINS, Consolidated Coal Co., St. Louis, MO
1951-52	CLAYTON G. BALL, Paul Weir Co., Chicago, IL

1952-53	WILLIAM W. BOLT, Pawnee, IL
1953-54	HAROLD L. WALKER, University of Illinois, Urbana, IL
1954-55	J. W. MacDONALD, Old Ben Coal Corp., Benton, IL
1955-56	EARL SNARR, Freeman Coal Mining Corp., Hindsdale, IL
1956-57	PAUL HALBERSLEBEN, Sahara Coal Co., Harrisburg, IL
1957-58	H. C. LIVINGSTON, Truax-Traer Coal Co., Chicago, IL
1958-59	A. G. GOSSARD, Snow Hill Coal Corp., Terre Haute, IN
1959-60	H. C. McCOLLUM, Peabody Coal Company, St. Louis, MO
1960-61	STUART COLNON, Bell & Zoller Coal Co., Chicago, IL
1961-62	ROBERT J. HEPBURN, United Electric Coal Co., Chicago, IL
1962-63	JOHN P. WEIR, Paul Weir Co., Chicago, IL
1963-64	E. T. (Gene) MORONI, Old Ben Coal Corp., Benton, IL
1964-65	JOHN W. BROADWAY, Bell & Zoller Coal Co., Chicago, IL
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1968-69	CLAYTON F. SLACK, Sahara Coal Co., Inc., Chicago, IL
1969-70	JOSEPH Q. BERTA, Truax-Traer Coal Co., Pinckneyville, IL
1970-71	R. F. DONALDSON, United Electric Coal Co., Chicago, IL
1971-72	CECIL C. BAILIE, Old Ben Coal Corp., Benton, IL
1972-73	E. MINOR PACE, Inland Steel Co., Sesser, IL
1973-74	ARTHUR L. TOWLES, Zeigler Coal Co., Johnston City, IL
1974-75	DALE E. WALKER, Southwestern Illinois Coal Corp., Percy, IL
1975-76	M.V. (Doc) HARRELL, Freeman United Coal Mining Co., Chicago, IL
1976-77	JOHN J. SENSE, Tosco Mining Corp., Pittsburgh, PA
1977-78	BILL F. EADS, Monterey Coal Co., Collinsville, IL
1978-79	WILLIAM E. WILL, Peabody Coal Co., Evansville, IN
1979-80	CHARLES E. BOND, Consolidation Coal Co., Springfield, IL
1980-81	WALTER S. LUCAS, Sahara Coal Co., Inc., Harrisburg, IL
1981-82	JACK A. SIMON, Illinois State Geological Survey, Urbana, IL
1982-83	H. ELKINS PAYNE, AMAX Coal Co., Indianapolis, IN
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1985-86	DAVID A. BEERBOWER, Freeman United Coal Mining Co., Mt. Vernon, IL
1986-87	MACK H. SHUMATE, Zeigler Coal Co., Fairview Heights, IL
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1988-89	GEORGE L. MAY, Monterey Coal Co., Carlinville, IL
1989-90	RICHARD R. SHOCKLEY, Illinois Department of Mines & Minerals, Springfield, IL
1990-91	DAN G. WOOTON, White County Coal Corp., Carmi, IL
1991-92	MICHAEL K. REILLY, Zeigler Coal Co., Fairview Heights, IL
1992-93	J. ROBERT DANKO, Peabody Coal Co., Marissa, IL

*Affiliations listed at time of presidency.

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1892-95	JOHN S. LORD, Chicago and Kansas City Coal Co.
1895-11	Institute inactive
1912-23?	MARTIN BOLT, Illinois Department of Mines and Minerals, Springfield, IL
1923?-29	FRANK R. TIREE, St. Louis, MO
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1954-63	GEORGE M. WILSON, Illinois State Geological Survey, Urbana, IL
1963-68	JACK A. SIMON, Illinois State Geological Survey, Urbana, IL
1968-75	M. E. HOPKINS, Illinois State Geological Survey, Urbana, IL
1976-78	HAROLD J. GLUSKOTER, Illinois State Geological Survey, Urbana, IL
1978-	HEINZ H. DAMBERGER, Illinois State Geological Survey, Champaign, IL

The *Bylaws* of the Illinois Mining Institute were last published in the 1992 Proceedings, pages, 170-173.

LIST OF HONORARY MEMBERS*

Listed are honorary members from the beginning of the Institute as far as our records revealed. Honorary members were not approved or elected every year. According to the IMI Constitution and Bylaws adopted June 24, 1913, Article II, Section 2: "*Any person of distinction in mining may be elected an honorary member of the Institute by two-thirds vote....*" In 1983, this section of the Constitution was amended to: "*Annually, one or more members recommended by a committee and approved by the Executive Board, who has rendered outstanding service to the Illinois Mining Institute, and thereby to the coal industry of the state, may be elected as an Honorary Member with dues being waived.*"

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Hugh Murray, Equality, IL
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1932 Thomas R. Stockett, Spring Canyon Coal Co., Spring Canyon, UT
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Eugene McAuliffe, Union Pacific Co., Omaha, NB
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1940 F. E. Weissenborn, Illinois Coal Operators Association, St. Louis, MO
1945 J. A. Jefferis, Illinois Terminal Railroad, St. Louis, MO
W. J. Jenkins, Consolidated Coal Co., St. Louis, MO
1948 J. W. Starks, Illinois Department of Mines & Minerals, Springfield, IL
L. E. Young, Mining Engineer, Pittsburgh, PA
1949 John E. Jones, Old Ben Coal Corp., West Frankfort, IL
F. S. Pfahler, Superior Coal Co., Chicago, IL
B. E. Schonthal, B. E. Schonthal Co., Inc., Chicago, IL
Paul Weir, The Paul Weir Co., Chicago, IL
D. D. Wilcox, Superior Coal Co., Gillespie, IL
1955 George C. McFadden, Carmac Coal Co., Chicago, IL
1958 D. W. Buchanan, Jr., Old Ben Coal Corp., Chicago, IL
1961 Fred S. Wilkey, Illinois Coal Operators Assoc., Chicago, IL
1963 George M. Wilson, Illinois State Geological Survey, Urbana, IL
1965 M. M. Leighton, Illinois State Geological Survey, Urbana, IL
1966 Carl T. Hayden, Sahara Coal Co., Chicago, IL
1968 John W. Broadway, Ben & Zoller Coal Co., Chicago, IL
Jack A. Simon, Illinois State Geological Survey, Champaign, IL
1969 B. H. Schull, Benkilley Mining Co., Marion, IL
1970 J. W. MacDonald, Consultant, Benton, IL
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Honorary Members, *continued*

1973 Paul Halbersleben Sahara Coal Co., Inc., Harrisburg, IL
1974 G. Clayton Ball, The Paul Weir Co., Evanston, IL
1975 C. C. Conway, National Mine Service, Nashville, IL
M. E. Hopkins, IL State Geological Survey, Urbana, IL
1976 Nate G. Perrine, Peabody Coal Co., St. Louis, MO
1978 Cletus A. Broecker, Amax Coal Co., Indianapolis, IN
1979 Thomas L. Garwood, Freeman Coal Mining Co., Benton, IL
1980 George C. Lindsay, Coal Mining & Processing, Chicago, IL
1981 Joseph Schonthal, J. Schonthal & Assoc., Highland Park, IL
1982 J. A. Bottomley, Sahara Coal Co., Inc., Harrisburg, IL
1983 Betty Conerty, Illinois Mining Institute, Urbana, IL
Joe Craggs, Peabody Coal Co., Taylorville, IL
1984 E. T. Moroni, Old Ben Coal Co., Herrin, IL
1984 E. Minor Pace, Inland Steel Coal Co., Mt. Vernon, IL
1985 Russell T. Dawe, Inland Steel Coal Co., Valier, IL
1986 E. H. Roberts, Inland Steel Coal Co., Mt. Vernon, IL
1987 William E. Will, Peabody Coal Co., St. Louis, MO
1988 Lanny Bell, Roberts & Schaefer Co., Chicago, IL
1989 M. V. (Doc) Harrell, Freeman United Coal Mining Co., Chicago, IL
1990 John C. Bennett, Peabody Coal Co., Belleville, IL
1991 Richard R. Shockley, Center for Research on Sulfur in Coal, Carterville, IL
1992 Walter E. Brandlein, Roberts & Schaefer Co, Chicago, IL
Dayton McReaken, Zeigler Coal Co., Fairview Heights, IL
Thomas Sadler, Old Ben Coal Co., Benton, IL
Raymond C. Taucher, Consolidation Coal Co., Pinckneyville, IL
1993 Fred Rice, Peabody Coal Co., Retired

*Affiliations listed are at time of award.

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PROCEEDINGS
OF THE
ILLINOIS MINING INSTITUTE

ANNUAL MEETING
101st Year
Collinsville, Illinois
Thursday and Friday, September 23-24, 1993

The opening session of the 101st Annual Meeting of the Illinois Mining Institute was convened at 10:00 A.M., Thursday, September 23, 1993, in the La Salle Room of the Gateway Center. J. Robert Danko, President of the Institute, presided.

OPENING

J. Robert Danko: I would like to welcome everybody today. Jack Tisdale of MSHA is going to be our guest speaker today at the luncheon. I look forward to his presentation. The exhibit hall will be open from 1:00 P.M. to 8:00 tonight. We have many good exhibits, and I hope you people take time to look at them. This year, we will keep them open longer to give people from the mines time to get down here. However, the work stoppage, I think, will keep a lot of people from coming. The fellowship hour will be held in the exhibit hall from 6:00 to 8:00 this evening. Also, we are selling raffle tickets for two airplane tickets to anywhere in the continental United States; the only places you can't go are Alaska and Hawaii. This will help our scholarship program, so buy as many tickets as you can.

We have a good program here this morning about clean coal technology in Illinois, and Richard Shockley will chair this meeting today. He is filling in for Kim Underwood who is unable to be here. Mr. Shockley is Director of the Illinois Clean Coal Institute. He is the past director of the Department of Mines and Minerals. He is an engineering graduate from Virginia Polytech and is a registered professional engineer in three states. With that, we will turn it over to Mr. Shockley.

President J. Robert Danko opens the 101st Annual Meeting.

TECHNICAL SESSION I: CLEAN COAL TECHNOLOGIES FOR ILLINOIS COAL

Richard Shockley: Thank you, Bob. When Mr. Underwood called to say he's not going to be here, would you please chair the session, I didn't have a lot of questions to ask. I said what most of you would say, "Sure, I'd be glad to."

After the papers, we will have time for questions, please use one of these mikes here across the front. We record our program and want to get questions recorded in the minutes.

Mr. Underwood was supposed to introduce me today, but since Bob has already done it, we'll get right into the session. We have a panel here. I'll be speaking for the Illinois Clean Coal Institute. Guy Gilbert will be representing the state's Energy and Natural Resources Department. We have Paul Musser with the U.S. Department of Energy, Mr. Hunter with Peabody Coal Co., and Ben Yamagata from the Washington Coal Coalition. So we have a good cross-section of people involved in the coal industry with the research that has been going on, with things that may give you some projection of what they see in the future. If we have any time at the end of the session, if you do not get your questions in after each paper, we'll take what time we have left to have a panel discussion, and you can direct your questions to anyone of the panelists here that will have spoken today. I will introduce each one of them as we begin.

I would like to share with you this morning a few minutes about the Illinois Clean Coal Institute.

ILLINOIS CLEAN COAL INSTITUTE'S HIGH SULFUR COAL UTILIZATION RESEARCH

RICHARD R. SHOCKLEY
Illinois Clean Coal Institute
Carterville, Illinois

ABSTRACT

This paper is an overview of the state Coal Research Program, entitled "Center for Research on Sulfur in Coal" (CRSC) legislated in the early eighties with the objective of exploring novel technologies for removing sulfur from the high sulfur Illinois Basin coals. About 90 percent of the approximately 60 million annual tons of coal produced in Illinois is being shipped to electric utilities in 12 states from Florida to Wisconsin. The high sulfur coal in the Illinois Basin has been the focal point of many myths and imaginations created by individuals and environmental interest groups concerning the generation of acid rain. In August of 1992, the CRSC name was changed to the Illinois Clean Coal Institute (ICCI) with a broadened objective to include any and all research that would support new markets and the continued utilization of high sulfur coal as the base energy fuel for electric utilities.

INTRODUCTION

In the late 1970s, the controversial acid rain issue discussions moved from problems of the local communities to the New England area and began to influence the relationships between Canada and the United States. As this happened, environmentalists became alarmed and began to hypothesize that the high sulfur Illinois Basin coal was the source of energy that generated the sulfur dioxide (SO_2) causing the contamination (acid rain) of many streams and lakes north and east of Illinois. State legislators of Illinois, recognizing that a stable coal industry greatly enhances the economy of the state, became concerned about the future and continued use of Illinois basin coal. They established and funded the Illinois Coal Development Board (ICDB) in 1982. The ICDB was to oversee a program of research and novel technology development to assure new and continued markets for the high sulfur coals in the basin. State funding for this research program is through the budget of the Illinois Department of Energy and Natural Resources (ENR).

ILLINOIS COAL DEVELOPMENT BOARD

The director of ENR serves as chairman of the ICDB with the membership consisting of representatives from both chambers of the Illinois General Assembly, director of the Illinois Department of Mines and Minerals , coal industry, United Mine Workers of America, electric utility, Illinois manufacturing, public interest, finance, and the Illinois Department of Commerce and Community Affairs. Several of the present members have been a part of ICDB since its inception which gives depth and continuity to the state research program. Staff support for the ICDB comes from ENR's Office of Coal Development and Marketing.

Technical review and support to the ICDB is provided by the Program Committee composed of a chair and 12 voting members appointed by the ICDB. The Program Committee consists of representatives from the U.S. Department of Energy, coal producers, utility industry, and organizations participating in many areas of coal research.

The state research program also receives direction and input on research ideas from the Coal Energy Advisory Committee, which is made up of coal producers and consumers, and the Clean Coal Research Association, representing the academic community and coal research organizations across the state of Illinois.

ILLINOIS COAL RESEARCH PROGRAM

The ICDB established the Center for Research on Sulfur in Coal (CRSC) in 1982 with the accounts payable function performed by the University of Illinois in Urbana. The physical offices were located within the Illinois State Geological Survey. Dr. William L. Wells was the first full-time director and served from June 1, 1983 through 1990. To remove themselves from the close association of the Geological Survey, which was receiving several research grants each year, the CRSC moved into private offices off-campus in February, 1986. A second move was made in 1989 when the present "Coal Development Park" complex near Carterville, Illinois, became available from the federal government.

The initial thrust of this program was organized through the Illinois State Geological Survey, the University of Illinois at Urbana-Champaign, and Southern Illinois University at Carbondale. Three additional organizations, the University of Illinois at Chicago, Northwestern University, and Argonne National Laboratory were included the second year. As the years progressed, all universities and organizations in Illinois with research capabilities were invited to participate in the program.

ILLINOIS BASIN COAL SAMPLE PROGRAM

The Illinois Basin Coal Sample Program was established in 1983 to provide standard samples from various points throughout the basin. These standard reproducible coal samples provide an avenue for comparison of results among individual researchers and laboratories. The sample bank presently has ten Illinois samples and two Indiana samples, all maintained by the Illinois State Geological Survey in its Applied Research Laboratory in Champaign, Illinois. A newly-printed brochure covering general information, average analyses, and minor and trace elements of each coal is available by contacting Dr. Carl Kruse, program manager.

The passing of the Clean Air Act Amendments of 1990 required reductions of sulfur dioxide (SO_2) and nitric oxides (NOx) emissions by the year 1995, with additional restrictions by the year 2000. Also, the ICDB's new future vision recognized that the research emphasis should move beyond SO_2 and NOx to include ozone (smog), carbon monoxide, particulate matter, hazardous air pollutants and management of coal combustion waste. With this new vision came the name change from "Center for Research on Sulfur in Coal" to "Illinois Clean Coal Institute" with a broad vision of needed research and a new motto of "Energy Research for a Cleaner Environment."

Figure 1 shows research areas under which the proposals funded by the annual ICCI request for proposals fall , and figure 2 shows the distribution of funds awarded by priority since 1983.

For the past several years, ICCI has increased its efforts to leverage the state research funds by cooperating and supporting (pennies for dollars) multimillion dollar projects with the U. S. Department of Energy, U.S. Environmental Protection Agency and other large research institutes. We not only have received vital research data quicker but have influenced a larger percentage of the proposed research sites and studies to be performed in Illinois using Illinois Basin coals.

RESEARCH DIRECTION

Solicitation for coal research ideas. This solicitation for novel research ideas is sent to over 400 individual researchers and research organizations prior to the preparation of the Program Implementation Plan and/or the Request for Proposals for the new year. We normally receive 100 plus responses and each idea is evaluated on its pertinence to address a need of the Illinois Basin coals.

Program Committee. Chaired by a member of ENR's Office of Coal Development and Marketing, this committee has 12 voting members appointed by the ICDB and representing DOE, research organizations and the industries involved in coal production and consumption. Up to six of the 12 members may be from institutions participating in coal research. Three appointed members shall be from the three qualified institutions that conducted the largest dollar volume of coal research funded by the ICDB during the preceding two years. The ICDB leans heavily on this committee for direction and priority of research. The Program Committee reviews for concurrence with the ICCI's biennial Program Assessment Report prior to submittal to the ICDB for approval.

Coal Energy Advisory Committee. This committee represents Illinois Basin coal producers and consumers who are aware of the issues at their individual operations brought about by the Clean Air Act Amendment of 1990. These individual issues could be pertinent to all operations consuming Illinois Basin coal and are considered by the ICCI's program for the next year.

Clean Coal Research Association. This committee represents the interest of the not-for-profit institutions in Illinois that are conducting clean coal research relating to the ICCI research program. Each institution which is a member has one board member. The ICCI director shall serve as an *ex officio* member of the Board with voice but no vote.

The ICCI considers the advice, guidance and research directions from these various committees essential for the state research program to be sensitive to the needs of the Illinois Basin. The research priorities changed from time to time. With the passing of the Clean Air Act Amendments in 1990, it was apparent that our research efforts must address those issues that were immediate concerns to the coal producer and consumer (fig. 2).

PRIORITY AREA	RANGE OF YEARLY PROJECTS	TOTAL NUMBER	$ AWARDED
Fuels and Chemicals	3-11	81	7,681,402
Coal Cleaning	3-16	100	8,316,783
Characterization	2-9	58	3,723,790
Combustion	1-8	58	4,271,683
Gas Cleanup	1-6	22	2,241,711
Related Studies	1-8	35	2,349,957
Other	1-2	8	273,098
	TOTAL	362	$28,858,424

Figure 1. ICCI research projects funded by priority area, 1983 to 1994.

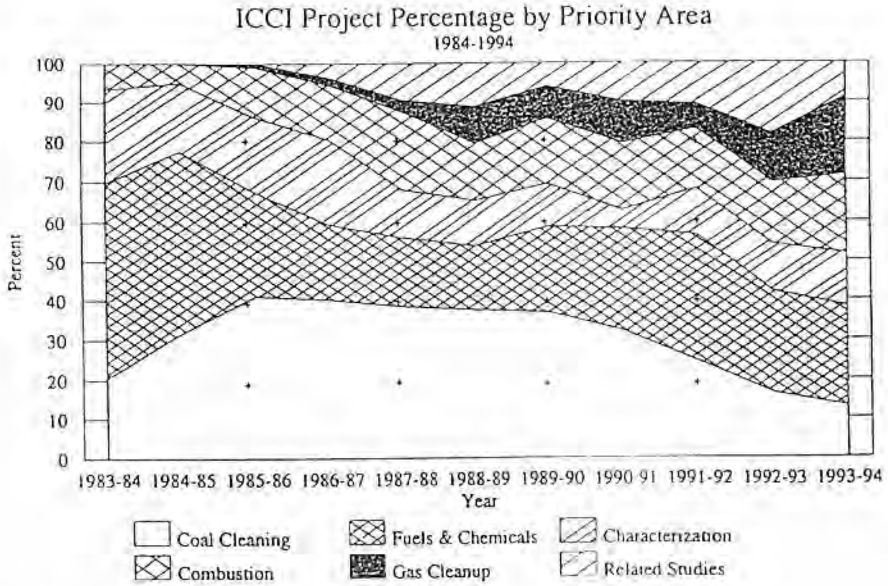


Figure 2. ICCI project percentage by priority area, 1984 to 1994.

PROPOSAL EVALUATION AND SELECTION

Once the Program Implementation Plan receives final approval from the ICDB, the ICCI staff prepares the request for proposals solicitation which is mailed to approximately 400 individual researchers and research organizations internationally. Annually, we receive about 100 proposals which are reviewed by the ICCI project managers to make sure they are responsive to windows of research as requested in the request for proposals.

Proposal Evaluation. Every research proposal acceptable to the ICCI staff is reviewed by at least three independent peer reviewers who have expertise in the particular area of research. Each group of peer reviewers then meets with the ICCI staff at Carterville and collectively reaches consensus on each proposal. The peer rating of each proposal is a guideline used by the ICCI staff in making their final recommendations to the ICDB for funding.

ICCI RESEARCH ACCOMPLISHMENTS

- *ISGS High Surface Area Hydrated Lime,* to remove SO_2 from coal combustion gases. Flue gas desulfurization also includes investigating UV light enhanced corona discharge across flue gas to convert SO_2 to SO_3 for water scrubbing to form sulfuric acid and with potential conversion of NOx back to nitrogen and oxygen. This would eliminate the generation of scrubber sludge.
- *PSI/Destec Energy/DOE project* in Terre Haute, Indiana. ICCI studies were instrumental in making sure Illinois Basin coals were tested in this gasifier.
- *Advanced Column Flotation Process* for recovery of clean coal from coal preparation plant effluent and ponded materials.
- *Non-destruction Methods for Determination of Organic Sulfur in Coal.*
- *Coal/Sorbent Carbonated Pellets* as Compliance Fuels.
- *Mild Gasification* of Illinois coals to produce liquids, gaseous and solid products including the Methoxycoal process.
- *Lightweight and ultra-lightweight aggregates from gasification slags.* Road fill materials using a mixture of scrubber sludge, fly ash and bottom ash with no leaching problems.
- Metal wastage problems in fluidized-bed combustors (FBC).

FUTURE TRENDS

Present regulations for SO_2 and NOx and proposed regulations on air toxins, global warming, particulate matter and combustion waste will all need to be considered as the ICCI/ICDB agree on research priorities for the new year. Input from all the advisory groups and review of the research ideas submitted from across the nation will be weighed as the ICCI makes preparation for the next request for proposals.

The utilities with their present emission allowances are waiting for the approval of the regulations for hazardous air pollutants, ozone and possible other controls prior to making firm decisions on how best to comply with the environmental standards. For this reason, ICCI's posture must continue to be to perform research on both pre-combustion coal cleaning and post-combustion flue gas cleanup. Another area that warrants more attention is continued studies on the management and utilization of the residues from coal combustion.

We, too, are concerned with maintaining a safe environment for the generations to come. Illinois has a vast natural resource in its coal reserves, and new technology is the answer to continued use and rebuilding of the coal industry in the Illinois Basin.

Scott Williams: I'm with Egyptian Energies. Is ICCI involved with the natural gas-coal combined firing project that is going on at Electric Energies?

Richard Shockley: We have some studies on the combined use of coal, methane and oxygen. Whether it is that particular one or not, Scott, I cannot tell you. But some of our people can.

Let's go on to the next paper. Mr. Underwood was supposed to be here this morning, but could not make it. He asked in his stead Guy Gilbert who works closely with Mr. Underwood. Guy has worked for several coal companies across the state and for the Illinois Commerce Commission. He is now a project engineer with the Illinois Department of Energy and Natural Resources. He works very closely with the ICCI to develop our research program.

Guy Gilbert: Thank you, Dick. Good morning. A lot of the things that Mr. Shockley spoke of this morning also hold true for the Office of Coal Development and Marketing. We have a clean coal research development and demonstration program. The Illinois Clean Coal Institute takes care of the research and helps target those technologies that are later developed into demonstration projects.

OFFICE OF COAL DEVELOPMENT AND MARKETING CLEAN COAL RESEARCH, DEVELOPMENT AND DEMONSTRATION

GUY C. GILBERT

Office of Coal Development and Marketing
Illinois Department of Energy and Natural Resources
Springfield, Illinois

INTRODUCTION

This paper is an overview of efforts by the state of Illinois to maintain and develop markets for Illinois high sulfur coal. Since 1978, the state of Illinois has actively sought to develop and expand the uses for Illinois high sulfur coal by funding and promoting various clean coal technologies, also known as CCTs.

MISSION

The mission of the Office of Coal Development and Marketing is to ensure the continued and expanded use of Illinois' coal resources in environmentally safe and economically viable ways. OCDM is committed to assisting the Illinois coal and utility industries to improve the image and utilization of high sulfur Illinois coal. And OCDM is committed to minimizing the economic effects of lost coal revenues while ensuring environmental quality with the use of Illinois coal.

The Illinois legislature over the past fifteen years has continually sought ways through the legislative process to aid in both the promotion and long term vitality of the Illinois coal industry. With the passage by Congress of ever more stringent clean air standards, the Illinois legislature recognized a need for Illinois to develop a pro-active program that would demonstrate CCTs that use Illinois high sulfur coal in environmentally sound and economically efficient ways. That commitment continues today. During 1993, the Illinois legislature and governor signed into law two new public acts that significantly bolster the commitment to the Illinois coal industry. Public Act 88-391 increases funding for Coal Technology Development Assistance to \$10 million, and Public Act 88-472 increases our bond authorization by \$35 million to \$182 million for clean coal demonstration projects.

As a result of this state commitment to the Illinois coal industry, there have been numerous benefits to both the CCT and coal industries. Since 1978, Illinois has co-sponsored 17 clean coal demonstration projects; 12 of these clean coal demonstration projects have been cost-shared by U.S. DOE:

Total state funding:	$ 157.5 million
Total federal funding:	195.1 million
Public and private funds	464.1 million
Total funding	816 million

These investments in Illinois, and more particularly the Illinois coal industries, have provided economic incentives for capital in the state that otherwise would not have existed. Additionally, the seed money provided by the state has attracted substantial amounts of non-traditional investment in Illinois industry. For every 19¢ invested by the state of Illinois there has been a match of 24¢ in federal funds and 57¢ in private industry funding. These investments often create or maintain long term jobs that will provide substantial benefits to the Illinois economy over the years.

DEVELOPMENT

Let us look now a bit more closely at some of the clean coal technologies the state is currently working on for continued development. Research is carried out to identify those ideas that may result in technologies that may prove beneficial to the Illinois high sulfur coal industry. Following a successful research program to identify a technology that would be beneficial, effort is undertaken to then develop the research technology so that it may be best applied to the specific area of the industry for which it was intended. Following successful development, the technology is then demonstrated at a scale sufficiently large to prove the industrial applicability of the technology. Currently, the state is involved in developing two clean coal projects. The high surface area hydrated lime development project seeks to develop an advanced sorbent material that can be used to adsorb SO_2 and can be used either directly in the furnace or within the cool side of the furnace duct work. This material has been researched, developed and produced by the Illinois State Geological Survey. The second development project in which the state is currently involved is the Roto-Filter technology. This is a SOx/NOx/Roxs absorption process researched, developed and produced by Air Purification, Inc.

DEMONSTRATION

Since 1978, Illinois has invested over $150 million in seventeen clean coal demonstration projects. Illinois has been a pioneer in the development of fluidized bed combustion, sponsoring five demonstrations in this field.

While scrubber technology has been in use for over twenty-five years and is a well proven technology, there continue to be advances made concerning certain facets of the technology. Illinois sponsored installation of a Chiyoda CT-121 Thoroughbred scrubber at the University of Illinois' Champaign-Urbana Abbott power station in 1984. This scrubber continues to operate today and has allowed the university to save millions of dollars in fuel costs through the use of high sulfur Illinois coal. Illinois is particularly proud of the fact that this project was the first demonstration of the CT-121 technology in North America and that the United States Department of Energy recently began demonstrating this technology earlier this year (1993).

Besides fluidized bed combustion technology and scrubbers, Illinois has also participated in the demonstration of various other advanced technologies, such as KilnGas, Copper Oxide Sorbent, Duct Sorbent Injection, Low NOx/SOx Burner for Cyclone Boilers, and Integrated Gasification Combined Cycle. Currently, Illinois is involved in six ongoing demonstration projects.

CURRENT PROJECTS

Following is a list of the ongoing Illinois clean coal demonstration projects and the total amount of funding from all project participants:

Gas reburn - sorbent injection	\$37.5 million
Pircon - Peck process	\$8.5 million
IRIS combustor	\$3.5 million
Micronized coal system	\$18 million
Mildgas	\$18 million
Fluidized bed combustion system	\$34 million

Listed below are the three most important factors of each ongoing clean coal technology demonstration project that Illinois is currently funding—project title, the prime contractor or firm actually conducting the demonstration and the project objectives that we expect to achieve:

Gas Reburn Sorbent Injection

Prime contractor: Energy & Environmental Research Corp.

Project objectives:

- Demonstrate 50% SO_2 and 60% NOx reduction using GR-SI technology on a T-fired and cyclone fired boiler.
- Demonstrate that the above can be accomplished in a practical cost-effective manner.

Pircon - Peck Process

Prime contractor: Resources and Agricultural Management, Inc. (RAM)

Project objectives:

- Demonstrate 90% SO_2 and optimizeD NOx reduction using the PPP.
- No waste product.
- The system output will be a salable fertilizer product.
- Fertilizer and emission credit sales will exceed flue gas cleaning costs.

Inertial Reactor with Internal Separation

Prime contractor: Tecogen, Inc.

Project objectives:

- Produce coal-water slurry fuel.
- Integrate combustor technology with a conventional fire tube boiler.
- Develop and demonstrate a fully operational prototype system.
- Conduct economic and market feasibility studies.

Micronized Coal Retrofit at Rochelle Municipal Utilities

Prime contractor: TCS, Inc.

Project objectives:

Annual reductions on a before-and-after basis

Item	Annual percentage reduction
Coal consumption	1.3%
Particulate emissions	90.7%
NOx emissions	19.2%
SOx emissions	50.0%
CO emissions	87.3%

Mildgas

Prime contractor: Kerr-McGee Coal Corp.

Project objectives:

- Design and construct a 24-ton/day process development unit (pdu).
- Operate pdu to obtain process performance data for design scaleup.
- Obtain large batches of coal-derived co-products for industrial evaluation.
- Prepare a detailed design of a demonstration unit.
- Develop plans for commercialization.

Fluidized Bed Combustion System

Project participants:

Illinois Department of Energy and Natural Resources
Illinois Capital Development Board
Southern Illinois University at Carbondale

This project has only recently been funded and is in the initial stages of the action plan.

This cogeneration power plant addition will likely add 3,000 kw of electric generation and 120,000 lbs/hr of steam capacity to the university power plant.

BENEFITS

The OCDM is to promote and maintain the Illinois high sulfur coal industry. Illinois seeks to preserve and promote employment and revenues; Illinois' commitment to clean coal technologies will protect 3 million tons of coal annually by 1995, saving nearly 550 direct mining jobs and 2,060 spin-off jobs. The primary use for Illinois coal is that of electric power generation. Illinois' clean coal programs will add over 293 Megawatts of new energy generation capacity to the state. This energy is worth over $39 million. To date, Illinois' clean coal programs have burned more than 13 million tons of coal valued at more than $311 million.

SUMMARY

In summary, the effort of the Illinois legislature and govenor's office, through the Illinois Department of Energy and Natural Resources, Office of Coal Development and Marketing, has resulted in substantial benefits to the state economy. As a result of current and ongoing projects, these efforts produce $86 million in wages each year, $79 million in coal sales each year and net new electricity generation worth $39 million. These numbers are expected to be maintained for the next twenty years and will likely grow as the state continues to invest in clean coal technologies. Illinois' clean coal programs and research have kept Illinois at the forefront of clean coal technology, research and demonstration, preserving the environment, fueling industry and protecting jobs.

Richard Shockley: Thank you, Guy. Our next speaker has been a test engineer for Appalachian Power Company. He has been a control design engineer for Hercules, Inc., a utility plant superintendent for the U.S. Department of Energy and Human Services and has been involved in the coal research development. At the present time, he is Program Manager for the Flue Gas Cleanup program for the U.S. DOE. He will be speaking on the future of clean coal technology in the United States. Let's welcome Paul Musser.

Paul Musser: Thank you, Dick. I'm glad for the opportunity to speak to you here this morning.

THE FUTURE OF CLEAN COAL TECHNOLOGY IN THE UNITED STATES

PAUL J. MUSSER
U.S. Department of Energy
Washington, D. C.

INTRODUCTION

On behalf of the Acting Assistant Secretary of Fossil Energy, I would like to thank Mr. Damberger and the Program Committee for asking me to present the DOE view on the future of coal and coal utilization technologies in the overall mix of energy resources.

DISCUSSION

As we all know, coal is the primary fuel source used for electrical power generation in the U.S. today, and will probably remain so for at least the next forty years. Our projections (fig. 1) indicate that coal use will increase by approximately 50 percent by the year 2010. Nevertheless, the Department of Energy's strategic plan for coal recognizes that significant advances in coal utilization technology will be necessary to support this expanded use of coal if the environment is to be protected.

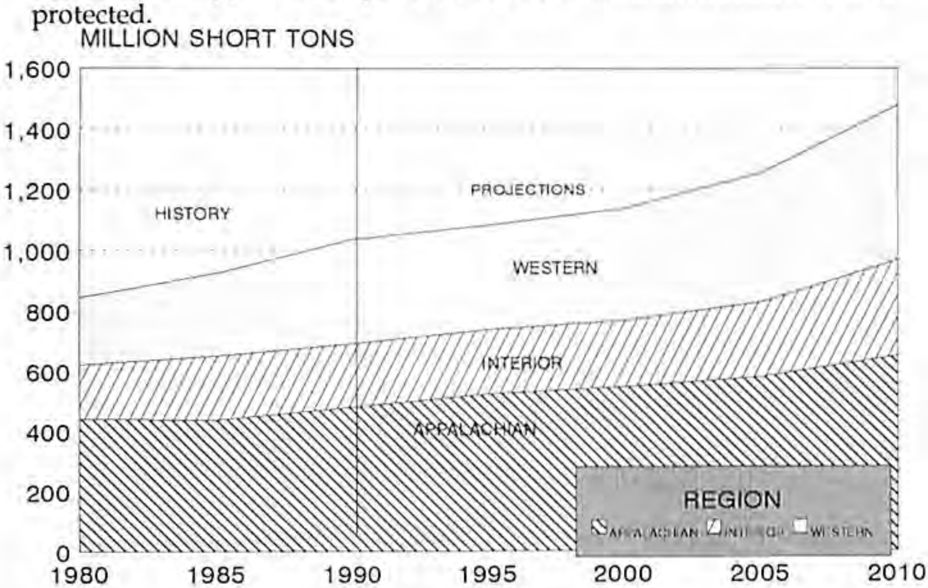


Figure 1 - Coal production growth, 1980 to 2010.

Figure 2 shows recoverable resources of approximately 260 million short tons, which are more than adequate to meet this projected need. Coal producers are ready, willing and able to provide for this increase in production. As is obvious from the current mix of energy resources used in electrical energy production (fig. 3), unless we suddenly decide to abandon our current system for power production and somehow replace the billions of dollars in capital investment now in place, coal will continue to play a major role in the nation's economy for the foreseeable future.

Coal represents our most logical source of energy for electric power generation and should enjoy a healthy growth over the next forty years. Does this mean that today's markets and uses will remain the same during this time? Not at all. This increased use has to take place while the nation is enacting and implementing ever tighter pollution control requirements. Any expanded coal use must confront and address additional concerns that include potential air toxic emissions, global warming, and public opinion constraints. This will involve not only the suppliers and users of coal, but governmental, civic, and health groups as well. Existing equipment will have to remain in use until it is replaced because its capacity is needed, but it will have to be used in compliance with the environmental regulations. New plants must become increasingly cleaner and more efficient as the economy expands under the emissions cap established by the Clean Air Act Amendments of 1990. How to do this is the real challenge facing coal producers and users, as well as their regulators and critics. It will require the cooperation and participation of each, who, at some point, must recognize that they are either a part of the problem or a part of the solution. Ultimately, the public must decide what it can and will accept in cost for what it has demanded in quality.

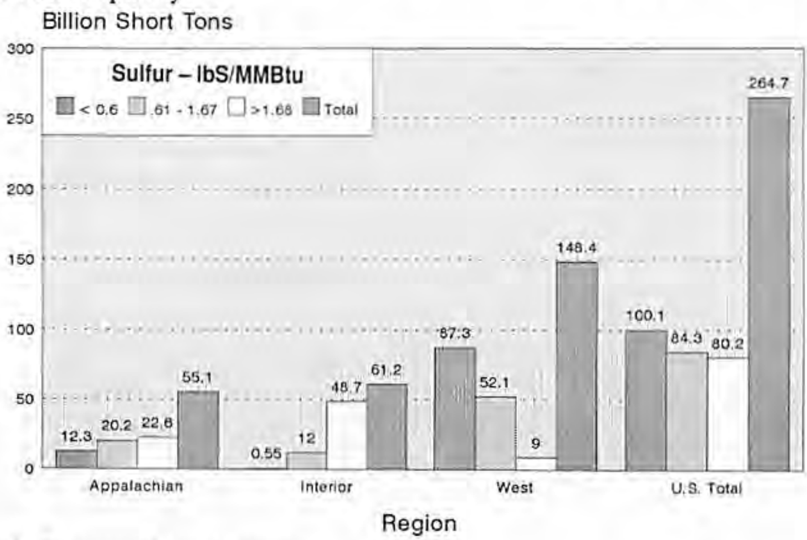
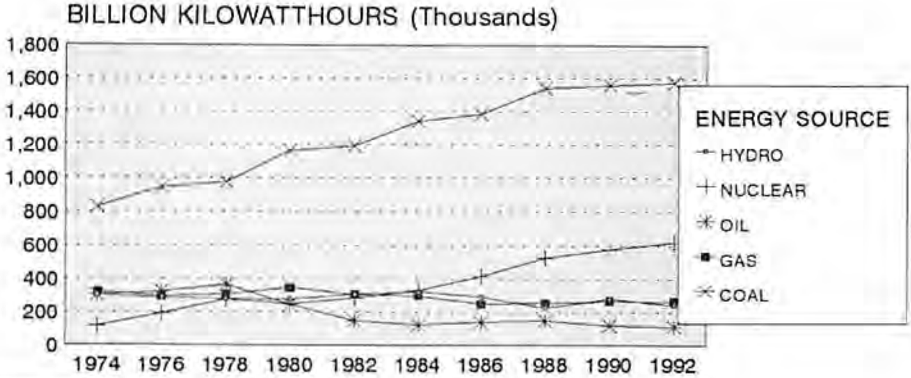


Figure 2. Recoverable coal resources.



	1974	1976	1978	1980	1982	1984	1986	1988	1990	1992
HYDRO	301	284	280	276	309	321	291	223	280	240
NUCLEAR	114	191	276	251	283	328	414	527	577	619
OIL	301	320	365	246	147	120	137	149	117	111
GAS	320	295	305	346	305	297	249	253	264	264
COAL	828	944	976	1,162	1,192	1,342	1,386	1,541	1,560	1,576

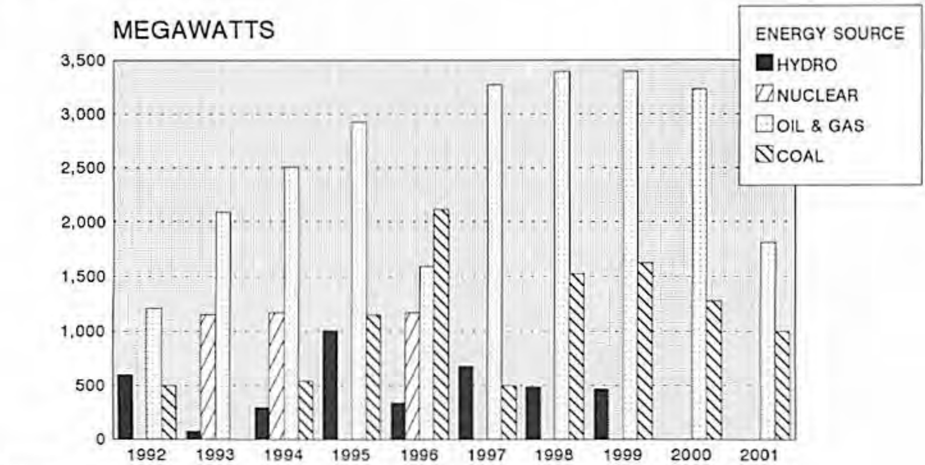
YEAR

Figure 3. Electrical generation by fuel source.

The utility industry is now examining its options for complying with the new environmental regulations. Projections show that a significant portion of the short term SO_2 emissions reductions required by the amendments will be accomplished by fuel switching. However, a much greater and long term environmental challenge lies in the provisions of the amendments that cap total U.S. SO_2 emissions at 10 million tons/year. Advances in clean coal utilization technology will be required if industry is to comply with this cap without imposing increasingly stringent financial burdens on consumers in an expanding economy.

The short term need (between now and the year 2001) for additional generating capacity expansion under the cap is apparently being accomplished by the increased use of gas turbines (fig.4). This is possibly the result of decisions made by the utilities to provide for increased demand while waiting for the final definition of the legislation in 1990. As can be seen, orders for gas turbine systems appear to peak at about 1998. After the year 2000, however, projected increases in demand for electrical energy will require the increased use of coal as discussed earlier.

To aid in the development of the technology required for these advances, DOE's coal technology research, development and demonstration program has as its highest priority the development of advanced power systems that can meet the anticipated environmental and economic demands of the twenty-first century. The strategy which establishes this priority has evolved over the past twenty years as the result of various research and development projects in many related fields or areas of development, some that have been successful, many that have not. Figure 5 shows the key strategic objectives that now govern this effort.



HYDRO	600	73	300	1,008	342	678	484	466	0	0
NUCLEAR	0	1,150	1,170	0.7	1,170	0.5	0.5	0.7	0.2	0.6
OIL & GAS	1,211	2,085	2,509	2,928	1,588	3,269	3,393	3,392	3,229	1,810
COAL	498	0.2	540	1,151	2,114	500	1,523	1,620	1,275	1,000

YEAR

Figure 4. Planned utility additions by energy source.

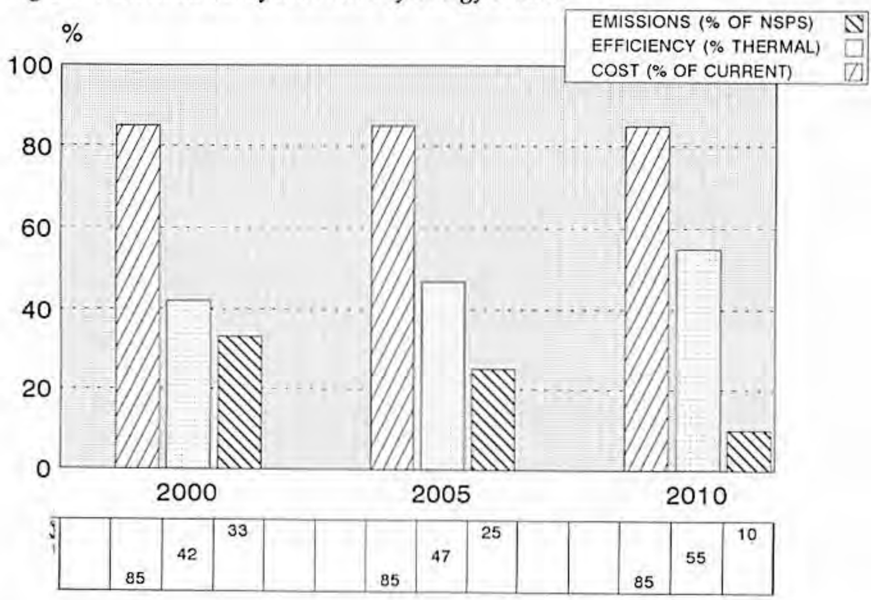


Figure 5. Strategic objectives–high efficiency power systems.

The initial targets of this strategy are currently being achieved in the Clean Coal Technology Demonstration Program (fig. 6). This program is a cost-shared, government-industry partnership, which brings to the threshold of commercial readiness a new generation of coal utilization technology options that will enable private utilities to assess the technical and economic potential of each in making their own determination as how best to proceed.

The Clean Coal Technology Demonstration Program consists of five rounds of solicitations. Figure 7 shows where the program is at this time. Five rounds have been completed, resulting in forty-one awards and representing a total government-industry investment of $4.7 billion. Throughout this program, private sector partners have contributed more than 60 percent of the costs of these first-of-a-kind projects.

- COMPLETED FIVE SOLICITATIONS
- 41 PROJECTS IN THE PROGRAM
- TOTAL PROGRAM VALUE - $4.7 BILLION
- DOE COST SHARE - $1.8 BILLION (38%)
- 6 IGCC PROJECTS - TOTAL ESTIMATED COST $1.59 BILLION - DOE SHARE $771 MILLION (48.5%)

Figure 6. Overview of clean coal technology demonstration program.

- GOVERNMENT AND INDUSTRY CO-FUNDED TECHNOLOGY DEMONSTRATIONS
- WILL DEMONSTRATE A NEW GENERATION OF COAL UTILIZATION PROCESSES
- LARGE ENOUGH FOR SCALE UP TO COMMERCIAL
- MAJOR INITIATIVE OF THE NATIONAL ENERGY STRATEGY

Figure 7. Status of clean coal technology demonstration program.

Within this program, a major method for addressing future needs for electrical energy involves advanced power systems using IGCC power plants in new and repowering applications. Figure 8 shows how this technology could conceivably be used to provide for capacity expansion within the environmental constraints of the emissions cap in two different scenarios: greenfield applications and repowering applications. A comparison of this technology with pulverized coal-fired power plants with emission controls is also provided. The relative cost and efficiency of this technology compared to pulverized coal combustion is shown in figure 9.

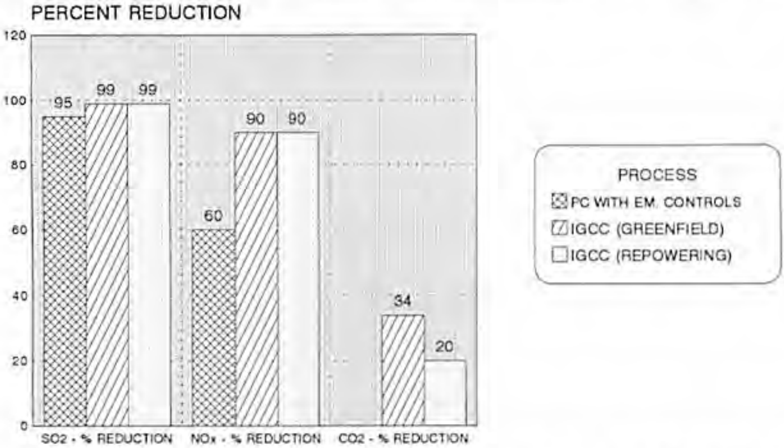


Figure 8. Clean coal technology demonstration program, projected performance of capacity for IGCC power plants in greenfield applications and repowering applications.

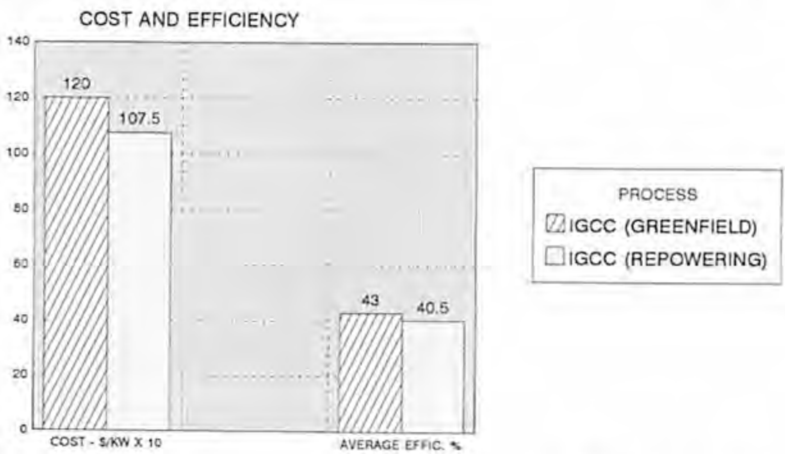


Figure 9. Cost and efficiency, projected performance of IGCC power plants compared to pulverized coal-fired power plants.

Further details on the six IGCC projects included in the Clean Coal Technology Demonstration Program, as well as the rest of the forty-one projects involved, are available in the CCT Demonstration Program Update that was issued in February, 1992; copies are available from DOE and a new update will be available shortly.

Based on data obtained from these demonstrations, projections of performance of commercial units have been made and are shown in figure 10. These projections indicate that emission rates can be maintained or lowered as capital costs are reduced and efficiency is increased. Figure 11 shows how developmental activities can be expected to further improve the performance of these coal-based, combined cycle power systems in the future.

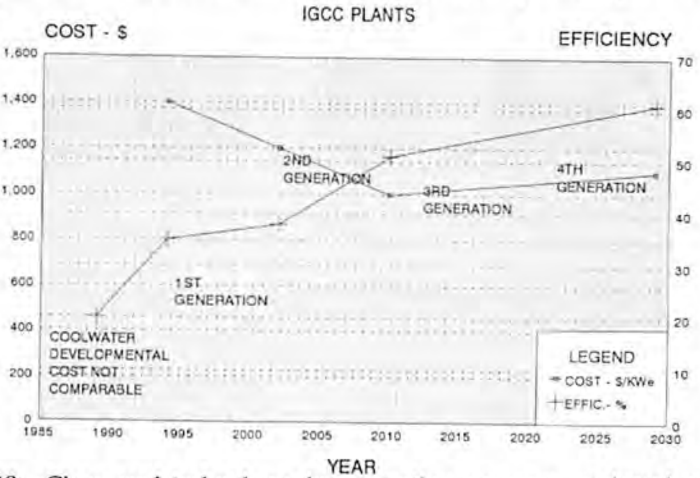


Figure 10. Clean coal technology demonstration program, projected cost and efficiency of commercial units.

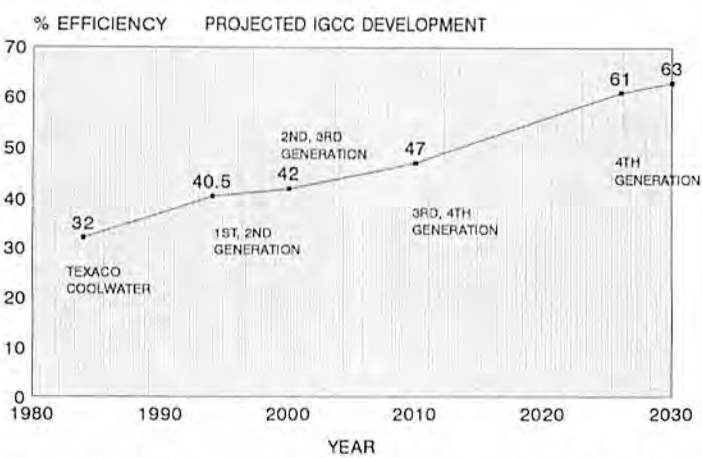
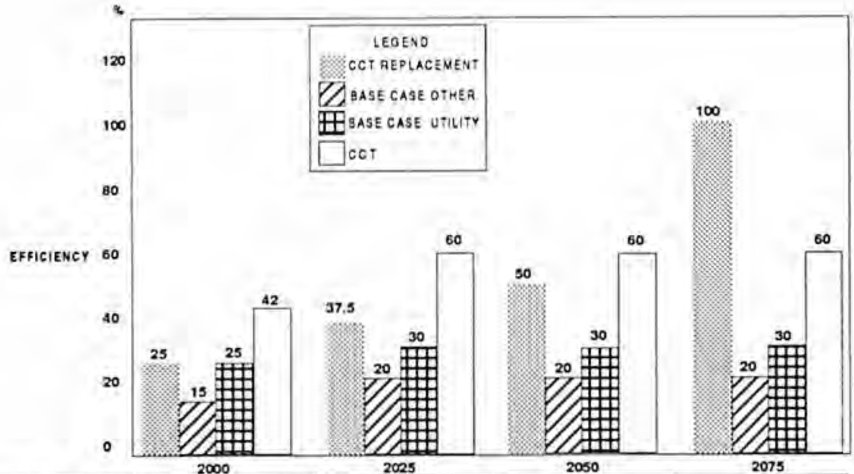


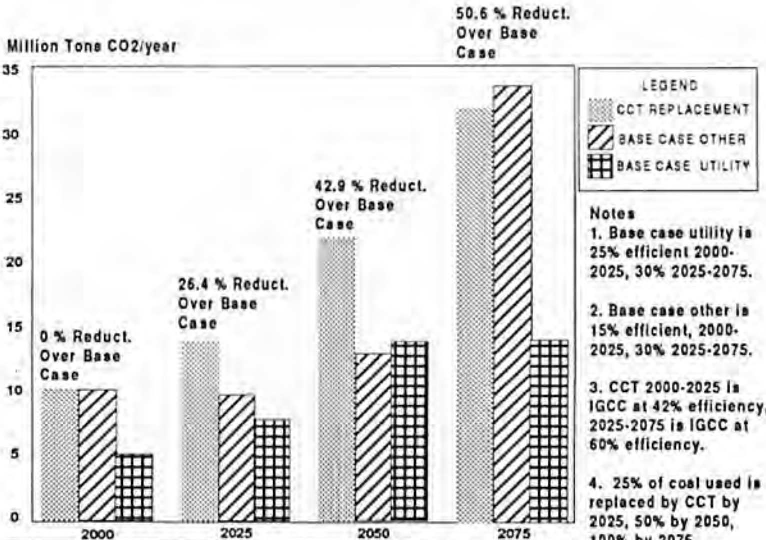
Figure 11. Projected performance of coal-based, combined cycle power systems.



	2000	2025	2050	2075
CCT REPLACEMENT	25	37.5	50	100
BASE CASE OTHER	15	20	20	20
BASE CASE UTILITY	25	30	30	30
CCT	42	60	60	60

YEAR

Figure 12. Efficiency improvements with new power plants.



	2000	2025	2050	2075
BASE CASE CO2	10	14	22.5	32
CCT CO2	10	9.995	13	34
BASE CASE COAL USE	5	7	14	14

YEAR

Figure 13. Potential world wide carbon dioxide reductions - efficiency improvements.

Increases in environmental performance will be necessary under the SO_2 cap, but that these increases are achievable. Figure 12 illustrates the importance of this increased performance as old, uncontrolled plants are retired and replaced by new plants capable of achieving 99 percent reduction, which will permit capacity expansion and increased coal use without further deterioration of the environment. Increased efficiency is also important to addressing other concerns as well. For example, while there is as yet no firm consensus on the effects of increased CO_2 levels in the atmosphere, there are many advocates of CO_2 emissions control. Figure 13 shows that CO_2 increases can be significantly reduced over the long term with healthy coal use increases, if high efficiency Clean Coal Technologies are used to replace existing obsolescent technology in an orderly fashion.

SUMMARY

The Department of Energy believes the future of coal use in the United States for the next forty years is almost a certainty. This use, however, will be constrained and controlled to a degree not widely practiced at this time, and will require innovative thinking by producers, users, and critics alike. The situation can be summarized by the following analogy.

In the late sixties, I had the pleasure of attending one of the earlier national conferences on air pollution control in Washington, D.C. Then Vice President Humphrey, the keynote speaker, made a comment or statement to the effect that, with respect to SO_2 emissions, the atmospheric environment would be cleaned up. In response, Mr. Phillip Sporn of American Electric Power, implied that if anyone present thought the national economy would suddenly shut down in order to clean up the atmosphere, they should think again. Both of these distinguished gentlemen were correct. As the Vice President stated, the environment is being cleaned up, and as Mr. Sporn predicted, it is not being done by shutting down the nation's power plants and factories.

We believe this procress started back in the sixties and seventies, will continue and that it will continue with coal as the primary source of energy for electrical power production. In other words, we feel that coal is here to stay, but that all of us should expect dramatic changes in how we go about using it in the future.

Richard Shockley: Thank you, Paul. Our next speaker is Robert M. Hunter, Manager of Research and Technical Service, Coal Services Corp., St. Louis, Missouri, a subsidiary of Peabody Holding Company.

He has been involved in coal and raw material sales, technical services for Amax Coal Co., Director of Quality Assurance for Peabody Coal Co., and Chief Chemical Engineer for Pittsburgh Steel. He is going to talk to us today about the industry perspective of clean coal technology. Mr. Robert M. Hunter.

Robert M. Hunter: Thank you, Dick and thank you for this opportunity to speak to you today.

CLEAN COAL TECHNOLOGY–AN INDUSTRY PERSPECTIVE

ROBERT M. HUNTER
Coal Services Corporation
St. Louis, Missouri

INTRODUCTION

In a recent speech, an executive of British Coal stated that the U.S. coal industry is the envy of all coal-producing countries because of the Clean Coal Technology Program. If you look at all the coal-producing countries, not one has anything approaching the research funded by the U. S. Department of Energy (DOE). The DOE is to be applauded for the most successful program that it has developed and demonstrated of new and innovative ways to utilize coal.

Coal is the fuel of the future. With a two- to three-hundred year supply of proven reserves, it only makes sense that we should learn how to burn the world's most abundant energy resource. The combustion of coal produces SOx and NOx that may have the potential to produce undesirable effects on the environment. The Clean Coal Technology Program is a workable partnership between the coal industry, utilities, equipment manufacturers, and government that has demonstrated its ability to solve many of the problems.

OBJECTIVES

The objective of the Clean Coal Technology Program is to develop and transfer the demonstration project technology to real-world applications. The replication of the demonstration projects to prove plant situations is to minimize the risks to the utility industry. The projects, which in some cases are in the third and fourth generation of development, must be applied to the "real world". The real world includes the utilities which are highly regulated and must convince the various state public utility commissions (PUCs) that the risk they take will be minimal. Projects that are funded by the federal government and industry must be completed, and the technology transferred reassure the rate payers and the PUCs that the advancements are good for the rate payer, company and environment.

When the Clean Coal Technology Program, Round 5, was first announced, it was indicated that it was to be the final round. All indications are that there may not be a Round 6. This is a concern for both the coal and the utility industries. It is imperative that the clean-burning technology reaches maturity.

The funding to date has produced many technologies that include chemical cleaning and advanced physical coal cleaning as part of the pre-combustion technology field. Generation and combustion technologies show a great deal of promise; they include pulverized coal with combined cycle and atmospheric and pressurized fluidized bed combustion technologies.

REPOWERING EXISTING UNITS

The coal cleaning and pulverized coal with combined cycle technologies are applicable to retrofitting older boilers while the fluidized bed technologies have limited application to repowering of existing units. When contemplating repowering of existing units, the integrated coal gasification combined cycle technology has a great deal of potential. The technology utilizes higher efficient thermal cycles that produce lower emissions per megawatt than current pulverized coal units.

Other technologies which show promise for the repowering of older units include slagging combustors, low NOx burners, furnace sorbent injection, and duct-injected sorbents. Many individuals and companies that are not associated with the Clean Coal Technology Program are working on various chemicals for injecting and have shown a great deal of ingenuity in the variety of products that can be utilized as sorbents. There is great potential for using this method for sulfur capture. We feel there will be remarkable progress made in bringing these products to the market place in the near future.

POST-COMBUSTION TECHNOLOGY

In addition to the previously mentioned technologies, the post-combustion technologies, such as flue gas desulfurization, get the most "press." This press is not always good when it comes to mandating or not mandating scrubbers. Flue gas scrubbers that can regenerate the sorbent and both selective and non-selective catalytic reduction will play a major role in extending the life of older plants.

Advanced flue gas desulfurization projects are currently being demonstrated at the following plants:

APS	Harrision 1-3
Atlantic Electric	England 1 and 2
IP&L	Petersburg 1 and 2
Kentucky Utilities	Ghent 1
NYSGE	Milliken 1 and 2
Ohio Power	Gavin 1 and 2
OMU	Small 1 and 2
PENELEC	Conemaugh 1 and 2

PSI Energy	Gibson 4
SIGECO	Culley 3
TVA	Cumberland 1 and 2
Virginia Power	Mt. Storm

These plants are employing various processes to capture SO_2 which include wet lime and wet limestone utilizing both inhibited and forced oxidation. Additionally, the Clean Coal Technology Program has shown that considerable operating and cost efficiencies can be produced with systems that simultaneously remove the SOx and NOx. There are several demonstration projects of this type under the current Clean Coal Technology Program that indicate they will be applicable to repowering older units.

ROUND 5 DEMONSTRATION PROJECTS

Camden Clean Energy Partnership, L.P. This project will demonstrate the British Gas/Lurgi fixed-bed, oxygen-blown gasifier technology. High sulfur coal from West Virginia is gasified, and the clean gas is combusted in gas turbines. The two combined cycles are projected to increase the efficiencies by as much as 20 percent. The process is expected to reduce both SOx and NOx well below the most stringent environmental standards. This project also includes a first-time demonstration of the molten fuel cell.

Air Products/Foster Wheeler and Deutsche Babcock will team up to build a second generation pressurized, circulating fluidized-bed boiler. This second generation of a PFBC boiler will employ a topping combustor and advanced hot-gas cleanup.

Centerior Energy has joined forces with LTV Steel and Air Products and Chemical to demonstrate the production of hot metal and power from a combined cycle plant utilizing high-quality gas from the COREX process

PENELEC (Pennsylvania Electric Company) will repower the Warrent Station with an externally-fired gas turbine, resulting in a combined cycle power plant. The external system will employ a ceramic heat exchanger that will withstand the high temperatures generated in the modern gas turbine.

Easton Utilities, Cooper Bessemer, and Arthur D. Little will jointly build a two-engine diesel power plant that will add about 14 MW to the Easton No. 2 unit. The project will operate as part of a combined cycle plant when the engine exhaust passes through a heat recovery boiler. NOx and SOx will be controlled by a selective catalytic recovery system and dry flue gas scrubber, respectively. The system will utilize a coal-water slurry following cleaning by a two-stage cleaning and slurrying process.

SUMMARY

There are various types of technology that are likely to be successful at repowering old plants and in new plants. DOE has provided a broad range of options. Diversification of plants makes the various options site-specific with the wide variety of plant configurations, space available, and capital costs playing a role in selecting technologies.

Programs sponsored by organizations such as EPRI and the Illinois Clean Coal Institute (ICCI) benefit the DOE programs. Some EPRI- and ICCI-sponsored projects are directed toward the future use of high sulfur mid-western coal. The recent third quarterly report of ICCI indicates that the areas of research include chemicals from coal, coal cleaning, coal combustion, coal characterization, desulfurization, gas cleanup and the ongoing Illinois Basin Coal Sample Program.

CONCLUSION

We need to continue to refine the programs started in Clean Coal Technology Program Rounds 1, 2, 3, and 4 and aid in bringing the technology to the marketplace.

The projects selected at all levels of the Clean Coal Technology Program cut across a large number of technologies. Utilities and coal companies as a group or individually would not have the resources for this type of research and development. It is imperative that DOE not eliminate the Clean Coal Technology Program after Round 5. One of the primary reasons for the continuation of this program is the lack of an industrial sponsor for coal as there is for the oil and nuclear programs.

All of the projects mentioned can be attributed to the existing DOE programs. It should be noted that these projects of the Clean Coal Technology Program and the successes in the demonstration phases do not insure deployment in the competitive market place. The significant risks and costs associated with new technologies present an opportunity to the coal, utility, and governmental entities that are interested in the deployment of these technologies.

As in many countries, the federal government must support the concept of implementing these projects that present high risk. The private and federal resources that are represented by these projects need to be expanded to implement the technologies. If we do not continue to implement the technologies produced by this program, other countries will refine and improve these technologies. As in other programs such as automotive and electronics, we will become dependent on others and not take advantage of our technological advances. Clean Coal Technology Round 5 is a step in the right direction, but a Round 6, 7, and even 8 may be necessary to be able to utilize our most abundant fuel in a clean and environmentally safe manner.

Richard Shockley: Thank you, Robert. Mr. Ben Yamagata is our last speaker this morning. He is the Executive Director of the Clean Coal

Technology Coalition in Washington, D.C. He will be speaking to us this morning on the federal perspective of the present and future of coal and coal technology. Mr. Yamagata.

(Mr. Yamagata's paper was not available for publication)

Richard Shockley: Thank you, Ben. We appreciate all of our fine speakers this morning and the information they brought to us. Not only information but plenty to think about for the future. Thank you all for attending. Be sure to come to our luncheon to hear Jack Tisdale from MSHA's Accident Investigation Program, who will talk about MSHA's current programs and directions. If you haven't gotten a luncheon ticket, you can purchase one at the front desk.

Again, thank you for coming. This technical session is adjourned.

LUNCHEON MEETING

Thursday, September 23, 1993
LaSalle Room, 12:30 P.M.

J. Robert Danko: Welcome to the annual luncheon of the Illinois Mining Institute. I would like to introduce the head table. Starting to my right is Guy Gilbert; he is with the Illinois Department of Energy and Natural Resources and was a speaker for this morning's session. Next to him is Dave Webb who is Second Vice President of the IMI and is also chairman of our Scholarship Committee. Next to Dave is Robert Hunter, a speaker this morning, Manager of Research and Technology Services of Coal Services Corporation in St. Louis which is part of Peabody Holding Company. Next to him is Jack Tisdale, our luncheon speaker today, from MSHA. Next to Jack is Dick Reisinger, chairman of the second technical session to be held on Friday morning. He is Senior Engineer with Coal Services Corporation in Henderson, Kentucky. Next to him is Randy Britton with National Mine Service; he is chairman of our Honorary Membership Committee. To my left is Dayton McReaken, who is retired from Zeigler Coal and was last year's Honorary Member. Next to him are Jewel Rice and Fred Rice; Fred is the Honorary Member this year. Next to him is Richard Shockley, who was chairman of the technical session this morning and is Director of the Illinois Clean Coal Institute in Carterville. Connie Wiggins is Safety Manager with Peabody Coal; he will give our invocation.

Connie Wiggins: Would you please stand. We asked for members who have died in the past year; we only heard of one; there may be more. Robert Oswald, a preparation engineer from Midland Coal Company passed away this year. We will have a few moments of silence.

Our Father, as we come before you today, we thank you for this day and for this opportunity to gather together to exchange knowledge, to help further our industry and benefit from it. We pray for our industry at this time, the troubled times that we are in, and that you would see your way clear to help us to work out reasonable and economical solutions to our problems so that we might all get back to work. We pray for Robert Oswald's family, that you be with them and give them grace and mercy at this time. We ask now, Father, that you bless this food for us and that we might partake of it and gain nourishment to strengthen our bodies to go out and do your will. Please guide us and help us to follow you in all ways. We give you praise. In Jesus' name, amen.

J. Robert Danko: We are here today for the 101st IMI annual meeting. I would hope that after the luncheon, you will visit the exhibits. Our exhibitors have spent much effort. Don't forget that we are selling the raffle tickets for the two free trips to anywhere in the continental United States that Zeigler donated to raise some money for our scholarship program. The more tickets you buy, the more scholarships we can give out.

I would now like to recognize and ask any and all lifetime Honorary Members from the past to stand that are here today. We have six here today. [*Applause*] Now, any past-presidents of the IMI that are present here today, please stand. [*Applause*] Thank you.

I've also been notified that we would like to have a couple minutes of silence for Clayton Ball, who was president of the Paul Weir Company in Chicago. He passed away in 1993. He was a long time member of the IMI. He was made an honorary member in 1974 and was a president of the IMI in 1951-52. Thank you.

All of those who just stood know what it takes to get this off the ground and to put this program on every year, and all the work and the people behind it. I would like to recognize or give credit to all the directors on the Executive Board who have helped and put their time in to make this a good Institute this year; and to all the committee members, and particularly the Advertising Committee, with its twenty members, who solicit the exhibitors and advertisers, and thus help raise the money for our scholarships; and Phyllis Godwin and her people out at the registration desk that work long hours. I can't forget Heinz Damberger and his volunteers from the Illinois State Geological Survey who work hard and put in a lot of time. I'd like to thank all of these people for a job well done. [*Applause*]

Now, I would like to introduce Dave Webb, General Superintendent of Freeman United Coal Mining Company, chairman of our Scholarship Committee. Dave will you come up and introduce the college representatives.

David Webb: Thank you, Bob. The Illinois Mining Institute is again proud to recognize the 1993 scholarship recipients. Even through these tough economic times, the IMI has appropriated $10,000 in scholarships to bright, hardworking mining engineering and technical students at universities and colleges to secure our industry with skilled leaders to continue our advances in mining. I would like to thank the Scholarship Committee this year for their direction: Dr. Paul Chugh from SIU, Carbondale; Aaron Jackson, Kerr-McGee Coal Company; and George Woods, Wabash Valley College. Special thanks go to John Howard of Wabash Valley College for the preparation of the scholarship certificates. I understand that Dr. Chugh is not here today, but Dr. Ed Thomason will be here for SIU-Carbondale; if you would like to come up to the podium here along with your scholarship recipients, we will hand out those scholarships at this time.

Edwin Thomasson: Dr. Chugh sends his regrets that he could not be here for the luncheon today. He is attending the coal conference in Pittsburgh and delivering a paper there. He will be in tonight and will be delivering a paper here tomorrow. Our scholarship recipients are as follows: Mr. Dennis Connor; he could not be here today, I think he has classes; Mr. Tony Graham; Mr. Lars Lindquist, who is on a cooperative work program with U. S. Gypsum, working for six months in Iowa; Ms. Tracy Brewer, who also has classes today; Tracy just finished a work program with U.S. Gypsum; Robert Wireman, who is here; and Leticia Lockett, who is one of our lady mining engineering students; unfortunately, she couldn't be here either. So, with that, you have Tony Graham and Bob Wireman here; we'll take the certificates back for the others and present them at a later time. Thank you very much.

Dave Webb: Thank you. The next university represented is the University of Missouri at Rolla. Dr. Jerry Tien, please come up and introduce the scholarship recipients from the University of Missouri.

Jerry Tien: We at the University of Missouri at Rolla appreciate the continuing support for our department. This year we have four recipients. Three of them are seniors and one is a junior. Geographically, there are two Illinois boys; another is as close as Fenton, Missouri, and another fellow is from Arkansas. The first is Terry Croxford from Alton, Illinois. He is a senior and worked this summer. In fact, all of our students here had summer jobs and some in the coal mines as well. The next is Brian Fortelka, from Oswego, Illinois, a junior. Chris Huet is a senior from Arkansas. The last is Matt Tobey from Fenton, Missouri. Thank you very much. Please, go ahead and buy those raffle tickets so we can give more scholarships.

Dave Webb: From Wabash Valley College, Dean George Woods. Please come up and introduce your scholarship recipients.

George Woods: We have five scholarship recipients. Three are from our John A. Logan attendance center and two are from our Southeastern Illinois College attendance center at Harrisburg: Ron McCrary, Jeff Grammer, Tom Van Zandt, Paul Money, and Mike Dunn. Wabash Valley College is very appreciative of the continuing support by the IMI and we thank you very much.

Dave Webb: One more college, Rend Lake College. Is Dr. Martin Kern here? Or anybody representing Rend Lake College? We also have a Mary McKendry, recipient of the scholarship award from Rend Lake. Is she here?

That concludes our scholarship presentations.

J. Robert Danko: I just hope we can keep all these coal mines running for all these young people to get a job in. The way things are looking, you don't know from one day to the next. They say every black cloud has a silver lining; I hope some silver starts falling out of this one.

The next person I would like to introduce is Randy Britton, who is with the National Mine Service. Randy is chairman of the Honorary Membership Committee. I've asked Randy to say a few things about the individual they have selected this year to receive the award.

Randy Britton: Thank you, Bob. The Illinois Mining Institute is proud to honor one of its longtime members with the Honorary Membership award. Our recipient was born in West Frankfort, Illinois, and is the son of an Illinois coal miner. He is married to the daughter of an Illinois coal miner, and we thank you, Jewel, for attending with Fred. He has been an active member in the Illinois Mining Institute for 38 years and has been in the mining industry for 47 years. He started in the coal mining industry at the age of 17 as a construction worker sinking a shaft in Redmont, Illinois, for a minimum wage of 15 cents an hour. He worked for Peabody Coal Company for 42 years where he was a supervisor of underground operations in the states of Illinois, Indiana, Ohio, Kentucky, Colorado, Utah and Queensland Mine in Australia. Before retiring as vice president of Peabody's Eastern Division, he was Vice President Operations in 1987. He served as a captain of the Springfield and Eldorado Mine rescue teams in the state of Illinois for 14 years. He has over forty years of service to mine rescue teams throughout the Midwest. Throughout the United States, he was involved in fighting over 120 mine fires and rescue recovery operations. He helped get the charter for the Illinois Mine Rescue Association started. He was named the Outstanding Coal Miner by the Illinois Department of Mines and Minerals in 1984. And, for 1993, it is my pleasure and that of the Illinois Mining Institute to honor Mr. Fred Rice as our Honorary Member for life. However, before we do any presentations to Fred, I'd like to ask Mr. Dayton McReaken to relive some of his personal experiences with Mr. Rice.

Dayton McReaken: Well, I have to say that, no doubt, Fred Rice has had a unique mining career. I don't think anyone could match it. My first acquaintance with Fred Rice, and I'm not sure he remembers this, was about 1949 when he was a mine manager at a Peabody mine, and I was working on the third shift. A couple of us fellows went in and asked Fred if we could move up to day shift. Fred told us we were doing so good on third shift that he would just keep us on there. I was thinking about that a while ago, where he got that idea that you do so good you get to stay on third shift.

Another thing I remember about Fred, and I haven't told him this before; this has stuck in my mind for a long time. It involves a fellow by the name of Dick Griffin who Fred worked with for many years at Peabody Coal Company; he was Fred's boss and Fred was his boss. You know how Fred's career was up and down. Then, Dick left Peabody and came with the coal company I worked for. I was Dick's righthand man; his flunky, really. Dick and I had disagreements lots of times; we'd talk it over and discuss it, and I'd say we should do it this way, we should do it that way. Finally, when he gave in to me, he would always say one thing. "All right, we'll do it your way, but you're as silly as Fred Rice." Dick didn't know it, but I took that as a compliment.

But that isn't really the story that I want to tell today. I told this story last year, and some of you were here. Little did I realize when I first met Fred Rice, before my mining career and my life was finished in the coal mines, what Fred Rice would mean to me. Our paths crossed lots of times. The particular thing I'm talking about was in 1963 in a mine fire in southern Illinois. We had three men sealed up in this mine fire and Fred was working there with the Springfield rescue team. He was captain of the rescue team on the third shift. I was working on the second shift with the Benton mine rescue team. Also, at that time, I was employed as safety manager at this coal company, and a fellow named Joe Williams, retired state mine inspector who is a fine fellow, was the second shift mine manager at this property. So, this mine fire was in a four-entry system of panels. It was off of a nine-entry set of cross section entries. The west was in approximately 3,000 feet from the mouth of these cross section entries. When they sealed the fire up, they sealed out the mouth of these cross section entries, which made it around 3,500 feet from the location of the fire.

We sealed the nine entries out at the mouth and went through the regular procedure and let it stay that way until the 48 hours and time was up to go back. And then the rescue teams came in. That is when Fred got involved. He came down as captain of the Springfield mine rescue team.

We would go in with our apparatuses and build these nine stoppings 500 feet in and then go in and air them out and then take those out and move them on up. All you fellows understand that, 500 feet at a time. Well, when we got to within about 1,500 feet—and this figure plays a part in the story—from the location of the mine fire, the company rep was a little bit excited. This particular company had a very aggressive top management person, who was a good talker and a very aggressive fellow. He got a hold of myself and Joe Williams. We were the company men under his supervision. We were young fellows, and he had a little plan of what he was going to do. He was going to let Joe Williams and me stay underground. We were 1,500 feet from the location of this fire. The time was set for that night at 11:15 for Joe and me to go in to knock out the intake and return stoppings. This would have taken us about 20 minutes through the rock falls and everything. We were going to follow the air in and see what was going on with this mine fire. We had three men sealed up in this mine fire. The rescue team on the third shift, which Fred was the captain of, was to go on the bottom and stay and back us up. So, when Joe Williams and I were going in about 11:00 P.M. at the location, we were the only two left in the coal mine to get this job done.

Joe said to me, "Wormy, you know what we are playing: You Bet Your Life!" And I said, "Yeah, I think that's right. But you know what, we got a slim chance of ever being president of this company if we don't do it." We were the only company personnel besides being the mine rescue team there. So, we talked it over a little bit, and Joe and I were sitting there about 11:10 talking: are we going to do this or are we not going to do it. We knew it was hazardous. But, we decided we would do it and at least one of us would be president within six months.

Well, about 11:13 or 11:14, the phone rang where we were there; the message was. "Come out of the mine; we are not going to do it." That tickled us to death. So we came out of the mine, back up on top and another rescue team member came to us and we said: "What's happened?" And he said, "I'll tell you what's happened." The Illinois State Department of Mines and Minerals director, appointed only three days earlier at that time, was there; and a couple of state employees, and a couple of experts out of Washington, D.C. They were ventilation and fire experts. This aggressive company man had talked them into this plan, saying it was okay to do this. So when they called Fred Rice and his rescue team over, they said to Fred, "We want you to go to the bottom and back this deal up." Fred listened to him and said "Are you telling me that?" He said "Yes," and explains to him again. Fred told him, "Let me tell you something. You people own this place; you government people can run it and manage it all you want to, but what I want you to do is to give me time to get my rescue team out of this county before you blow this place up." All this you know put a little fear into the political appointees and management people; and that is why they decided to bring us out of the mine.

Now what happened on this situation, to show you why I owe so much to Fred Rice. About ten days from then, we went ahead and built the other airlocks and went right on into this thing. We got within 50 feet of this fire this time and the same thing was going to be done again. Joe Williams and I were going to go in with a couple more men this time and knock out the intake and return and inspect this fire, which was only five minutes from where we were. So we went in there and the thing got out of control in just five minutes' time; completely out of control! We had the fire, we had the water hose, we had the rock dust, everything within 50 feet, instead of 1,500 feet. It only took us five minutes to get into there instead of 20. The methane in this area around this fire location was anywhere from nine percent to 25 percent—it varied all over. The fresh air had only been on it about five minutes; previously it would have been on it 20 minutes. At the bottom of this fire, where the fire started to gob, was red coal and some blazes coming up. We did get that thing under control; we barely did. We were only 50 feet and 5 minutes away, all the fighting equipment there and plenty of available people. And it proved beyond a doubt that on February 8, 1963, if they hadn't listened to Fred Rice, I'd be dead today. And I want to thank Fred for that, very much. Thank you.

J. Robert Danko with Fred Rice, 1993 Honorary Membershp Award recipient.

J. Robert Danko: I've worked with Fred for 27 years, worked for him; I can't beat that story. I could tell a whole lot more. Fred's got all my respect. I think it is time Fred came up. Congratulations, Fred. You deserve this recognition.

Fred Rice: There was nothing about this award that is for after dinner speaking or anything. As most of you know, I'm a damn poor after dinner speaker. I want to thank Randy, the Honorary Membership committee, Bob Danko; and I thank you, Wormy. I sure appreciate your words. Thanks again. I appreciate it.

J. Robert Danko: At this time, I would like to introduce our speaker for the luncheon, Mr. Jack Tisdale, Manager of the Accident Investigation Program of the Mine Safety and Health Administration in Arlington, Virginia. Jack has a B.S. degree in mining engineering from the University of Illinois, and an MBA from the University of Pittsburgh. Jack has also held positions in the industry as corporate safety manager and vice president of operations; so he is well-versed in the mining industry. Welcome, Jack.

Jack Tisdale: Thank you very much. Whenever the Acting Assistant Secretary, Edward Hugler, received Heinz Damberger's letter to be a speaker here, he looked at his schedule and found out that he had a conflict. So he then went to the administrator for coal mine safety and health who also looked at his schedule and he had a conflict, and so, I'm the substitute. But, one thing that I would like to thank Heinz for: he gave me this magazine [*A Pictorial History of Coal Mining in Illinois*, by Chris Ledvina], and I looked through it a little while ago and there are mines in there that I worked in. There are mines in there that my father worked in; and there are also mines in there that my grandfathers worked in. So, I thank you, Heinz. It is my pleasure to join you today at this important annual meeting.

MSHA'S CURRENT PROGRAM AND DIRECTIONS

JACK TISDALE
Mine Safety and Health Administration
Arlington, Virginia

PROGRESS MADE TOWARDS SAFER WORK PLACE

So that the issues and programs I discuss are framed in the right light, let's start with a conclusion that just about everybody can agree on. That is that the mining industry, labor and government—working together—have done a remarkable job of making the workplace safer over the years. Long-term injury rates have declined, and, last year, the entire mining industry recorded an all-time low in on-the-job deaths. Specifically, the total number of mining fatals in 1992 were 97, 54 in coal mining and 43 in metal-nonmetal mining; and thus far in 1993, the total is 61, 28 in coal and 33 in metal-nonmetal. Illinois had 7 in 1992, 2 coal and 5 metal-nonmetal. In 1993, Illinois has 0 in coal with only 2 in metal-nonmetal. I doubt there are many, if any, American industries that can point to such a strong record of safety progress over the long term.

Contributing to the improving national record, of course, were many individual safety and health success stories. Some mining operations have gone on to win Sentinels of Safety trophies in a competition sponsored by the Mine Health and Safety Administration (MSHA) and the American Mining Congress for being the safest operations in the country during the previous year. These mines worked for hundreds of thousands of hours without a lost-time accident during 1992. Many other operations also had long periods of safe operation.

In general then, while the mining industry still has a long way to go to reach zero fatalities, there is much that's positive in the national safety and health picture.

You could say the water glass is half full—to use the old analogy about the different ways that people perceive the world. However, it is the nature of our job at MSHA that we must focus the greater part of our efforts on the half of the glass that is empty—the fatalities, injuries and health problems that still persist.

What are the problems we are focusing on? There are several. The first I would like to discuss is small mines.

FOCUSING ON SMALL MINES

We are focusing resources on small mines. The statistics tell why. In 1992 at both surface and underground coal mines employing more than 50 miners, the fatal incident rate was 0.02, at mines employing 20 to 50 miners the rate was 0.07, and at small coal mines employing less than 20 miners the rate was also 0.07. At underground mines these rates were 0.03, 0.13 and 0.19, up to 6 times greater.

It has long been apparent from accident and injury statistics that small coal mines employing 50 or fewer employees experience a disproportionate number of serious and fatal accidents compared with larger operations.

Small mines are concentrated in four states - West Virginia, Virginia, Kentucky, and with a lesser amount, in Pennsylvania.

In response to this problem, MSHA has developed and is focusing increasingly on procedures for improving safety in the following major areas involving small, underground coal mines.

Enforcement procedures. We have been stressing the importance of a thorough and complete inspection of every mine, regardless of size, to provide the needed incentive to comply with mining laws. MSHA oversight procedures for small mines were placed in effect on June 7, 1993. Also, instructions for activities to apply increased inspection time for problem mine operations were issued on January 11, 1993.

Management oversight procedures. Supervisors travel with inspectors; supervisors debrief inspectors after each inspection; citations and orders for appropriateness are reviewed; inspector assignments are rotated; inspections are followed up; and enforcement sanctions are initiated where operator compliance is deficient.

Increased inspector presence activities include: "impact" inspections at irregular intervals with at least two inspectors; "stretch" inspections in which an inspection is spread over a period of time; additional spot inspections; inspectors traveling in pairs to offset intimidation where it might exist; and group inspections of all or most of a mine in one day.

Information considered when determining whether to apply increased inspection time is: the mine's compliance history; the accident and injury rate along with the number and types of injuries; mine management's safety efforts, such as procedures used in the mine, the quality and type of instructions given the workforce and training provided to the employees; and management's involvement or commitment to the safety and health of the miners.

Mine operator assistance. MSHA's responsibility is to enforce the Mine Act and regulations through fair and impartial inspections. It is understood that mine operators are responsible for their compliance with health and safety regulations and safety records, and should take whatever actions are necessary to make needed adjustments. MSHA expects improvements at mines with poor compliance histories and will assist mine operators where possible. The agency has a number of programs available to assist mine operators in improving compliance. They are the job safety analysis program; joint mine assistance program; small mines training initiative; technical assistance in mine ventilation, respirable dust or roof control;

accident analysis; and discussions with mine inspectors, supervisors and subdistrict and district managers.

MSHA has entered into several agreements with four states to provide assistance to mine operators. These agreements are covered by the Joint Mine Assistance program which is a coordinated effort conducted with the state mining authorities of Kentucky, Pennsylvania, West Virginia and Virginia.

Evaluate financial ties or management control. Business arrangements of small mine operators can be an important factor in the safety and health of mine operations. Small operations may be controlled by higher authority obscured by organizational arrangements to the extent that the local person in charge lacks authority to make needed decisions to react to safety and health issues.

A business arrangement of particular concern is that in which a larger company employs a contract mining company to insulate the larger company from civil penalty assessments. These smaller operators often refuse to pay civil penalty assessments; then they go quickly out of business before the civil penalties are collected, only to be replaced by another small operator. This cycle can be repeated with the larger company subsequently hiring other small contract mine operators to enter the mine site and extract the coal.

Where MSHA finds that the contracting company's control is great enough and available information is such that the contracting company can be classified as a "co-operator" under Section 3(d) of the Act, the inspector will then cite both the contract miner and the contracting entity. It is important that MSHA continue to explore and uncover business arrangements that adversely affect the safe operation of mines.

State grants program. This program is also included in our small mine program. Each state applying for federal assistance under the State Grants program is required to describe in detail how it will address health and safety issues and is encouraged to give a high priority to education and training projects aimed at reducing deaths and serious injuries at smaller operations and several other high-risk mining areas. Applications will be evaluated to determine how comprehensively each addresses those priority issues and other activities to be performed under the grant. MSHA is interested in grant programs which use innovative training techniques, provide for mine specific training and result in improved safety management.

Collection of fines for violations. We have taken a number of steps to ensure that civil penalties assessed against mine operators are paid. Follow-up activities to collect delinquent civil penalties from nonpayers include a field collection program. Under this program, civil compliance specialists are stationed in MSHA coal districts having the highest concentration of active mines and delinquent debt. These specialists meet face-to-face with mine operators or their representatives in Kentucky, West Virginia and Virginia to collect delinquent penalties.

A major event in mine safety occurred last winter, the explosion at the Southmountain Coal Company, Inc., No. 3 mine. On December 7, 1992, at about 6:15 a.m., a methane, then coal dust explosion occurred on the 1 Left pillar mining section of the No.3 mine when an explosive methane-air mixture was ignited by the open flame from a butane cigarette lighter. The coal dust explosion continued to propagate from the section to the surface of the mine. Eight miners on the working section were killed and another miner working in an outby area was injured.

The following factors led to the explosion: the pre-shift examination was incomplete prior to the explosion; the bleeder entry was not maintained; the bleeder entry was not examined weekly in its entirety; section ventilation controls were not kept in place; rock dust applications throughout the mine were inadequate; and searches for smoking articles were not thorough enough. All of these factors constituted violations of basic safety regulations. The following lessons are learned from this explosion:

- The critical importance of making complete examinations as required by regulation.
- The importance of maintaining ventilation systems in accordance with the approved plan. Specifically, the bleeder entries must be maintained free of roof falls, and the ventilation control devices must be properly located, installed and maintained to direct the flow of air in its required direction and volume.
- The folly of miners smoking underground is broadcasted loud and clear. The use of smoking underground will not be completely eliminated unless and until mine management and the miners themselves take stern and effective measures, as required by law, to prevent the carrying of smokers' articles underground.
- The importance of rock dusting to prevent the participation of coal dust in an explosion is obvious.

EDUCATIONAL EFFORTS

We made an extra effort to insure that these lessons were shared with the coal mining industry. The accident report was used to disseminate the information containing the lessons learned. Two thousand additional copies were printed and distributed, one for each federal inspector for instructional purposes at each coal mine inspected during the third calendar quarter of 1993. Remaining copies have been distributed at locations and meetings for mine operators. Discussions on the accident and the lessons learned have been presented across the country at various industry meetings. As a result of the explosion, MSHA has started some actions designed to discourage the type of non-compliance found. The following categories of violations will be reviewed for possible special assessment: all violations for conditions that affect the airflow in an underground mine; all violations of workplace examination requirements, such as pre-shift, on-shift and weekly examinations; and all violations relating to the prohibition of smoking materials underground.

Our agency also is developing a comprehensive training course on the design and use of bleeder systems for presentation to the coal mining industry. The course will be a regularly offered at the Academy in Beckley, West Virginia

A Procedure Instruction Letter was issued to District Managers with instructions for specific points to consider when evaluating for approval bleeder systems of the type used at the Southmountain Mine.

MINE SAFETY ENFORCEMENT IN GENERAL

On the general topic of enforcement, it is our experience that a minority of mining officials and miners, not the great majority of safety-conscious people, are responsible for many of the accidental deaths and serious injuries that occur each year. MSHA has not hesitated to send a message about those who blatantly ignore safety and health. We've done so by widely publicizing criminal investigations and prosecutions of persons and companies whose actions recklessly threatened miners' safety or health or led to their deaths. We've also publicized major civil fines in mine safety and health cases. Examples have been Pyro Mining Company, J & T Coal Company, and Firecreek, Inc.

Respirable Coal Dust

During the past two years, more than 130 mining companies, mine operators and management officials or others have been convicted on or pled guilty to criminal charges involving safety or health violations. Mainly, these have been cases of altering respirable coal dust samples. Other cases involved penalties for safety and health violations, some totaling hundreds of thousands, and even millions of dollars.

With that in mind flagrant violators, especially repeated offenders and those whose neglect of their responsibilities leads to a fatality are subject to heavy civil fines and, in many cases, criminal prosecution. It is our clear policy to use the full range of our enforcement powers to reduce accidents, and we have not hesitated to do so.

One area of special urgency is that of accidents involving employees of independent contractors working on coal and metal and nonmetal mine sites. In the past five years, the work forces of coal mine operators declined significantly while the number of contract workers they hired more than doubled, and contractors' fatality rates were more than twice as high as those for mine operators' workers. Last year, 20 percent of coal deaths involved contractors (11 contractors out of 54 coal deaths). So far this year, that rate has increased to 36 percent (10 contractors out of 28 coal deaths). Contractor deaths also have grown in the metal and nonmetal industry in recent years, but this year to date, the rate of contractor fatalities has sharply improved over last year's total.

Also, mine health issues demand more attention, as they do in other areas of our national life. Control of respirable coal dust and silica dust continue to be two areas needing attention. Pending mine air quality, diesel, noise and other regulations reflect growing health interests.

In June of 1992, MSHA's task group on respirable dust in coal mines issued their report on the control of respirable dust. This report resulted from a comprehensive, year-long review of the respirable dust program. The report identified existing problems and potential vulnerabilities in the program and developed recommendations to effectively address these concerns. These recommendations were in the following areas:

1. Stronger enforcement.
   a. Respirable dust plan approval process.
   b. Single sample compliance determinations and one-day spot inspections.
   c. Increased sampling and monitoring of operator. sampling activities.
   d. Increased emphasis on operators who fail to sample.
2. More representative samples.
   a. Define "Normal Production Shift."
   b. Use of tamper-resistant equipment.
   c. Screening of samples for low weight, no weight and tampering.
   d. Eliminating void codes.
   e. Addressing non-traditional shifts.
3. Stronger certification and recertification procedures to conduct respirable dust sampling.
4. Stronger emphasis on education and training.
5. Develop means for continuous monitoring of dust levels and control measures.

MSHA continues to fully endorse these recommendations and has either implemented or is in the process of implementing the programs necessary to accomplish the goals set forth in the recommendations.

Three of the recommendations which have already been implemented resulted in more frequent one-day sampling and on-site monitoring; the issuance of citations for dust standard violations based on the results of a single MSHA sample measurement; and the use of newly designed tamper-resistant cassettes. The majority of the other recommendations, when implemented, will focus on the monitoring of the work environment, control of worker exposure, education and training, and the role of the miner in the respirable dust program. The remaining recommendations are long-term in nature and will focus on developing instrumentation applications for the continuous monitoring of both the mine environment and the engineering parameters used to control respirable dust.

Regulations for Diesel Equipment

As you know, the Diesel Advisory Committee, established by the Secretary of Labor, recommended MSHA promulgate regulations for the approval of diesel equipment, the use of diesel equipment, and the control of diesel exhaust emissions. We acted on the committee's recommendations and issued proposed regulations for public comment. Formal comments recommending changes to the proposed regulations were subsequently received.

A major area of concern by those commenting was the proposed requirements related to control of diesel particulate. In the proposed rule, a diesel particulate index would be computed, which would establish the ventilating air quantity required to dilute diesel exhaust particulate generated over an engine test cycle to an average level of 1 milligram per cubic meter of air. This index should in no way be confused with a permissible exposure limit or PEL. MSHA has not established a PEL for diesel exhaust particulate. We are presently working to determine how to best utilize the index in establishing ventilating air requirements at mines.

In their report, the Diesel Advisory Committee considered that diesel exhaust emissions probably did present a cancer risk to humans. The National Institute of Occupational Safety and Health (NIOSH) subsequently completed a risk assessment of human lung cancer from diesel exhaust particulate on the request of MSHA. NIOSH estimated a risk of lung cancer of one in one thousand at an exposure of 0.045 milligrams per cubic meter of air.

NIOSH noted that their risk estimate was based on a series of assumptions and it involved a considerable amount of uncertainty. After reviewing the available information for establishment of a PEL, MSHA issued an advance notice of proposed rule making to obtain any additionally available data. In response to the notice, we have received public comments on the development of a diesel exhaust particulate PEL.

MSHA recognizes that the establishment of a PEL is meaningless without an accurate and precise instrument to measure the diesel particulate level in mines. Samplers for use in mines have been developed and their use has been evaluated. These samplers, however, are not yet commercially available at a reasonable cost. Further, the precision of the current sampling systems can limit their applicability if the level of diesel particulate to be measured is below 0.5 milligrams per cubic meter of air. Work is continuing on improving the methodology to assess diesel exhaust particulate in coal mines.

Promulgation of the proposed diesel regulations and the examination of the need and an appropriate limit for a diesel exhaust particulate PEL are progressing.

Regulations on Ventilation

Also, in regards to regulations, I should comment on the ventilation regulations. The parties to the lawsuit on the ventilation regulations, the

United Mine Workers of America, the American Mining Congress, the National Coal Association and MSHA asked for a stay in the scheduled briefs required of all parties for six months, or until March 14, 1994. The parties have been continuing to discuss the issues and asked for the stay for the following reasons, as expressed in the Court's decision.

1. The respondent MSHA is planning to re-propose certain of the ventilation regulations that are the subject of the petitions in these cases, and has expressed a willingness to issue memoranda clarifying some of the standards which may alleviate the petitioners' concerns with other regulations. MSHA is hopeful that it can accomplish these tasks in less than six months. Also, during this time, the parties anticipate that a new Assistant Secretary for Mine Safety and Health will assume office and that the presence of the Assistant Secretary will facilitate agency decision-making on the issues in question. If these clarifications are issued and these re-proposals are adopted as final rules, it is reasonably likely that they would address the parties' concerns and eliminate the need for judicial review of several of the rules now subject to challenge.

2. Additionally, the three petitioners, as they have gained experience in the implementation of the new regulations and clarification of MSHA's interpretation of them, are developing a better understanding of which of the rules still require this Court's review. Thus, experience, continued discussion, and further decision-making may eliminate many of the issues currently to be presented to the Court; and it is entirely possible that one or more of the petitions in these cases would be withdrawn. The U.S. Court of Appeals granted the requested stay.

   Except for the coal mine ventilation regulations just discussed and possibly the metal and nonmetal explosives regulations, other regulatory activity must wait until an Assistant Secretary has been confirmed.

ACCIDENT EDUCATION AND PREVENTION

At MSHA, we talk endlessly in person or at meetings about the many sides of enforcement, training, regulations, fines for non-compliance, conquering difficult mining conditions, new technology and so on.

Our agency has literally made many tons of educational materials on accident prevention and other subjects available to safety and training departments.

And still, miners and supervisors continue to die and suffer crippling injuries every year in senseless and preventable accidents and face avoidable health risks as well. We should all ask: How can that be? Also, why has not more been done to advance the methods and technology for controlling respirable dust, particularly in longwall mining?

Part of the answer to that question is the kind of environment that causes supervisors and employees to work and make decisions with a high regard for safety—or just the opposite? This environment includes what we call the bundle of company traditions, attitudes, managerial systems, policy, beliefs, aids and impediments to success in the company boardroom or work area; that is an aspect of our working lives worth considering.

The odds are that most of you work in healthy company cultures. However, such environments vary widely from company to company. The best corporate cultures feature top management with the character and leadership ability to clearly show its unswerving devotion to strong safety and health policies and practices. Also, every employee knows without asking, and carries out, the rules set by the company.

What is troubling and what we've found much too often, is a management practice that tacitly acknowledges violating the law at the front-line supervisor level to keep production moving. At the higher management levels in some operations, we find a practice of not knowing and not wanting to know about safety and health conditions in the mine.

The result is that management, knowingly or not, encourages risk-taking at the mine site. At such a mine, supervisors are indifferent to their own safety or to the well-being of fellow employees. They apparently cannot see that cutting corners on safety costs a company much more than using safe, productive methods. I think you're all familiar with the types of failings that have contributed to highly publicized mine explosions and other types of accidents in which there were multiple deaths in the past few years.

Findings of our accident investigators routinely identify clear-cut violations of the most basic safety rules and practices. Findings include, for example, that miners travelled beyond roof supports, that at another mine officials were fully aware of certain violations, the finding that a fatal explosion occurred when methane was ignited by a cigarette lighter and that the company's procedures for preventing smoking, monitoring methane, controlling ventilation and other requirements were inadequate and the determination in another explosion that some of the air had been short-circuited because of illegal changes.

MSHA's procedures for investigating accidents are currently under review with the purpose of making them more thorough and complete. Some changes are occurring gradually. For example, equipment or machinery manufacturers are more apt to be invited by MSHA to be a resource for information on equipment capabilities and functions. We also recognize that penalties assessed for violations contributing to fatal accidents are likely to be high and, therefore, feel an obligation to ensure the citations and orders are appropriate and correct. The accident investigators will expand their investigation into work procedures and work instructions that relate to the accident.

INVOLVING MANUFACTURERS

Finally, there is one more area of comment. We recognize that there are marketing and cost considerations that could, arguably, inhibit the development of innovative products. That may well be why manufacturers have not put enough effort into resolving coal dust exposure problems, for example. Today, we have highly sophisticated longwall mining machines which produce vast amounts of coal. They also generate increased amounts of respirable coal dust, a well-known health hazard. It seems quite clear that safeguards for the control of dust have not been an equal part of the effort to increase the productive capacity of this mining equipment. In this and other areas of worker well-being (noise and ergonomics to name just two), manufacturers can and should show more leadership. This is an issue whose resolution is long past due.

J. Robert Danko: Thank you, Jack. Are there any questions for Mr. Tisdale?

Now would be the time to introduce our president elect Mr. Robert Shanks, but he is in Washington, D. C. at this time and could not be here. I'm sure Bob will do a good job next year. It is also the time that the president-elect presents the outgoing president with the souvenir gavel. So, I would like to introduce Mr. Dave Webb of Freeman United Coal Mining Co., Second Vice President of the Institute, who will take over Bob Shanks duties here today.

Dave Webb: Thank you. Customarily, it is the honor of the First Vice President to present the outgoing President with this souvenir gavel to recognize the President's efforts to the IMI. Unfortunately, Bob Shanks has been called away to very important business, so it is my pleasure as Second Vice President to present Robert Danko this gavel for his efforts as President of the 101st Illinois Mining Institute. Thank you very much, Bob.

President Danko holds the souvenir gavel he received for his 1992-93 term and for presiding at the 101st annual meeting.

J. Robert Danko: Thank you, Dave. It has been a wonderful year, and thanks to everybody for all your help.

That concludes our luncheon program today. I hope you will take the time to visit the exhibitors here today and buy some raffle tickets. The annual fellowship will be from 6:00 to 8:00 P.M. this evening in the exhibit hall. There is a free continental breakfast in the exhibit hall in the morning starting at 8:00 A.M. So you can also come and have breakfast and visit the exhibits and then attend the Business Meeting which will be here in the LaSalle Room starting at 9:00 A.M. Our Friday technical session will start here at 10:00 A.M. and our four speakers will discuss new developments in coal production. Thank you all for coming.

FRIDAY MORNING
Business Meeting
September 24, 1993 – 9:00 A.M.
LaSalle Room, Gateway Center

J. Robert Danko: Welcome to the Business Meeting this morning. If everyone can sit down we'll get started. First, we will have the Secretary-Treasurer's report out of the way.

SECRETARY-TREASURER'S REPORT

Heinz Damberger: Good morning. Membership is holding steady at close to 1,200 members. I was a little concerned about how attendance would develop this year, the strike being on and, of course, with the big rains coming through; but we had yesterday, at about 6:00 P.M. over 700 people attending. About 75 additional people had preregistered, but not picked up their packet yet, and there are usually some people coming in on Friday mornings. [*Actual attendance was 743, including 18 students*].

We are doing quite well with our exhibits, too. We are not sold out as we were last year for the Centennial, but we are above the level of the year before. We are holding even with advertising in the Proceedings, which is mainly due to the excellent work of our Advertising Committee. This has been a very active committee over the past several years. Taking these two sources of income together, we have increased income, mostly from the exhibits. We had substantial extra expenses last year which show up in our financial report. We also had some extra income: coal companies made donations to defray the extra costs, and we came out of the Centennial meeting pretty much as expected—even. I have copies of the financial report, which was audited and approved by our Auditing Committee. Anybody who is interested in the details, may pick up a copy here and look at it.

The bottom line is: we are ending up with a total cash balance of about $28,000 plus; looking down the road, which we always do for the board meeting, we expect to be at about the same level, maybe $1,000 less, at the end of the next fiscal year. There are going to be some decreases in income, especially from exhibits. But, we are in stable financial condition. These are the main points I need to make here as Secretary-Treasurer. If you have any questions, I will be glad to field them. If not, thank you.

FINANCIAL STATEMENT SUMMARY

Cash Balance Beginning 9/1/92	$49,617	Cash Balance Ending 8/31/93	$28,918
INCOME		EXPENSES	
Advertising	20,283	General Operating Expense	24,096
Annual Dues	15,933	Annual Meeting Expenses	60,996
Luncheon Receipts	2,680	Publication Expenses-	
Dinner Dance Receipts	2,425	Proceedings	14,763
Exhibit Fees	22,720	Scholarships	10,000
Registration Fees	7,625	Subtotal Expense	109,855
Donations	4,500		
Short Course	540		
Mining History Fund	2,070		
Centennial Souvenirs	6,199		
Centennial Memento	183		
Convention Raffle	2,538		
Interest	676		
Miscellaneous	184		
Convention Cash	600		
Subtotal Income	89,156		
TOTALS	$138,773		$138,773

ASSETS AS OF AUGUST 31, 1993

Fixed Assets	
Office Equipment & Furniture	11,730
Liquid Assets	
Cash	28,917
Bonds	500
	29,417
TOTAL ASSETS ON 8/31/93	$41,147
TOTAL ASSETS ON 9/1/92	$64,947
1992-93 LOSS	-$23,800

NOMINATING COMMITTEE REPORT

J. Robert Danko: Bob Shanks of Arch of Illinois, chairman of the Nominating Committee, is not able to attend. His committee recommends the following roster of officers and new executive board members:

President:	Robert Shanks, President, Arch of Illinois
First Vice President:	David Webb, General Manager, Freeman United Coal Mining Co.
Second Vice President:	David Young, President, Old Ben Coal Co.
Secretary-Treasurer:	Heinz Damberger, Head, Coal Section, IL State Geological Survey

New members to the Executive Board:

George A. Woods, Dean, John A. Logan College
William Noel, Jr., President, Long-Airdox Co.
Ronnie Marcum, Vice President of Illinois Operations, Consolidation Coal Co.
Donald Kinstler, Director of Underground Operations, Peabody Coal Co.

Are there any other nominations from the floor? If not, I would entertain a motion for the recommendations of the Nominating Committee to be approved. [*The motion was approved, seconded and passed by an oral vote of the members present*]. So, the new officers will stand as read and recommended by the Nominating Committee.

HONORARY MEMBERSHIP COMMITTEE REPORT

Next, we will have a report from the Honorary Membership Committee. That actually was taken care of yesterday at the luncheon meeting. Randy, do you have anything to add? I think it went very well yesterday. [*Fred Rice, Peabody Coal Co. (retired), was awarded the 1993 Honorary Membership Certificate at the annual Institute luncheon held on Thursday.*]

ADVERTISING COMMTTEE REPORT

J. Robert Danko: Larry Steward, do you have anything you would like to cover this morning?

Larry Steward: I believe Heinz touched on the important points for our committee.

J. Robert Danko: When is the drawing for the raffle tickets?

Heinz Damberger: At noon, immediately following this morning's technical session.

J. Robert Danko: Well, I'll buy some more raffle tickets if you all will. It is for a worthy cause. At this time, I would like to introduce Dave Webb, who is the chairman of the Scholarship Committee this year.

SCHOLARSHIP COMMITTEE REPORT

David Webb: Thanks, Bob. I am pleased to say that the Executive Board approved the same amount of scholarships as we had this year. We've seen raises for the last two years. Distributions will total $10,000 for next year's scholarships, and that is a good thing, especially in these tough times. I would like to ask some of the directors from our different colleges to speak a little bit about their respective programs. I see Dr. Paul Chugh from SIU-Carbondale. Could you start us off.

Southern Illinois University

Paul Chugh: Thank you, Dave. On behalf of the University, College, and Department of Mining Engineering, I'd like to thank the Illinois Mining Institute for supporting the undergraduate and graduate programs at SIU.

Last year, we were allocated $4,000. We gave seven scholarships. All of the students were above 2.8 gpa, and I believe several of them were here yesterday to receive their plaques.

Let me quickly give you a report on the department. It is in extremely healthy shape. We have 33 undergraduates this year, primarily juniors and seniors. We have 22 graduate students, which is the largest enrollment in the history of our department. And we have seven post-doctoral people. Our plans are to cap undergraduate enrollment at 40 students and graduate from six to eight students each year. Our industrial advisory board fully concurs with this plan that we have put together for our department. The average ACT score for all the students in the department was 24.

The department signficantly expanded its presence in the aggregate industry in Illinois, which is one of the largest industries in the United States. We placed about fifteen students in summer jobs. They were all the students who wanted to work in the summer. So we were extremely fortunate to get all of our students who wanted to work in the industry. Several worked for the aggregate industries. Several of them for the coal industry. We have four programs right now with three companies, and we are hoping to expand it during the coming year.

In the graduate programs area, we have initiated a flex M.S. program to attract students currently employed in the industry. Our advisory board likes the program, and we currently have four students enrolled in it. The M.S. program emphasizes environmental issues associated with mining and processing industries. I would be happy to talk with anyone who may be interested.

In the research area, I am pleased to report to you that we hope to receive early next week a four-year research award from DOE to study the economic and environmental issues related to underground disposal of coal combustion residues. The total amount of this award will be close to $3 million. That's the reason I was in Pittsburgh yesterday, giving a talk on my project. The disposal of residues will include subsidence control studies due to backfilling.

Over the last year, we have also significantly enhanced coal processing research. We have received two significant grants in that area. I reported to you last year that that was one of my highest priorities. And I think we are doing extremely well in this area. I believe you have picked up the brochure on outreach programs at our exhibit booth which describes how we intend to serve the area coal industry. I still have some brochures if you are interested.

Let me conclude by saying that the department is doing as well as, or better than can be expected to with the allocated resources. We will have to expand the department if we are going to go beyond this point. Let me again thank IMI for supporting the department; you can count on our support for the industry to the best of our ability. Thank you.

SIU Scholarship recipients Robert Wireman (left) and Anthony Graham (center) with Dr. Edwin Thomasson.

Dave Webb: Are there any representatives here from the University of Missouri. Mr. Wilson? Great. Would you like to give us a talk about your program.

University of Missouri at Rolla

John Wilson: I would like to thank the IMI for supporting our program; it has been a major part in helping to increase the number of students interested in the mining industry who come from Illinois. I would like to thank members of the IMI for producing so many summer jobs. Despite all the problems, we had at least eight students working in Illinois. That is very commendable. It was a good experience. I really appreciate the cooperation.

Chancellor John Park has asked me to again convey the appreciation from the University of Missouri at Rolla for the many many years of help and the help we continue to get. He made a point of calling me up and asking me to say that.

Before I get into discussing the mining department, I should mention that, just like most places, each of the four campuses of the University of Missouri is going through changes. We have a fixed universe of money available. And, if you are going to improve your program, you have to find ways of using that money effectively. It was decided to initiate an early retirement program; the funding that would be freed by reducing the number of faculty was to be used to enhance the salaries of the remaining professors and academics, to increase the quality of staff, and to be able to compete in the Big 8 or Big 10 group of universities and to induce good quality academics. So we are all trying to do more work and better quality with fewer people—just like the mining industry. I did want to mention that the University of Missouri is composed of the campuses St. Louis, Kansas City, Columbia and Rolla, has about 5,200 hundred students, which is getting close to the optimum. We have 440 students who are entering the program with ACTs better than 30. That says a lot about the quality of these students we have been able to bring to the University of Missouri campus.

The mining department of which I am chairman, is a member of the School of Mines and Metallurgy—the original University of Missouri. We have 105 students now, 95 undergraduates and 10 graduates, which is a far cry from the 35 we had three years ago. I am pleased to say that everyone of those who wanted to work this summer was working in quarries, metal mines, coal mines in Illinois and out west, even in Appalachia. That is one of the strong points in our program, encouraging the students to work in the industry. We will graduate 10 students; six graduated in May and there will be four in December. I think the number of graduating students is going to run to between 12 and 16 a year in the near future. I am comfortable with that number, because we get a number of inquiries from the quarry industry, from the metal mines in the Missouri lead belt and from the coal mines out west. We can provide that number. If it weren't for the scholarships, we would not have been able to get the numbers where we are. I think we are almost at critical mass. I think if we had 105 to 110 undergraduates, that would be the cap. I wouldn't want more, which might increase the unemployed or give false hope to students. The classes are a nice size. I know every student personally on our campus in the mining department, and we are at the size we can do that. It is good to manage a situation like that.

I should mention that our students are a very active bunch. You probably saw some of them here yesterday. We have a strong SME chapter of the American Institute of Mining Engineers. They have a mine rescue team which competes twice a year. They didn't do as well last year, because we had a lot of freshmen on the team, but they are doing better this year. They were actually here in Benton, Illinois, checking out the coal mine rescue programs to see how they differ from the hard rock ones; I think they are probably going to enter one of the local competitions this coming year. We did have a team of students in the collegiate competition, which is really a hard rock thing, but it is a lot of fun. The students enter a team that competes with the teams from Montana, Nevada, and Colorado Schools of Mines—an old-fashioned mining competition. They loaded railroad cars, laid track and drilled holes and all that stuff. It was the first team we had in the last few years, and we came in second. But it is good for them to meet with their peers. They go to Elko, Nevada, and although that is a bit of a jaunt, they really have a good time. We also had a group of students at the American Mining Congress mining show in Las Vegas. As I said, we have a very active group; they raise money for the local community, selling bratwurst, for example. This is all part of building character. I am really pleased that we have kids who have that incentive. And it is great when they come to me and say, "Dr. Wilson, I'm going to need a summer job next year. What are you going to do for me?" They are eager to get jobs.

We are involved in research. Not as much as I would like to be. My main objective there was to get the enrollments to healthy numbers so we can no longer be the poor boys on the campus. We are at that level with 100 students, so we have a good program. We are well supported in general, except from the point of scholarships. I have a problem ahead of me this year; we need more scholarships. So I'm on the phone talking and writing letters to some of my old cronies to try to get the money that we've already committed to the students. We also have the Board of Higher Education coming on campus; we are going to be re-accredited this October.

Dr. Norman Smith has elected to retire; he'll be leaving in May. Norm has been the cornerstone of our department for quite a while; a very likable guy. We have got to replace him. He has been particularly helpful to me during the three years I've been here. I know Norm is well known by the members here. He couldn't make it today because he has four classes and he would have a hard time making them up.

Having said all that, I am pleased to tell you that we are doing quite well. The research activity is not as big as Paul's, with all the dollars flowing into his department. But we do work on surfactants in coal cleaning, and we are looking at transporting coal in the form of slurry through pipelines. Peabody is one of the consortium members. There are three industry members, three utility companies and a transportation pipeline company involved in this. We are also doing work in rock mechanics, rock properties, things of that nature. And we have recently started to do some work on desulfurizing fine coals with one of my doctoral students. I think we will always have the 10-to-1 ratio of undergraduate to graduate students. It is the way we are structured and the way I see the needs are. I am going to have people phoning me up saying do you have a student who is graduating this December because we are looking for somebody at XYZ quarry in Iowa or this coal company in western Kentucky. So we are doing well, and I appreciate all the help you are giving. Thank you very much.

University of Missouri scholarship winners. Left to right: Matthew Toby, Brian Fortelka, Terry Croxford and Chris Huett with Dr. Jerry Tien.

Wabash Valley College

Dave Webb: Thank you, John. Wabash Valley College, George Woods.

George Woods: On behalf of Wabash Valley College, we also thank you for the scholarships. This year we had $1,500 allocated to our department; we broke that into five scholarships of $300 each. All of our scholarship recipients were here yesterday for the luncheon. They also asked me to thank you again for the scholarships. We had two from our program at Southeastern Illinois College at Harrisburg: Paul Money and Mike Dunn. Then from a John A. Logan location in Carbondale there were three recipients: Jeff Grammer, Robert McCrary, and Tom Van Zandt.

Our two year degree program has around 30 students. Those are split between the John A. Logan location and the Harrisburg location. That is probably a very small part of what we do now for the industry. In addition to our two-year degree program, we provided services to over 10,000 miners in the state of Illinois last year; that is, coal, metal and non-metal. We maintain three other locations besides the John A. Logan location and the Southeastern location. We have a facility in Marissa, through Belleville Area College; we have a program, with assistant instructors, classrooms, where we maintain a training program for skills, maintenance and retraining for the mining industry. We also have a location in Springfield at the Capital Area Vocational Center, with the same type of activity there. In addition, we have our home site at Wabash Valley College in Mt. Carmel. Through these sites, we maintain a lot of services for the coal mining industry through skills training, electrical, hydraulics, welding and just a variety of health and safety classes, not only for the miners, but also for their families.

Again, on behalf of Wabash Valley College, I would like to thank the IMI for their continuous support of our programs and for the scholarships.

Southeastern Illinois Colleges scholarship recipients. Left to right: Jeffrey Grammer, Ronald McCrary, Thomas Van Zandt, Paul Money and Michael Dunn with George Woods.

Rend Lake College

Dave Webb: Thank you George. Rend Lake College, Chris Nielsen.

Chris Nielsen: I'm the new guy on the block at Rend Lake College. I may look unfamiliar to some of you guys. But, I'd like to thank the IMI on behalf of Rend Lake College for the scholarship to our students. I would like to say this about Rend Lake College: it has gone the path of a lot of the industry. Fifteen years ago, we were putting out literally hundreds of coal miners through our mining technology program. Right now, like George just told you, we are primarily engaged in the maintenance and retraining of the existing industry. But, don't think for a minute that there aren't worthy students at Rend Lake College who could use this scholarship money. I brought our scholarship person with me today. As I rode up here with Mary McKendry, the person we selected to receive the scholarship, she told me a couple of things about herself that impressed me. For one, this little lady has been a section supervisor for eleven years and has supervised for Inland Steel and Consol. And the other thing I learned about Mary was; she won't be happy with anything less than an A. So, she has an excellent work ethic. She is pursuing a degree in industrial electronics. So, Mary if you will come forward. This is Mary McKendry.

Dave Webb(left) with Chris Neilsen and Rend Lake College scholarship winner Mary McKendry.

Dave Webb: I thank all the colleges for reporting at this IMI session. Every one of the scholarship recipients from all the schools were able to attend our meeting sometime yesterday or today. And that says a lot for the universities and the ability that they have. Thank you very much.

J. Robert Danko: Thank you, Dave. That was quite impressive; how many students do we have in Missouri? Did I get that right, there are 100 in the mining field?

Is there any other business from the floor? Don't forget about the 10:00 o'clock technical session that will meet here in this room. There are some good presentations. Dick Reisinger will be chairing that.

Question: President Danko, where did the Executive Committee decide to meet next year?

J. Robert Danko: The committee met yesterday and we are obligated to meet here next year.

Question: Are the dates set for next year?

Heinz Damberger: I was looking for my calendar, but I don't have it. We used to meet early in October. A number of years ago, we moved it up a little bit, mostly because of weather, to Thursday and Friday of the last full week of September [*The 1994 annual meeting will be held September 22-23*].

John Wilson: Well, the beginning of the semester is chaos the first month or two. We brought a bus load. They are all missing classes, but I told them, "You got to go to the IMI."

Heinz Damberger: What would be a better time for you?

John Wilson: Before school starts or when it is well into the semester. But I realize we are in the minority; just a casual comment.

J. Robert Danko: Anybody else have any questions?

John Wilson: I just want to make a point about the fact that we have 100 students; that translates to 10 or 12 graduates per year. We could graduate five in the winter and six in the summer. Last year, we had six graduates. All six had jobs two months before they graduated, such as tunneling under the Boston harbor, in construction, to strip mining in Louisiana, to the Bailey Mine in Pennsylvania, to a gold mine in Nevada. So the field is much bigger, thank goodness, than the coal industry.

J. Robert Danko: My problem is: I got about 250 company people competing for about 70 jobs. I will be glad when this strike is over. It is getting highly competitive and very difficult; there are a lot of good people losing their jobs.

Well, if there is nothing else, the meeting is adjourned. Come back at 10:00 for the technical session.

TECHNICAL SESSION II: NEW DEVELOPMENTS IN COAL PRODUCTION

J. Robert Danko: I would like to welcome everybody to the Technical Session II of the IMI. I think we have some good speakers and a good program this morning. I want to remind everybody that the IMI supports a lot of schools and puts out quite a few scholarships; those tickets being sold out there for the plane tickets will help provide for the scholarships. I'd like for everybody to get out there and buy some more tickets.

At this time, I would like to introduce the chairman of the technical session who is Dick Reisinger. Dick is a Senior Engineer with Coal Services Corporation in Henderson, Kentucky, which is a subsidiary of Peabody Holding Co. Dick, it is all your's.

Richard Reisinger: Thank you, Bob. Good morning to everybody here. When Heinz and Bob asked me to put together a program for this year's meeting, it didn't really take me very long to come up with a topic of discussion to guide in the selection of our speakers today. In light of the 1990 amendment to the Clean Air Act, high sulfur coal producers in our area were forced into an uphill battle to maintain coal production and jobs in the state of Illinois. We talked a little bit about this yesterday. Half the battle of maintaining business was getting the utilities to accept clean coal technology and being able to burn high sulfur coal produced in the state. In my opinion, the second half of the equation is for the producers, and it challenges the operators to concentrate their efforts on cost efficiencies to entice the utilities to burn the high sulfur coal in the Illinois Basin. Along these lines, we put together a program on new developments in coal production. Today's speakers include Gene Willis with Joy Technologies, Dr. Paul Chugh with SIU Carbondale, Gene Wilson with Fletcher and John Sammarco with the United States Bureau of Mines.

Our first speaker is Gene Willis, Vice President of Sales, Joy Technologies in the Mining Machinery Division, out of Franklin, Pennsylvania. Gene's been there for the last three years in his current capacity. Prior to that he worked in Mt. Vernon as the general manager of the Midwest region for ten years. He has a B.S. in industrial engineering from Geneva College. The topic of Gene's discussion today is advances in continuous haulage.

Gene Willis: Thank you, Mr. Chairman. On behalf of Joy Technologies, it is certainly a pleasure to be here at the IMI, particularly, at a technical session. Generally, you don't let a salesman come up and do a technical presentation. But I am here by default; please bear with me a little bit.

ADVANCES IN CONTINUOUS HAULAGE

GENE WILLIS
Joy Technologies
Franklin, Pennsylvania

INTRODUCTION

Joy has done a considerable amount of work in continuous haulage over time in order to make the continuous mining process really continuous. Historically, productivity about doubled in the last ten to twelve years. Most of that increase in productivity came about through better management. We traded faster for more powerful, more reliable continuous miners. That enabled productivity to double in the last twelve years.

It is Joy's belief that continuous haulage is a key enabler to make the next quantum leap in productivity in room-and-pillar and development mining. Two concepts are used, segmented, cascading haulage and single, continuous belt haulage. Joy has chosen the single belt system and engineered it for reliability, productivity and cost-effectiveness. Joy's vision for this leap in productivity is manifested in the 3FCT, the focus of this paper.

Figure 1 represents a peek at the future; it is an artist's rendition of an automated, continuous mining system which the Bureau of Mines is currently working on. Everything is controlled from a command center located a couple of cross cuts back from the face. It includes a remotely controlled miner, a continuous haulage system directly to the belt, with a remotely controlled roof bolter. At Joy, we have been developing continuous haulage for well over 20 years; it has taken us this long to come to a suitable product.

Figure 2 shows some of the phases that we have gone through with respect to continuous haulage since1966. These are some of the 20 units that we have put in service over the this time period.

THE JOY 3CFT FLEXIBLE CONVEYOR TRAIN

To introduce Joy's concept a five-minute video was shown. Following is the text from this video.

> Since the introduction of continuous mining, the mining industry has been searching for a haulage system that would truly make mining continuous. Joy Technologies has developed the solution to this problem. The Joy 3FCT flexible conveyor train continuous hauling system eliminates the wait time for haulage vehicles and lets the miner/operator concentrate on mining coal.

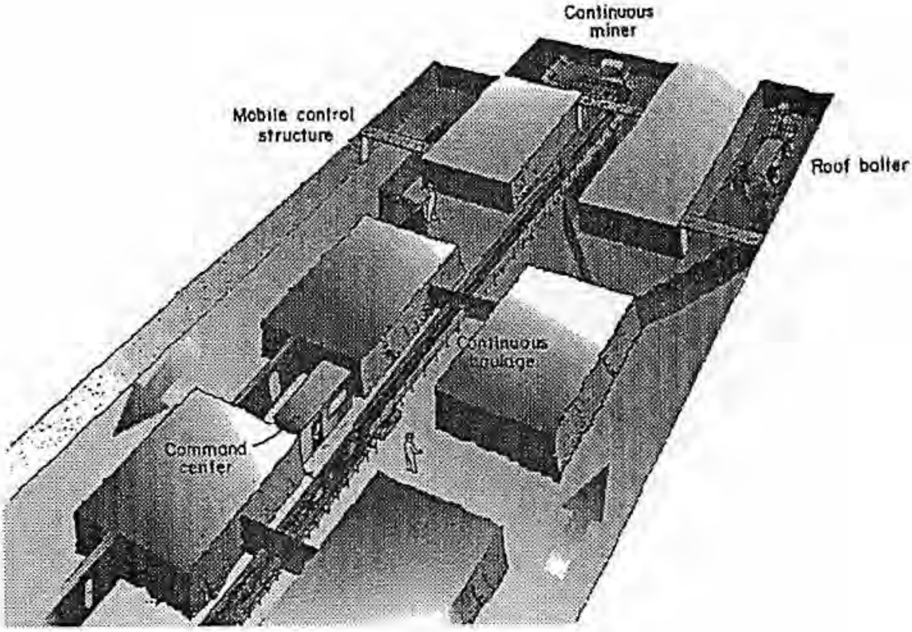


Figure 1. Conceptualization of targeted room-and-pillar mining scenario.

♦ 1966	Goodrich Belt	
♦ 1972	Serpentix	Peabody 10
♦ 1974	Wheel Mount	Ireland
♦ 1976	Roof Hung FCT	Laurel Run
♦ 1980	Side Loader Conv	Pittston
♦ 1983	Roof Hung FCT	Texas Gulf
♦ 1988	Crawler FCT	Camp #1
♦ 1992	Crawler FCT	Camp #1

TOTAL OF 20 SYSTEMS

Figure 2. Phases of continuous haulage development.

The 3FCT requires only one operator and lets him concentrate on the coal coming off the miner conveyor. By giving this job to the FCT man, the miner-operator can focus on cutting coal. Thus, the productivity and the quality of the product being mined is improved. Production averages of over 2,000 tons per shift have been achieved.

The 3FCT is a flexible-belt conveyor that can tram around 90 degree bends. It is a marriage of two major components: a belt conveyor structure that is mounted on a flexible single track crawler. At the heart of this system is the patented Joy belt. This belt has the ability to negotiate mine entries without losing its trough. To accomplish this, it is stretchable to eight percent longer than it's relaxed length, so that when it goes around the corner, it does so smoothly. The feature that allows this, the stretch limiter, is molded into the center of the belt. This prevents over-stretching and controls belt tension.

The 37 inch wide MSHA-approved, polyester-reinforced belt has a capacity of 15 tons per minute. The 3FCT is so flexible that it can be used in a variety of mining plans; the plans can be adjusted to meet various conditions.

The 3FCT can be furnished in various lengths up to 550 feet long and operate in seams as low as 54 inches. The 3FCT is composed of an inby unit with a loading hopper to receive coal from the miner and an outby unit that discharges the coal from the 3FCT onto the panel belt. Both units are equipped with two 30-horsepower belt-drive motors giving the FCT 120 horsepower to power the belt.

The flexible crawler structure is made up of a series of ball-jointed frames or corridors that let the 3FCT crawl across uneven floor, through dips and twists and around corners. The 30-horsepower traction cars are spaced every 60 feet along the train and tram the system at 70 feet per minute. Takeup cars are furnished to take up wear in the crawler chain.

The open structure and unitized construction makes the 3FCT easy to service. The FCT operator uses a radio remote control. A lighted display shows him detailed information. The operator can check the condition through the onboard monitoring system. If anything interrupts the mining cycle, the display will show what is happening.

In the case of mine belt problems, the FCT control will shut down; when the panel belt restarts, it will signal him that it is running again.

The FCT discharges onto the panel belt. There are basically two methods of doing this. Either the FCT crawls up a ramp onto a roadway immediately above the panel belt; this roadway is on a track so it is easily moved as the panel belt is moved up. Or, the FCT trams beside the panel belt. A traveling bridge conveyor transfers the coal from the FCT to the panel belt. This method may be used where height is low and entry width is available.

The FCT is truly a continuous hauling system. It is designed with the flexibility and capacity to meet your mining needs. The 3FCT increases productivity and the rate of advance while assisting you in providing the lowest cost per ton.

SPECIFICATIONS

That's how far we've come in the last 20 some years. Basically, the 3FCT is a remotely controlled conveyor from the end of the miner to the front of the mine belt. These are 550 to 950V machines. They have 30-horsepower traction for every 60 feet. They utilize four 30-horsepower belt drives which have recently been upgraded to a 40-horsepower hydraulic pump. The belt is 37 inches wide with a built in stretch limiter. It conveys at 13 to 16 tons per minute, trams at 70 ft/min. and turns on a radius of 28 feet. Figure 3 provides an overall view of the equipment on a hydraulic-mounted belt conveyor. Figure 4 gives a cross-section of that FCT on the belt conveyor, showing the height of the opening we would like to have. Seventy inches is about where we would like to have it because we have increased the height of the hydraulic load frame. When you go back and look at the FCT on the conveyor (fig. 3), this is the only opening that has to be 70 inches, but the FCT inby can be lower once it is down off the low frame structure. Figure 5 illustrates the inby hopper; 44 inches with the tail over the top of it gives you the kind of room height that you need. Figure 6 shows the side-by-side discharge, if you want to put it into a lower seam application. It is 10 inches lower than the over-the-top discharge.

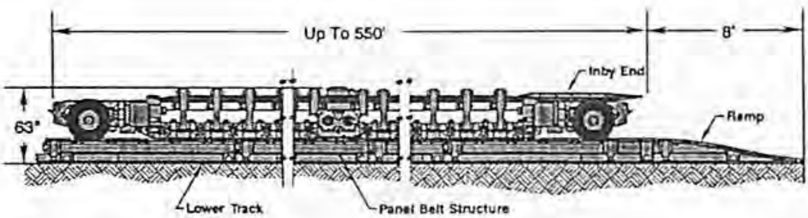


Figure 3. Overall view of the 3FCT on the hydraulic low frame.

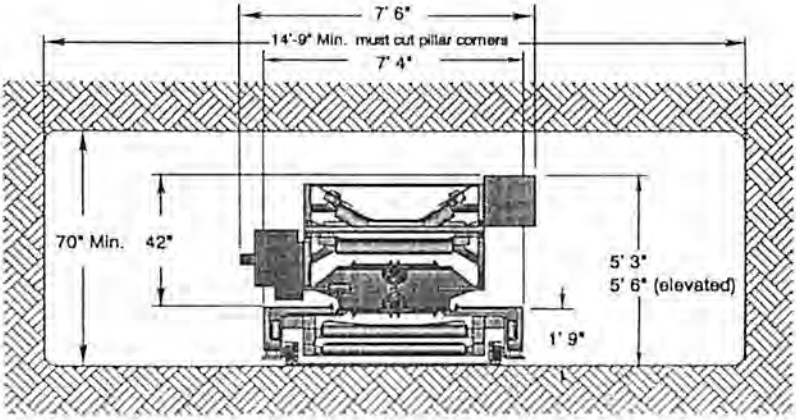


Figure 4. Cross-section of the 3FCT on the conveyor belt.

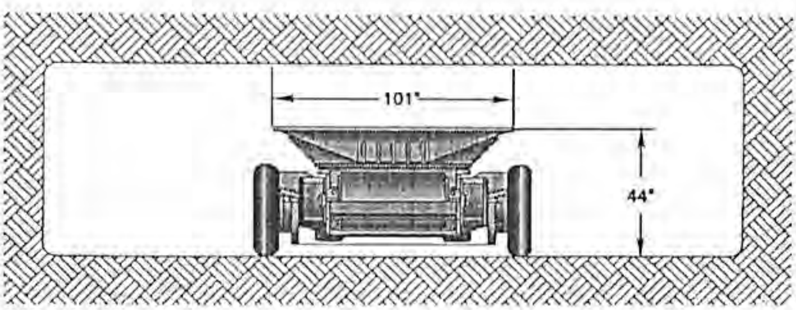


Figure 5. The 3FCT inby unit hopper.

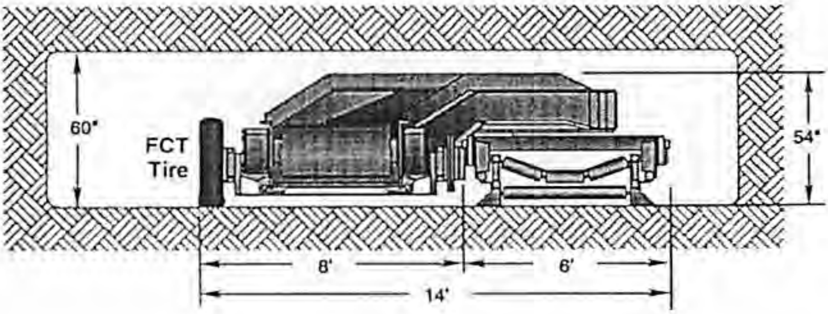


Figure 6. 3FCT and low frame, side by side discharge.

MAXIMIZING UTILIZATION

Mine Plan

As we have developed the continuous haulage, there were two important considerations to maximize utilization of the FCT. Figure 7 shows a mine plan and the belt takeup utilized by one of our customers to maximize utilization of the FCT. They developed 14-entry mains; off the mains they drove 7-entry panels which maximizes the use of the FCT through the whole production phase. This example utilizes a 300-foot system on a 60 by 50 foot mine plan. It appears to be the most effective if you can adjust your mine plan.

Belt Takeup

The other issue is belt takeup. Joy just developed a system utilizing hydraulics to bring up the mine belt with the FCT on top of it. Visualize the FCT on the low frame at the outby end so it can be trammed up on top until it is in full position (fig. 8a). The FCT is parked on top of the belt structure (fig. 8b). Then, through hydraulic cylinders, the front end is pushed out approximately 8 to 10 feet and two hydraulic jacks are positioned so that they lock into the roof, and at that point (fig. 8c), the load of the system is thus transferred to two auxiliary rails through cam-operated hydraulic cylinders (fig. 8d); then it is pulled forward, utilizing the hydraulic cylinders (fig. 8e). Going through a series of such moves between cross cuts and belt takeup creates an effortless move up the belt. Figure 8f is a view of the over-the-top discharge of the system. One customer went so far as to put a roof bolter near the hopper front end of the FCT; General Chemical set roof bolts with it.

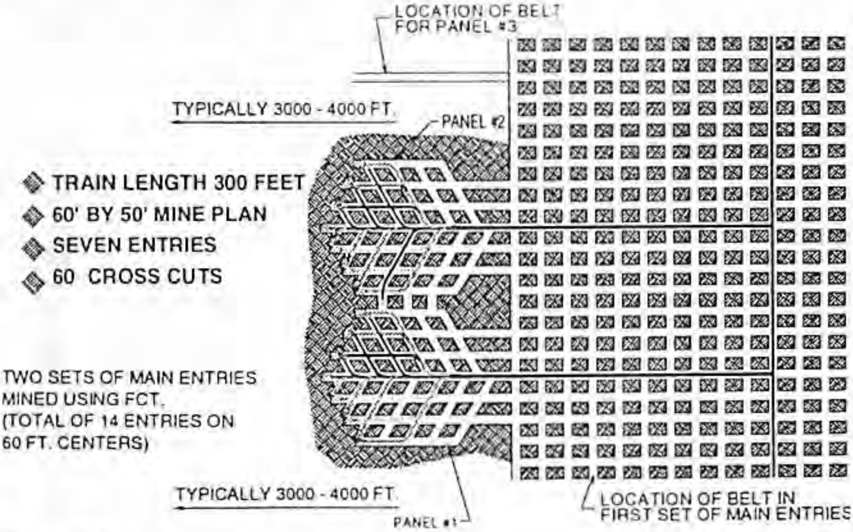


Figure 7. Commercial mine plan and belt takeup to maximize utilization of the FCT.

SUMMARY

Thus, the FCT conveys and trams simultaneously, is flexible, remotely controlled, reliable and productive. It is a one-man operation. The expectation is a 50 to 100 percent gain in productivity, depending on where you are when you start.

Table 1 lists the systems that Joy currently has in operation, except for an idle one in Illinois which is included for reference to highlight its performance while it was in operation. Seven units will be in operation within the next two months. The one in Colorado is the oldest; it has produced 3.9 million tons. The average per month production is 80,000 tons. These average tonnages per shift are on a day-one basis. The potential of the machine is quite impressive as indicated by the best shift productions of 2,900, 3,300, 2,900, 2,200, 2,200 tons of a machine that has only been in operation since July. The potential is there to average 2,200, 2,300, or 2,400 tons, depending on conditions. The availability has been very good, as high as 96 percent and nothing below 90.

FUTURE DEVELOPMENTS

Joy is looking to adapt the system for applications in lower seams, and is considering to make it wider for bigger miners. In early 1995, we will also introduce Jana control, which is a new electronic system from Joy. Eventually, we'll put a proximity link to the miner, in which case an operator would not be needed; everything would be controlled by the mine operator.

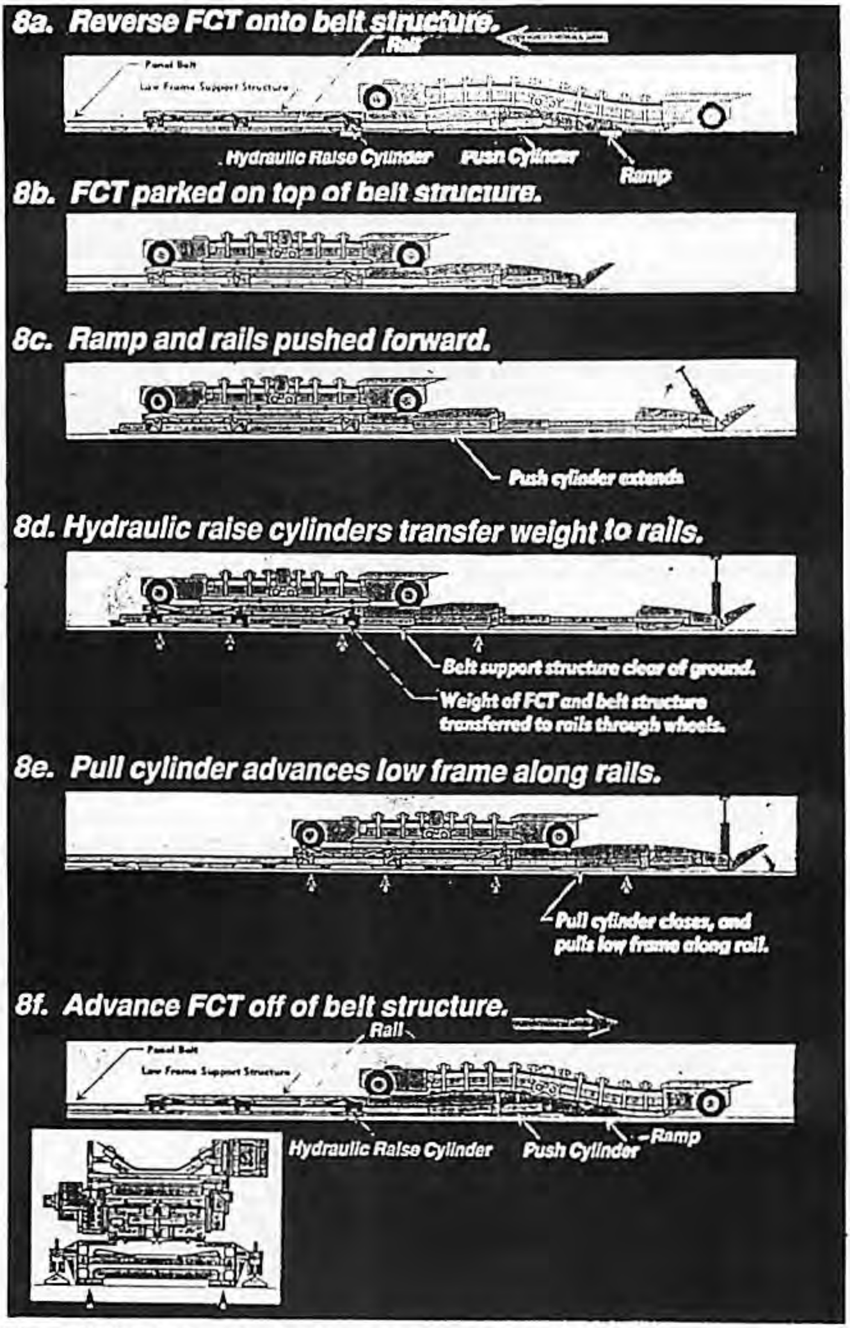


Figure 8a-f. Moving the 3FCT on and off of the mine belt.

Table 1. Joy 3FCT machines currently in operation.

Location	WY	KY	KY	KY	IL	IL	CO	IL
Start	Jan89	Jan 91	Dec 92	Jan 93	May 93	July 93	Oct 93	Oct 93
S/N	113	115	118	119	117	120	121	122
Plan	3 entry	7 entry	7 entry	7 entry	7 entry	7 entry	3 entry	7 entry
Miner	Bore Miner	14CM	14CM9	14CM9	12CM12	14CM15	14CM10	12CM12
Material	Trona	Coal	Coal	Coal	Coal	Coal	Coal	Coal
Height	8 ft	65 in	65 in	62 in	78 in	66 in	96 in	84 in
Length	465 ft	300 ft	300 ft	300 ft	300 ft	420 ft	540 ft	420 ft
Tonnage	3.9M	.99M	356,217	234,069		257,401		
Ave/mo	80,000	49,690	76,119	75,000		64,300		
Ave/shift		1,675	1,750	1,600		1,800		
Belt hrs	7,403	2,460	764	390		516		
Tram hrs	1,989	1,220	359	220		119		
Best shift	2,929	3,375	2,955	2,220		2,637		
Best drive	465 ft	675 ft	592 ft	505 ft		316 ft		
Best month	90,000	89,600	83,083	82,994		72,372		
Availability	98%	91%	93.5%	96.5%		92.2%		

Richard Reisinger: Thank you, Gene. Our next speaker is Dr. Paul Chugh from Southern Illinois University in Carbondale. I am sure many of you in this room are familiar with Dr. Chugh. He is professor and chair of the Department of Mining Engineering down there. He has a B.S., M.S. and Ph.D. So he's kind of three up on you there, Gene. His M.S. and Ph.D. came from Penn State University, and Dr. Chugh's resume´ includes 32 years of industry, academic and research experience in the coal industry. We are going to take a little twist here to go from haulage to longwall mining; Dr. Chugh's presentation is on design of longwall chain pillars for weak floor strata conditions. Paul.

Paul Chugh: Thank you, Dick. Today, I'll be talking with you about an exciting technical development in the department which should be of significant interest to our industry. Let me begin by saying that longwall mining requires analysis of the stability of chain pillars.

DEVELOPMENT AND APPLICATION OF A LONGWALL GROUND MECHANICS MODEL FOR PREDICTION OF GROUND MOVEMENT AND FOR PILLAR DESIGN IN COAL MINING

YOGINDER P. CHUGH, GUOLIN YANG AND ZHANJING YU

Southern Illinois University
Carbondale, Illinois

ABSTRACT

There has been a need to develop a simplified model which can simultaneously analyze stress distribution in longwall mine workings in coal including roof-pillar-floor interaction and associated surface and subsurface subsidence. This paper presents development and application of such a three-dimensional model to predict subsidence, associated tilt, and strain and design chain pillars in longwall mining of coal.

Our three-dimensional model is based on simple, stratified continuum with horizontal beds with cohesionless interfaces. The model permits solution of problems such as longwall mining with chain pillars, room-and-pillar workings, caving of roof beds, non-linear behavior of caved rock and linear or non-linear coal pillars and immediate floor strata. The model has been validated for several operating coal mines in the United States with good results for predicted subsidence, curvature and tilt and for stress in chain pillars at one mine. Applications of the model for design of longwall chain pillars and assessment of subsidence impacts on surface drainage are presented. The validation and application indicate that the longwall ground mechanics (LGM) model can be a good design and planning tool for longwall coal mining.

INTRODUCTION

Surface subsidence due to underground coal mining is a serious environmental concern. It can cause damage to surface and subsurface structures, change surface and subsurface drainage patterns and negatively impact agricultural productivity. Therefore, prediction of subsidence and its impacts is an extremely important aspect of underground mine planning (orientation of mining panels, geometry of mining panels and chain pillars, mining sequence, etc.).

Currently, the influence function method is the most widely used method to predict subsidence from longwall coal mining . The influence function method may provide accurate results if a suitable function can be established for a specific site or region based on field observations. The method, however, suffers from generality and cannot be used in virgin areas. Furthermore, there has been a need to develop a model which can simultaneously analyze stability of mine workings and associated surface and subsurface subsidence.

A three-dimensional numerical model, named the Longwall Ground Mechanics (LGM) model, was developed to simulate the ground movements due to coal mining[1]; it is based on a laminated medium used in conjunction with the boundary element technique. The results we obtained were reasonable. Recently, this model was further modified to simultaneously analyze both surface subsidence and in-mine stability of mine workings, including roof-pillar-floor interaction[2].

OVERVIEW OF THE LGM MODEL

The LGM model[1,2] is based on a laminated medium consisting of a pile of piece-wise homogenous isotropic strata. The Boundary Element Method with displacement discontinuities is utilized in the LGM model. Linear and non-linear material behavior can be incorporated for coal pillar and floor strata while overburden strata are treated as a linear elastic material. Caved gob in a panel is modeled using a suitable non-linear material behavior.

The model can suitably simulate ground movement due to coal mining where rock mass usually consists of distinct layers and relative movement along bed interfaces occurs. The LGM model is capable of modeling the roof-pillar-floor interaction in complex mining situations such as irregular mine layouts, weak floor strata, caved or uncaved workings, single or multiple panel problems, chain pillars and shallow or deep mining. It can provide load and convergence distributions in pillars, seam and mined areas, and it can simultaneously predict surface or subsurface subsidence, surface horizontal displacement and differential components (tilt, curvature and strain).

VALIDATION OF THE MODEL

The LGM model is validated for its ability to estimate chain pillar loads and to predict subsidence in longwall mining. The validation included comparisons of 1) computed vertical stress in chain pillars and surface subsidence with field observation data and 2) pillar design results using the LGM model with those obtained by the ALPS design technique[3] developed by the U. S. Bureau of Mines based on considerable field observation data and empirical estimation of pillar loads in multiple entry development systems. The ALPS method is extensively applied in the U. S. for chain pillar design.

Comparisons with Field Observations of
Pillar Loads and Surface Subsidence

Longwall mining at a southern Illinois coal mine was modeled using the LGM model. The mine extracts the Herrin (No. 6) Coal seam using a longwall mining method. Average mining depth is 198 m (650 ft), and the thickness of the coal seam is about 2.4 m (8 ft). The overburden strata mainly consist of shale, limestone, sandy shale, etc. The immediate floor strata consist of the common light gray underclay ranging from 0.6 to 1.5 m (2 to 5 ft) in thickness followed by 3 to 4.6 m (10 to 15 ft) of hard calcareous shale. The chain pillars are designed on 37 m by 18 m (120 ft by 60 ft) centers using three 5-m (16-ft) wide entries. The longwall is 293 m (960 ft) wide and 2,134 m (7,000 ft) long. Two panels had already been mined immediately to the north of the study panel (fig. 1). Both surface and underground monitoring studies have been conducted at the site in the past three years. Underground monitoring includes measurement of incremental pillar loads using vibrating wire stress meters, roof-floor convergence, coal pillar deformations and floor deformations. Surface subsidence studies include monitoring along and across the studied panel[4].

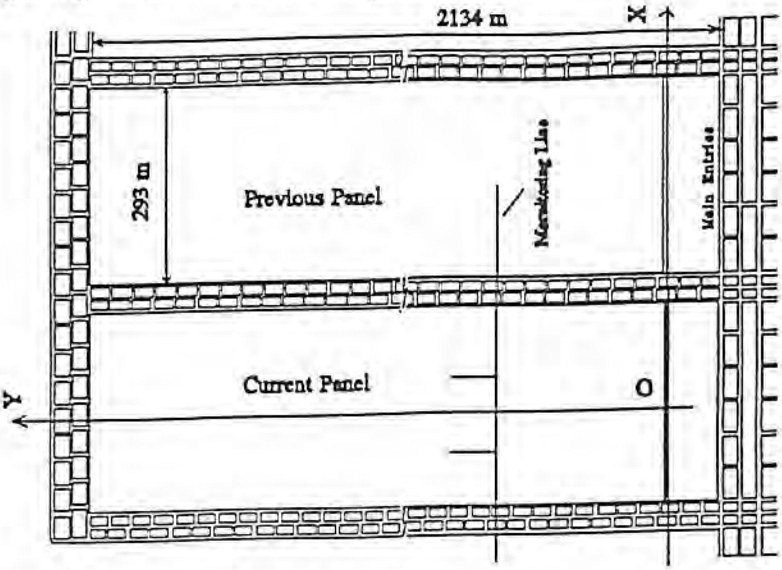


Figure 1. Mining layout for study panel.

The predicted and measured subsidence distributions along the monitoring transverse line are shown in figure 2. The predicted subsidence is in very close agreement with the field measurements. However, a shift between the predicted and measured subsidence distributions with respect to the x-coordinate can be seen (fig. 2). The adjacent panel was mined one year ago, but the model did not take the time effect into account.

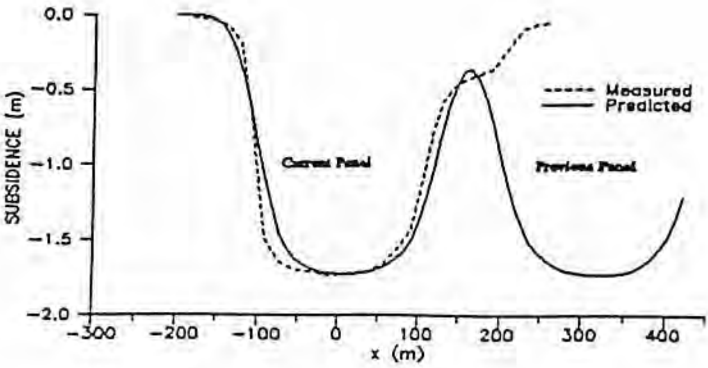


Figure 2. Subsidence along the monitoring line.

A comparison of the predicted strain in the x-direction with measured values along the monitoring line is depicted in figure 3. The predicted strain is generally close to the measured values. The slope or tilt in the x-direction along the monitoring line is shown in figure 4. Again, a close agreement between the predicted and measured values is observed.

Stress change at a measuring point in the pillar is depicted in figure 5 along with field measurements. The computation reflects field response reasonably well. A peak value is observed when the longwall face passes the pillar. Dynamic change in the pillar stresses can be taken into account for pillar design to insure stability or to plan subsidence at the surface during different extraction phases.

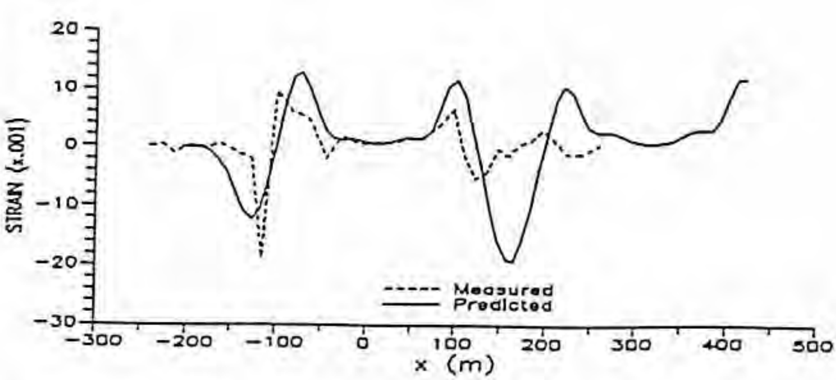


Figure 3. Strain in x-direction along the monitoring line.

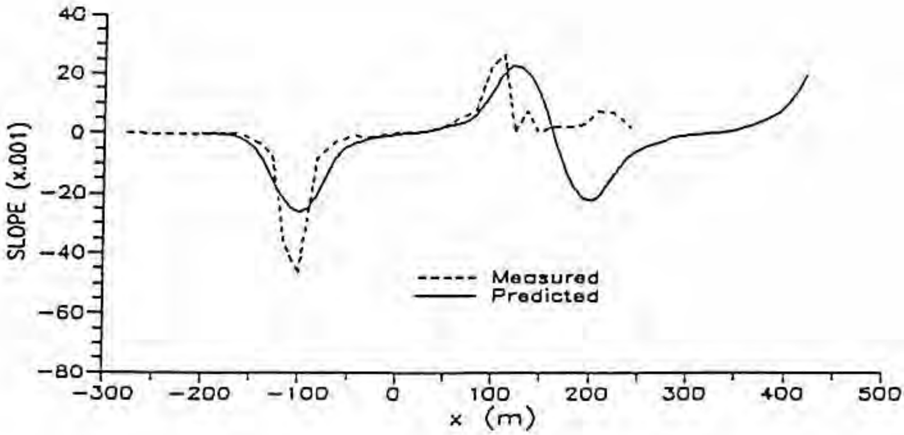


Figure 4. Tilt in x-direction along the monitoring line.

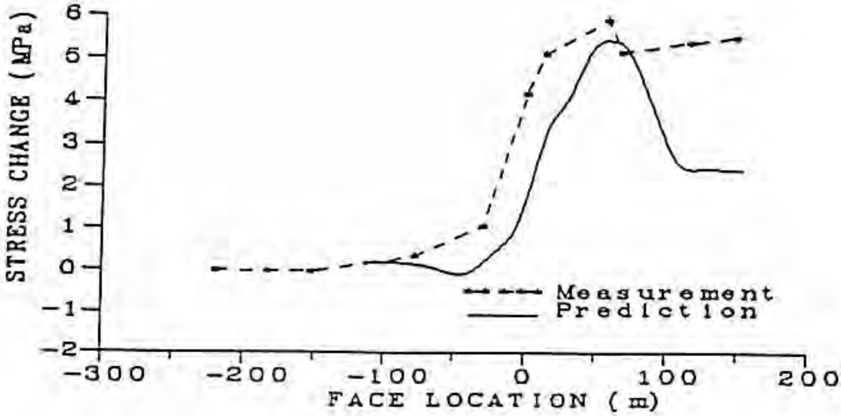


Figure 5. Stress change in the pillar adjacent to the face.

Checking with ALPS Design Technique

The LGM model was also checked with the ALPS method for design of chain pillars. Several examples were analyzed using both the LGM model and the ALPS method. The results provided by both approaches were comparable[5]. Results for one of those examples are presented here. The mining characteristics for the mine are given in table 1. Average vertical stresses over chain pillars and corresponding safety factors are illustrated in figure 6. The coal pillar strength was calculated using the Bieniawski formula[6]:

$$\sigma_p = \sigma_{cc}\ (0.64 + 0.36\frac{w}{h}) \tag{1}$$

where σ_p is the pillar strength, σ_{cc} is the in-situ coal strength or strength of the critical size cubical coal specimen, w is the pillar width and h is the pillar height. From the LGM model the average vertical stress over the chain pillar increases up to a peak value and then drops down as the longwall face

Table 1. Mining Characteristics for case study mine.

Mining Depth	152 m (500 ft)
Number of Entries	3
Pillar Size	13.4 m x 31.7 m (44 ft x 104 ft)
Entry Width	4.9 m (16 ft)
Panel Width	198 m (650 ft)
Mining Height	1.8 m (6 ft)
In-situ Coal Strength	6.2 MPa (900 psi)

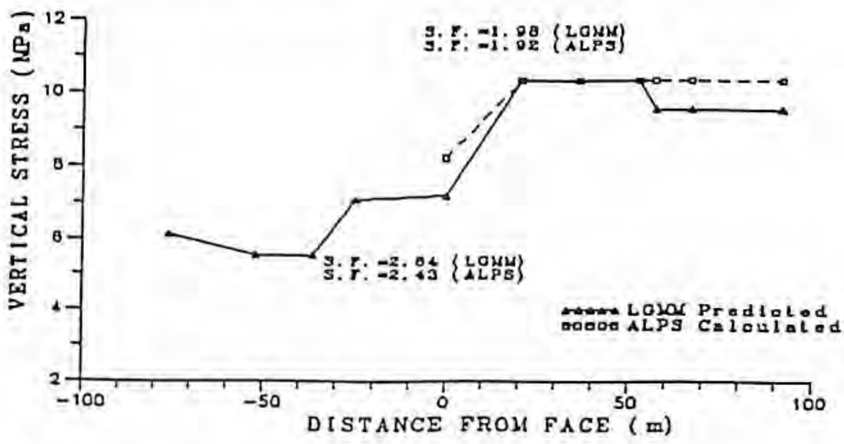


Figure 6. Average vertical stress over chain pillar on headgate using LGMM and ALPS techniques.

passes away. But for the ALPS method the pillar stress is based on a two-dimensional estimation; therefore, the peak value cannot be estimated. The results from the LGM model and the ALPS method are generally in agreement. The ALPS method is based on the strength of coal only and cannot presently consider pillar design based on weak floor.

The comparisons discussed above provide significant confidence that the LGM model can be a good mine planning and design tool in coal mining.

APPLICATION IN DESIGN OF LONGWALL CHAIN PILLARS

Since the LGM model can model roof-pillar-floor interaction and provide vertical load distribution in the pillars, it can be used for the design of longwall pillars if an appropriate pillar strength formula is incorporated. Furthermore, it should also be able to consider pillar design based on weak floor. After the validation studies mentioned above, a practical problem for the design of longwall chain pillars was undertaken for a coal mine in the Illinois Basin. The coal company requested to evaluate the current chain pillar geometry proposed by the mine and to analyze alternate chain pillar geometries recommended by the authors.

For this mine, the average mining depth is 113 m (370 ft), and the thickness of the coal seam is about 1.5 m (5 ft). The seam is associated with weak underclay of about 0.9 m (3 ft) in thickness. Consideration of the floor stability is critical in the mine because of the low strength of the floor strata. The overburden strata mainly consist of shale, sandstone and limestone.

Analysis of the Layout Proposed by the Coal Company

The coal company proposed to extract the seam using a longwall mining method with a four-entry headgate and tailgate development, a 229 m (750 ft) wide face, 1,829 m (6,000 ft) long panel, 18.3 m x 21.3 m (60 ft x 70 ft) pillar dimensions and an opening width of 6 m (20 ft). The longwall system is illustrated in figure 7. In-situ strength of coal is about 7.58 MPa (1,100 psi). The pillar strength was calculated as 37.6 MPa (5,456 psi) using equation 1. Cohesion of weak floor was estimated as 0.97 MPa (140 psi) and the ultimate bearing capacity for the weak floor underneath the pillar was estimated as 20 MPa (3,000 psi) using the approache of Chugh and Pytel[7]

Designations for the three rows of chain pillars I, II and III are indicated in figure 7. Each row chain pillar may also have position designation "a" and "b". The "a" position refers to the position adjacent to the longwall face while "b" designation refers to the position behind the longwall face. Both positions are critical, but the peak vertical stress is expected at position "b". The analysis results for chain pillar stability in terms of safety factor are shown in table 2. The results indicate that 1) all chain pillars at both positions "a" and "b" are stable with high pillar safety factors; 2) floor safety factors (safety factors against floor failure), although lower than pillar safety factors, are considerably higher than 1.3, typically considered adequate; and 3) the proposed chain pillar geometry is extremely conservative.

Furthermore, the results indicate that the chain pillar design based on the ALPS method would lead to an erroneous design in this case.

Table 2. Results of an analysis of the stablility of chain pillars

Element and Position		Geometry proposed geometry by coal company					
		Headgate			Tailgate		
		I	II	III	I	II	III
Pillar	a	6.58	6.86	6.31	3.89	6.97	5.42
	b	4.49	6.99	6.39	3.92	6.89	3.72
Weak floor	a	3.62	3.77	3.47	2.14	3.83	2.99
	b	2.47	3.85	3.51	2.16	3.79	2.04

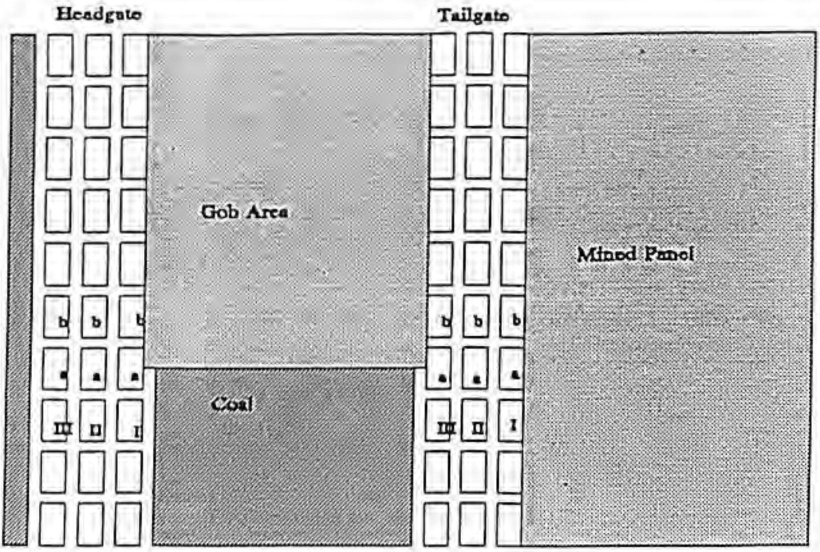


Figure 7. Illustration of longwall with four-entry development.

Development and Analysis of Alternate Mining Layouts

After evaluating various mining layouts and considering mine operational requirements, three alternate mining layouts are selected for analysis. For the three layouts, each panel is assumed to be 229 m (750 ft) wide, with a three-entry development (fig. 8). The characteristics of proposed alternate geometries are shown in table 3. The pillar and weak floor safety factors for the three recommended layouts are presented in tables 4 through 6. For Option I, pillar and weak floor in both headgate and tailgate entries are stable. For Options II and III, pillar and weak floor in the headgate side are stable, but tailgate chain pillars are expected to sink into weak floor strata after the face passes. The last two designs should benefit surface subsidence control since settlement of chain pillars into weak floor will produce more uniform surface subsidence.

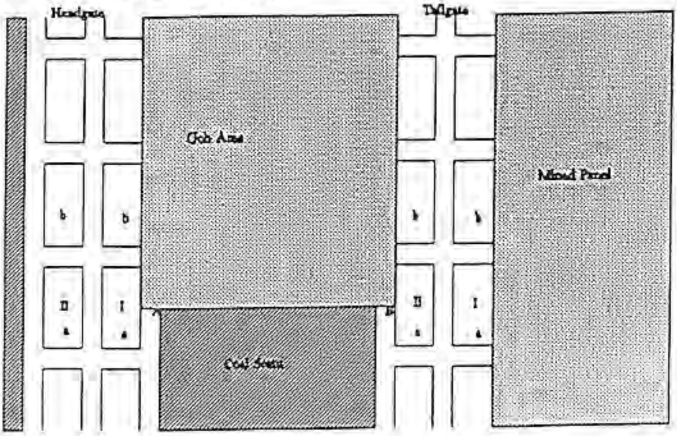


Figure 8. Illustration of longwall with three-entry development.

Table 3. Recommended layouts.

	Alt. Geometry I	Alt. Geometry II	Alt.Geometry III
Pillar size (I)	15.2 m x 15.2 m (50 ft x 50 ft)	14.3 m x 15.8 m (47 ft x 52 ft)	15.2m x 21.3 m (50 ft x 70 ft)
Pillar size (II)	15.2 m x 15.2 m (50 ft x 50 ft)	14.3 m x 15.8 m (47 ft x 52 ft)	12.2 m x 21.3 m (40 ft x 70 ft)
Opening Width (Headgate)	6.7 m (22 ft)	6.7 m (22 ft)	6.1 m (20 ft)
Opening Width (Otherwise)	6.1 m (20 ft)	5.5 m (18 ft)	6.1 m (20 ft)

Table 4. Results of an analysis of the stablility of chain pillars

Element and Position	Alternate geometry I Headgate I	II	Tailgate I	II
Pillar a	4.94	6.28	3.11	5.64
b	3.30	5.84	2.94	3.63
Weak floor a	2.54	3.23	1.60	2.90
b	1.70	3.00	1.52	1.87

Table 5. Results of an analysis of the stablility of chain pillars

Element and Position	Alternate geometry II Headgate I	II	Tailgate I	II
Pillar a	4.65	5.90	2.89	5.23
b	3.08	5.47	2.72	3.34
Weak floor a	2.00	2.55	1.24	2.24
b	1.32	2.35	1.17	1.43

Table 6. Results of an analysis of the stablility of chain pillars

Element and Position	Alternate geometry III Headgate I	II	Tailgate I	II
Pillar a	5.32	5.49	3.19	4.68
b	3.55	5.03	2.99	2.96
Weak floor a	2.74	1.82	1.71	1.57
b	1.83	1.69	1.60	0.99

ASSESSMENT OF SUBSIDENCE IMPACTS

The coal company also asked to simultaneously assess the impacts of surface subsidence on surface drainage patterns and ponding areas that may impact agricultural productivity. Three longwall panels as well as abandoned room-and-pillar workings in the overlying coal seam 36.6 m (120 ft) above were modeled using the LGM model. The predicted subsidence obtained from the 3-D modeling was superposed on the existing surface topography to develop the post-mining topography. From the pre- and post-mining topography maps, changes in drainage patterns and likely ponding areas could be clearly observed. These maps were utilized for purchasing subsidence rights as well as for developing reclamation plans for subsided areas. These analyses provide a useful tool for a mine planner as well as for operation staff.

Subsidence effects on all three creeks above the three panels are shown in figures 9 through 11. Dredging reclamation may be required for Creek 1 and Creek 2, while Creek 3 should not experience significant drainage problems after longwall mining. Subsidence distributions above the three panels, pre-mining topography and corresponding post-mining topography are displayed in figures 12 through 14. Ponding is observed in some areas and reclamation is required to ensure drainage.

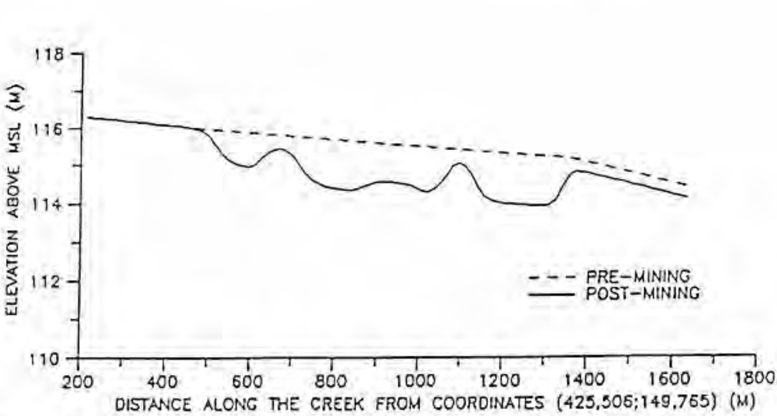


Figure 9. Topography along Creek 1.

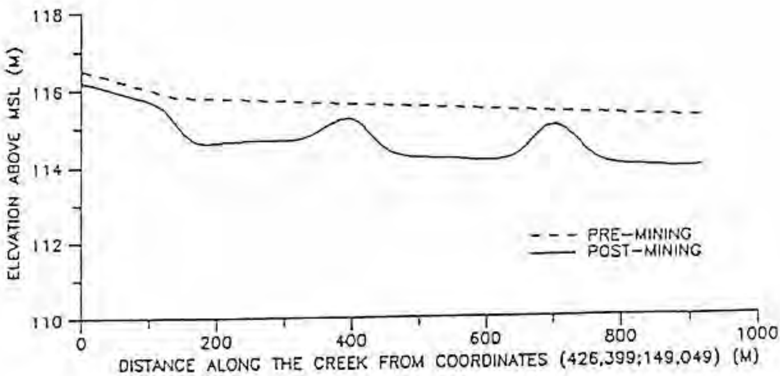


Figure 10. Topography along Creek 2.

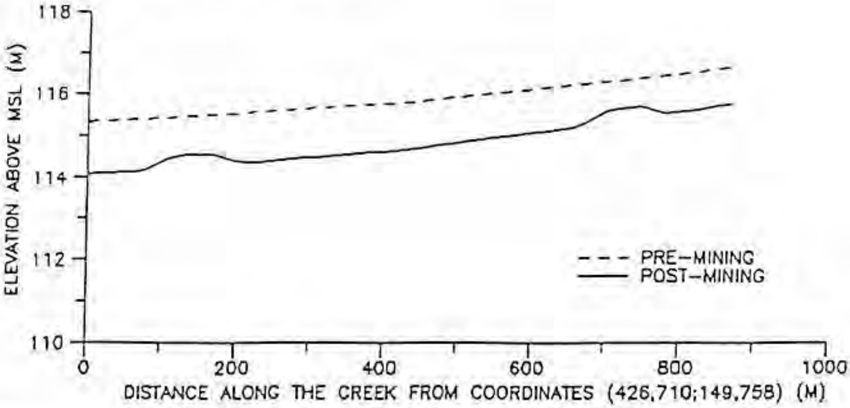


Figure 11. Topography along Creek 3.

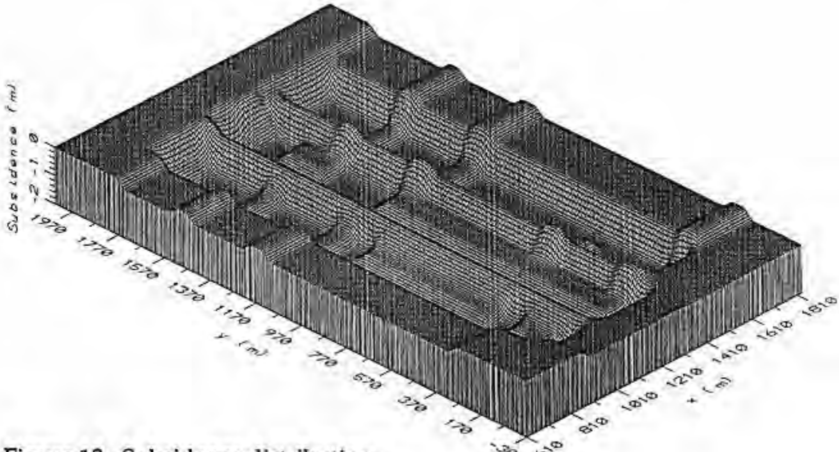


Figure 12. Subsidence distribution.

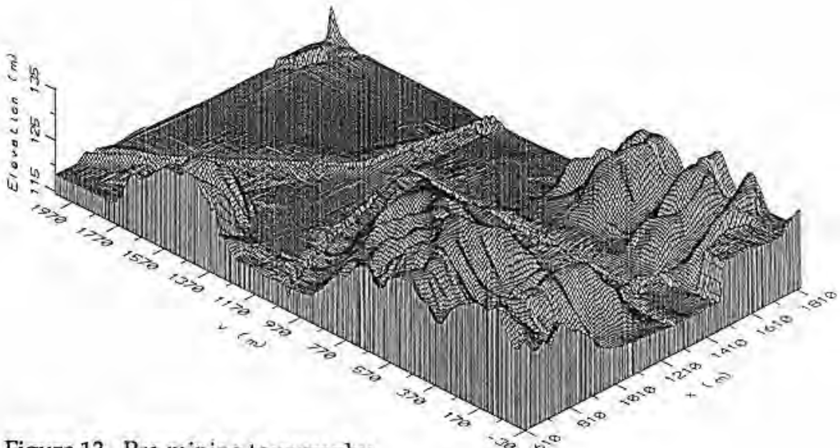


Figure 13. Pre-mining topography.

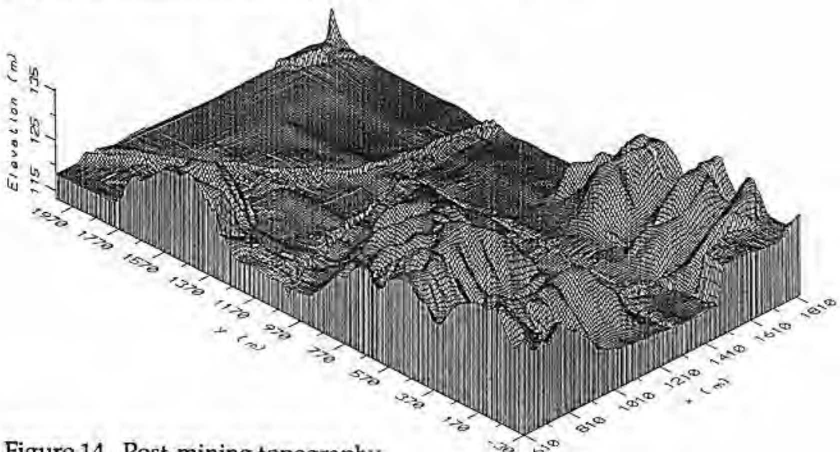


Figure 14. Post-mining topography.

CONCLUSION

A three-dimensional numerical model to solve ground mechanics problems involving room-and-pillar and longwall panels with chain pillars has been developed. The model can consider the presence of weak floor strata below the coal seam. The model was validated through comparisons with field measurements in coal mines of the Illinois Basin and with another design method. The application of the LGM model for the design of longwall mining geometries and for assessing subsidence impacts was presented. The authors believe that the LGM model can be a good design and planning tool for longwall mining. Validation of the model in any particular area prior to extensive application for mine planning and design is recommended.

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Dick Reisinger: Thank you, Dr. Chugh. I don't know how many engineers we have out in the crowd here today. But me being one, I certainly appreciate the work Paul has done. The bottom line is: it is going to make our mines better designed, better planned and is going to improve costs for us in the long run. I think that is what we are all shooting for here.

We are running a little bit ahead of schedule. Just a program note. Tim Burgess has been listed for the Fletcher presentation. But Tim got tied up with some business, and we have a suitable replacement in Gene Wilson. Gene is the Manager of Product Development for J. H. Fletcher Co. He is located in Huntington, West Virginia. Gene has a B. S. in applied science and electrical mechanics from Miami University in Oxford, Ohio. He has worked with mobile roof supports and the design of roof bolters since 1989 with Fletcher, and, prior to that, he was involved in miner drum design with several other companies. Gene is going to talk about mobile roof supports for pillar extraction; we are real interested and curious to see what Gene has to say.

Gene Wilson: Just from sitting up here and listening to what is going on, there appears to be some pretty exciting things going on out here. I would like to first of all thank you all for having us up here. As Dick said, Tim couldn't quite make it today; he is kind of tied to his desk. I do some of the R&D work.

The mobile roof supports have just come out of R&D and gone into the production department; I have been involved with them for quite some time.

TECHNOLOGY DEVELOPMENT FOR REMOTE, COMPUTER-ASSISTED OPERATION OF A CONTINUOUS MINING MACHINE

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ABSTRACT

The U.S. Bureau of Mines was created to conduct research to improve the health, safety, and efficiency of the coal and metal mining industries. In 1986, the Bureau embarked on a new, major research effort to develop the technology that would enable the relocation of workers from hazardous areas to areas of relative safety. This effort is in contrast to historical efforts by the Bureau of controlling or reducing the hazardous agent or providing protection to the worker. The technologies associated with automation, robotics, and computer software and hardware systems had progressed to the point that their use to develop computer-assisted operation of mobile mining equipment appeared to be a cost-effective and accomplishable task. At the first International Symposium of Mine Mechanization and Automation, an overview of the Bureau's computer-assisted mining program for underground coal mining was presented. The elements included providing computer-assisted tele-remote operation of continuous mining machines, haulage systems and roof bolting machines. Areas of research included sensors for machine guidance and for coal interface detection. Additionally, the research included computer hardware and software architectures which are extremely important in developing technology that is transferable to industry and is flexible enough to accommodate the variety of machines used in coal mining today. This paper provides an update of the research under the computer-assisted mining program.

[1] Presented by John J. Sammarco, U. S. Department of the Interior, Bureau of Mines, Pittsburgh Research Center, Pittsburgh, Pennsylvania.

BACKGROUND

Need for Research

Coal is the United States' most abundant fossil energy resource and constitutes over 80 percent of all nonrenewable energy reserves. At the present consumption rate, recoverable reserves of coal will last 240 years. About 80 percent of the coal mined in the United States is used to generate electricity, and coal comprises about 54 percent of the nation's electrical generating capacity, with the balance coming from nuclear, natural gas, hydroelectric and petroleum sources.

Inevitably, coal will become more difficult and potentially more hazardous to mine as miners are forced to tap into deeper and thinner seams. In 1991, according to preliminary data from the Mine Safety and Health Administration (MSHA), 61 coal miners were killed and 14,077 more were injured in coal mining accidents. For coal-generated electricity to remain affordable, future coal prices must remain competitive with alternative energy sources, while at the same time hazards to miners must be mitigated. This will be possible only through using mining systems that are more efficient and that reduce worker exposure to hazards.

New Approach

The U.S. Bureau of Mines has taken an entirely new approach in its research to solve these problems. Recent advances in automation technologies, particularly the development of fast, inexpensive computers, control software design and sensing technology, may potentially improve mining efficiency and worker health and safety.

For example, it is now possible to envision the relocation of mine workers from the relatively dangerous mine face, where many accidents occur, to a protected control center from which the operators can direct the activities of their machines via graphic, video game-like computer terminals (fig. 1). As a result, injuries, deaths and health problems due to noise and dust can be significantly reduced, and more coal can be extracted because of increased precision in controlling equipment in confined spaces.

The mining industry is cautiously optimistic about the potential benefits of computer-assisted mining. One major equipment manufacturer intends to follow the Bureau's work very closely, to the point of signing a formal Cooperative Research and Development Agreement.

Research Program Design

The Bureau's research program in computer-assisted coal mining involves the development of critical technology necessary to allow computer-assisted operation of all mechanized equipment normally used at the face for room-and-pillar mining while permitting workers to be located away from the active face area. The Bureau is developing the technology that will allow the operation of the equipment to cut a system of 3 to 5 parallel passageways, or "entries," and the connecting cross passageways ("cross

Figure 1. Computers and displays such as shown here will permit underground machine operators to control their machines while remaining safely away from danger.

cuts") forming what is termed a room (passageway intersections) and pillar (blocks of coal between entries) mine. The equipment includes a 50-ton continuous mining machine, a roof bolter and two shuttle cars to haul the coal to the end of the belt.

Researchers foresee that the actual skills needed by mine workers of the future to operate the equipment will be substantially less than is required today. However, it will be a long time before a system is intelligent enough to handle all potential situations or avoid trouble, such as recognizing and freeing itself from a roof fall. In the near term, human interaction will be greater. Future miners will have be knowledgeable of—although not necessarily skilled in—traditional mining methods. The system will not be complicated, and present miners should have no trouble learning to use the control system. However, repair of the system will require highly trained personnel, as will the process of improving the software to be optimal for a particular mining geology.

Many mine workers understandably are concerned about the prospects for increased mining automation and its impact on future jobs. However, economic studies indicate that increases in underground automation technology are inevitable if the mining industry is to be competitive in the world energy market and survive in the future. In addition, the impact of computer-assisted mining on jobs in the foreseeable future should not be great because of the very nature of the mining process and the underground environment, and the difficulty of developing intelligent mining systems that can function autonomously in that environment.

The technologies for computer-assisted mining are being developed by building upon conventional, mechanized mining equipment used in well-understood mining methods.

By using familiar machines in familiar ways, the Bureau hopes to avoid confronting the barriers traditionally associated with introducing radical new machines and mining methods. This conservative objective means that continuous mining machines, roof bolting machines, haulage systems (both shuttle car and continuous) and mine ventilation systems will be transformed into computer-assisted, remote-supervised machines operating in well-understood situations.

For its initial research, the Bureau has targeted the continuous mining machine because it brings into play a number of research issues and is available commercially as a manually remote-controlled machine which can directly accept a computer's electrical control signals. Most of the technologies developed for the continuous mining machine will be applied, as appropriate, to the other equipment once the concepts have been proven and demonstrated.

Researchers are assessing other machines and systems used at the face to determine their readiness to accept computer control or whatever other special technology capabilities are needed beyond those required by the continuous mining machine. Continuous haulage systems have been assessed recently, and a simple application of the developing mining machine control technologies can be used to bring the best continuous haulage systems to a state of computer-assisted control. Computer-aided driving of shuttle cars is being investigated and poses special considerations in guidance technologies because of the range and speed of the vehicle. The maneuvering of roof bolters shares guidance and control issues with the mining machine. However, two major activities, ventilation and roof bolting, characterized by their dependence upon the manual skills of the worker, require and are being given special attention. Ventilation methods and equipment typified by the setting of line curtains, the positioning of auxiliary fans and the monitoring of air quality, which requires manual measurements of air velocity and methane, currently are manual, nonmechanized activities.

Researchers at the Bureau's Pittsburgh (Pennsylvania) Research Center also are investigating ways for mechanization and eventual remote deployment of ventilation systems and for possible uses of remote sensing instrumentation for environmental measurements.

The drilling, installation and setting of roof bolts is largely a mechanically-assisted, human operation. A major effort is underway at the Bureau's Spokane (Washington) Research Center to design and build an automated roof drilling and bolting machine using advanced computer-aided design and engineering tools. Research is also being conducted to develop drilling parameter sensors and methods for strata analysis during the drilling of the holes for the roof bolts.

Strata-sensing and analysis are essential for the proper assessment of roof conditions and the placement of bolts when human operators are no longer located at the bolting machine. Additionally, recent Bureau advances in ground penetrating radar, developed to measure and control the thickness of roof coal, can also measure the thickness and depth of the strata for 1 to 2 meters above the roof where the bolts are usually anchored.

The Bureau's goal of relocating the operator away from the coal face, while maintaining or improving machine performance, requires the development of a computer control system which is programmed to react quickly and predictably to instructions from the attending operator and to the information provided by various sensors. Thus the computer, using sensors and a computer program, must provide the same feedback control that is now normally provided by today's operator. Currently, the operator stands within sight and sound of the machine and works the controls of the remote control console in response to both the operator's observations and knowledge of the tasks the machine is to accomplish.

The foregoing vivid image suggests the major technical areas of research:

- Selecting and mounting position sensors on the parts of a machine that move, such as the appendages of a continuous mining machine (the cutter drum boom, gathering pan, conveyor tail and stabilizer jack).
- Computer control programs that account for the delays and coasting inherent in the appendage response to electric and hydraulic actuation.
- Sensors to measure the position and orientation of the machine and mine features relative to the surveyor's coordinates and to each other.
- Coal interface detection sensors that keep the machine in the coal seam and prevent it from cutting noncoal roof and floor.
- A computer control program that can receive an operator's instructions such as "mine the entry to a depth of 20 feet," and execute those instructions by converting them into a sequence of machine actions that are altered and controlled by sensor data.

Additionally, sensor-based, computer-assisted machine fault diagnosis and predictive maintenance programs are an essential technology in the research because they will be the key to reducing down time of the mining equipment by speeding repair and guiding preventive maintenance.

RESEARCH ACTIVITIES

Following are some of the Bureau's principal activities, accomplishments, and ongoing efforts.

Long-range Plan. A research group at the Pittsburgh Research Center was formed in the mid-1980s to conduct the pioneering research and planning for this major effort. A long-range plan was written that detailed the need for and benefits of the research effort as a means to fulfill the Bureau's mission. It also detailed the technology areas and gaps that needed research and laid out milestones and coordinated the efforts between centers. Several researchers were hired to provide specific mechanical, electrical systems and computer expertise needed for the effort.

Support Services. A research undertaking such as this one depends on a number of support activities and facilities. Machinists and mechanical and electrical engineers must design modifications to the machine, install sensors, build support equipment and work closely with the U.S. Department of Labor's Mine Safety and Health Administration (MSHA) for electrical approvals. A network of computer workstations was set up to support computer software development. An expansive enclosed surface test facility existed at the Pittsburgh Research Center, but an experimental mine had to be located. Two control centers were built—one that remains at the Bureau's surface test facility and another for use underground. Each provides a relatively comfortable environment for researchers and the computers required for the experiments. The required experimental approvals from MSHA had to be obtained. Finally, two mining machines and their control systems had to be maintained; one, at the surface test facility, was an old machine used for preliminary studies, and the other was a new machine, described below.

Continuous Mining Machine. After preliminary investigation and experimentation on an existing mining machine at Pittsburgh, a state-of-the-art, commercially-available continuous mining machine was acquired by the Bureau in January, 1989. This machine is representative of those used in most room-and-pillar sections in U.S. coal mines. It has a cutting width of 3.3 meters (11 ft)and can work in a mine section up to a roof height of 3.2 meters (10 ft). The machine can be operated from the operator's cab, but is usually operated by radio remote control. The crawler track motors are two-speed using a solid state controller. The movement of the machine appendages is controlled by electrically operated hydraulic valves, which are either fully open or fully closed. The operator, standing near and within line-of-sight of the machine, depending on where experience tells the operator is the best point for the activity to be controlled, has full control over the machine from a remote control console consisting of levers and switches, that hangs from a neck strap (fig. 2). The operator can see and hear the machine and uses this as feedback for controlling, for example, the cutter motors, height of the cutter drum, and direction and height of the conveyor discharge at the rear of the machine from which the cut coal is deposited into a waiting haulage vehicle. The operator uses levers, one for each crawler track, to control machine motion. Similar levers control cutter boom and conveyor discharge position.

Several large, explosion-proof enclosures, measuring 0.75 by 0.68 by 0.30 meters (2.5 x 2.2 x 1.0 ft), were added to the machine to house the power supply,

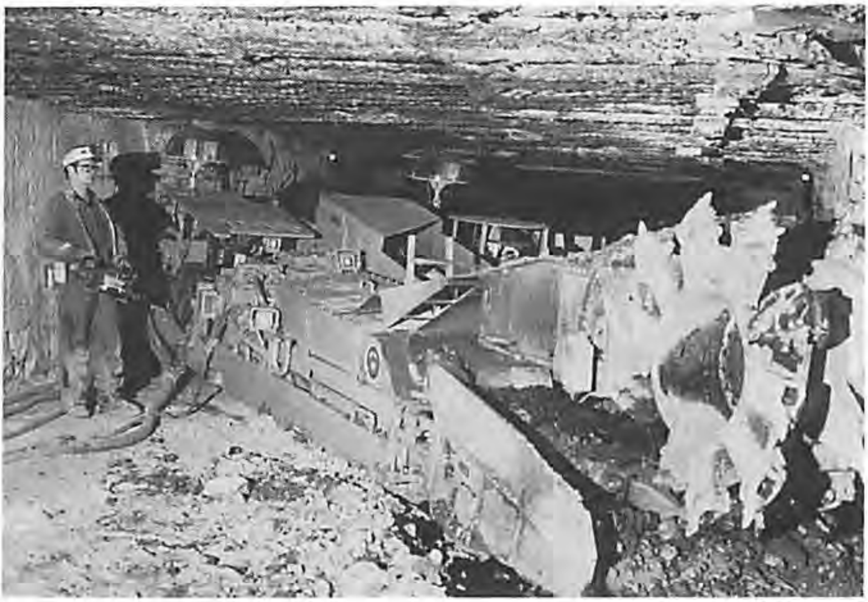

Figure 2. An operator controls a continuous mining machine using a radio remote control, "pendant" console-levers and switches hanging from a neck strap. Being able to relocate the operator to a haven of safety is the Bureau's research goal.

computer system, and sensor interface electronics for an external data acquisition system. Two television cameras were mounted near the rear of the machine; the one on the left side is mounted on a pan-tilt head, while the other is mounted on the right in the operator's cab to provide a fixed view of the cutting head. A TV monitor in the control center simultaneously displays both pictures on a single screen.

In January 1991, when the installation of sensors and computers (described in more detail later) was completed, the mining machine and the underground control center were installed in an experimental production section of an underground mine provided for the Bureau under a Memorandum of Agreement with the Marrowbone Development Corporation, of Naugatuck, West Virginia (fig. 3).

Figure 3. Experimental computer-assisted continuous mining machine, surface control center and underground control center. The machine and underground control center supported underground experiments from January, 1991 to January, 1993.

Since that time, experiments have been conducted on machine appendage control, machine guidance, sensors for the detection of the coal-roof boundary and simple automated mining cycles, using a script as the source of computer commands to the machine. Each experiment was first conducted at the surface test facility before being performed underground. Two milestones achieved underground were the nonline-of-sight teleoperation of a continuous mining machine and the hands-off computer control of the cutting cycle of a continuous mining machine.

Machine Control System. The machine control system provides all machine actuations and executes control of machine appendages. The technology deals with appendage sensors and the response times of the electro-hydraulically actuated appendages to the electrical control signals from the control computer.

All of the machine appendages, the cutter boom, gathering pan, conveyor tail (both left and right and up and down motions) and stabilizer jack (foot) pivot on hinges. The basic sensor must measure the angle between the appendage and the body of the mining machine. Precision potentiometers, which can be connected so that they produce an electrical voltage proportional to the rotation of their shaft, were mounted at suitable locations to the body of the mining machine in explosion-proof enclosures for protection. The potentiometer shaft was connected to the appendage by a linkage. Because of space limitations, a clinometer, a sensor that reports direction of gravity (down), was mounted on the stabilizer jack to measure its approximate position relative to the machine.

Surface and underground experiments were conducted with loaded and unloaded appendages to establish appendage response to the electrical control signals. Simple algorithms were developed for each appendage and programmed into the on-board machine control computer. Thus configured, the machine computer could be commanded not only to "raise the cutter boom," followed by a "stop," but also to "move cutter boom to 25 degrees." Positional control accuracies of all appendages exceed the requirements for accurate mining.

Experiments were also conducted to determine the response characteristics of the machine from the point where the electrical signals actuate the tram controls. Such parameters as the time delay to first motion and to final speed, the final speed values, turning centers, radii and speed were determined. These parameters are used in the motion control programs that take data from a position sensor. Some of these parameters will vary randomly depending upon the mine floor conditions and make accurate motion control a challenging task.

Computer System. The computer system is used to coordinate the actions of the machine appendages and machine motions to perform useful work. At the lowest level, the computer system must provide the electrical signals (that is, "on" or "off") to the actuators and must gather sensor data. At the higher levels, it provides the coordination of the appendages and machine movements to perform the sump and shear operations. At even higher levels, it must coordinate these cutting actions to perform the cutting of entries and cross cuts. At each of these levels, the computer system must perform these maneuvers based on interpretations of sensor and stored data from a multitude of sources.

The Bureau's first control system was designed to execute control scripts, a listing of machine commands that are followed in order. The task was to perform a cutting cycle. In simple terms, the actions involved raising the cutter drum close to the roof, advancing the machine and thus the cutter .35 meters (1.1 ft) into the coal near the roof and lowering the cutter to the floor; this ripped the coal from the face. The commands in the script supplied the machine control computer with the name of the appendage or track movement and the position desired. The machine control computer on the machine or navigation computer then issued low-level actuator commands and used sensor data to track progress and halt the action when the desired position was reached. The script was written, stored and executed from a computer workstation using a program designed for this purpose. A network of microprocessors handled the flow of commands between the workstation, laser navigation and machine control computer.

Computer-assisted control of the machine requires much more complex and interactive actions than that provided by scripts. Bureau researchers are now engaged in developing a more comprehensive control system. As pointed out earlier, the computer should respond quickly and predictably to sensor or operator input. In control jargon, these response characteristics are termed "real-time" and "deterministic." The Bureau has chosen to apply the tenets of the real-time control system architecture developed by The National Institute of Standards and Technology (NIST) for the U.S. space program. Under a Memorandum of Agreement with the Bureau, a prototype computer architecture called MASREM (Mining Automation Standard Reference Model), patterned after a similar model developed for the National Aeronautics and Space Administration, was produced for the complete automation of a mining system.

The control architecture and software design resembles an organization chart of a business or military unit. Although much too complex to describe here, its essential elements are as follows:

The software program is composed of a number of small modules each of which acts in the same way, but on different data. A "chief" at the top receives a command such as "mine entry to depth of 40 feet." This chief, who has a "card file" of all the commands that can be given to it, recognizes that a new command has arrived and finds the "card" that matches "mine entry to depth of 40 feet." This card has a list of conditions and commands, or job assignments, to be given to each of several subordinates. Each subordinate is a specialist and has a specialized group of commands it coordinates. The chief gives each of the subordinate modules the command that it is expected to do. These subordinates do exactly what the chief did, looking up the "file card" for that command, and issuing the commands listed on the card to their subordinates, and so on down the organization.

Each "card" also contains instructions on what sensors to be looking at while assigning commands to the subordinates; sensor data can cause instructions to be skipped, halted or altered. At the bottom, the commands on the "card" are pure actuator "on" or "off" commands directed to a specific actuator, such as a cutter motor, or cutter boom up. Each subordinate also reports to the immediate supervisor that it is either executing, done or has encountered a fault. The entire process repeats from top to bottom about 20 times a second. Because actions of the mining machine take time, each subordinate is reporting "executing" to its supervisor most of the time, although it is checking sensors and machine progress 20 times a second.

The contents of each of the "cards" in each module is written by researchers who must have detailed understanding of what and how tasks, like mining coal with a mining machine, are done. The process which defines all of the commands and how they are distributed among the modules is termed task decomposition and is the first and most important step in developing a hierarchical control system.

Navigation and Guidance. The objective of the current research on navigation and guidance is to develop a sensing system that provides position and heading data that are accurate enough to support the development and testing of the computer software for motion control and coal cutting algorithms. Computer-assisted guidance requires data of two types: First, the position and orientation of the machine on a coordinate grid, which is analogous to latitude, longitude and compass directions or bearings and, second, the position of physical obstacles such as the ribs and face in relation to the machine. The entries and crosscuts developed as the mining machine advances under computer control could be stored in a map to be used for navigation by shuttle cars and scoops. Three systems are under various stages of development that provide the coordinate information for continuous miner guidance. Two systems are being investigated that provide the distance and direction of obstacles from the machine.

Two coordinate measurement systems, which require the accurate placement of sensors in the mine entry directly behind the mining machine, have been developed. Both use triangulation methods. One system uses two lasers located at the rib on either side of the entry and behind the machine. The lasers track the angles to two reflecting targets on the rear corners of the mining machine. The other uses four "string transducer" sensors mounted in pairs in a location similar to the lasers. Each sensor reports the length of a thin steel cable running from the sensor to hooks where it is attached to the rear corners of the mining machine. Trigonometry is employed in both systems to provide the position and orientation of the machine.

A third system—still under investigation—is an inertial system that uses the high technology of the military. The inertial system uses high-tech laser gyroscopes and acceleration detectors to calculate changes in position and orientation of the machine by sensing its motion.

The Bureau is investigating ultrasonic ranging sensors placed strategically on the mining machine to provide machine-to-rib distances to the rear and along both sides of the machine. Such data will be instrumental in establishing computer-assisted machine guidance for entry navigation for all but the most demanding movements. Additionally, the Bureau and the Field Robotics Center at Carnegie-Mellon University are working to obtain a perimeter scanning (lighthouse) laser ranging sensor that will provide the distance to all surrounding obstacles or ribs. The major design obstacle is engineering the equipment so that it is rugged and safe to use in methane atmospheres, an MSHA requirement for all electrical devices used near the face. When mounted on the machine, it would provide the obstacle data for computer-aided motion control.

Any of these navigation systems, to a greater or lesser degree, are directly applicable for computer-assisted control of the movements of roof bolters, shuttle cars, continuous haulage systems and other mobile machines used at or near the face.

Coal Interface Detection(CID). One of the most difficult problems that the Bureau faces in developing computer-assisted mining is what is termed "in-seam guidance," that is, keeping the cutting head of a mining machine within the desired boundaries of a coal seam, regardless of the type of geology encountered.

The effectiveness of a CID sensor depends strongly on the existence of measurable differences in some property of coal and rock. Consequently, the Bureau developed extensive laboratory capabilities at the Pittsburgh Research Center and is collecting samples and making field measurements in order to obtain fundamental properties of coal and the adjoining roof and floor strata in major U.S. coal seams. These properties include mechanical, thermal, nuclear, optical, chemical and electrical parameters. By understanding these properties, the Bureau can use them to help identify which sensor(s) would be most appropriate for a particular coal seam.

Many different concepts are being investigated, including vibration, natural gamma radiation, infrared (IR) thermography, x-ray fluorescence and synthetic doppler radar. Since each sensor has its own advantages and limitations, the concept of combining the outputs of several sensors to approach the performance of an ideal sensor is also under investigation.

The most promising CID techniques include commercially available natural gamma radiation coal-thickness sensors and thermal-imaging video cameras and analysis software, as well as synthetic doppler radar and a variety of machine data, such as cutter motor currents. Direct video and auditory signals can be used, but require a human for interpretation and manual control when cutting near the roof or floor. Techniques for rapid computer discrimination between machine vibrations (or acoustic noise) caused by cutting coal or that from cutting the roof or floor material, are being pursued with moderate success.

The thermal imaging camera was successfully used to detect and control the height of the cutter boom for a demonstration at an Open Industry Briefing in April, 1992. The thermal imager, which presents an object-temperature picture rather than a reflected-light picture of the scene, was placed some distance behind the machine so that it viewed the cutter drum as it approached the roof. Bright spots appear in image that indicate frictional heating when the cutter bits contact the harder material of the roof.

A commercial video surveillance system was used to automatically indicate when the bright spots appeared. The resulting alarm signal was routed to the control computer to stop the upward motion of the cutter boom. This concept holds promise and efforts are underway to refine the system for this specific application.

Machine Diagnostics. Downtime of a mining machine during production is costly and becomes even more so with computer-assisted machines, since a more productive and expensive machine is involved. Predicting component failure for planned maintenance and quick fault diagnosis with efficient repair are important factors in reducing machine downtime. The detection of malfunctions or deteriorating components must use sensors, and resulting data must be processed by a computer in real time. The final result will be for the computer either to make a recommendation to a human for maintenance or to point out the location of the faulty part and specify a procedure for its replacement. The nature of the problem suggests the utilization of expert systems that use sensor data as input.

The Bureau demonstrated an interactive troubleshooting aid to help or train maintenance personnel in the identification of control malfunctions in the pump, tram, conveyor and cutting electrical circuits.

A sensor-based hydraulic diagnostic expert system has been developed. It uses 38 sensors and can diagnose faults in the five functional hydraulic circuits of the mining machine at the Bureau's surface test facility. However, such diagnostic expert systems are highly machine-specific, and further development beyond proof that the concept works has predominantly been left to equipment manufacturers.

Research is also underway on methods for the early detection of electrical failures of "mining machine type" motors by examining the voltage and current phasers during the steady state operation of a motor. Insulation breakdown is the usual failure mode. Adaptive learning networks are being applied to the analysis of the phaser signals.

SUMMARY

As can be seen, the U.S. Bureau of Mines research program on computer-assisted mining is making steady progress. The results of the underground experiments in guidance, computer control and coal interface detection technology during 1991-92 have been highly successful. These experiments allowed researchers to gain practical experience and to demonstrate technologies to the mining industry. Valuable knowledge is being obtained by subjecting the equipment to the rugged mining environment and from feedback from mine personnel.

A substantial number of mines are not likely to use computer-assisted equipment until sometime after the turn of the century, but some elements of this technology are almost certain to be adopted within the next few years.

That concludes my presentation on our computer-assisted mining program. I'll take any questions you may have at this time.

Question: You mentioned that you had been looking at roof-coal interface detection. Have you done any work or are you planning to do any work on detecting floor-coal interface, especially with soft floor conditions?

John Sammarco: Yes. All these examples I was pointing out point towards the roof. That was the first area we looked at. That radar system that we developed, with which we won the R&D 100 award, can look down into the floor as well and tell you what you have, so you can avoid mining any of the floor material; it looks at both the roof and the floor.

If there are no other questions, I'd like to thank you for this opportunity to speak and tell you about some of the research that is going on at the Bureau of Mines. Thank you.

Dick Reisinger: Thank you, John. I would like to extend my appreciation to all the speakers today: John Sammarco, Gene Wilson, Gene Willis and Dr. Chugh.

One item of business yet, Heinz tells me, is that we are going to draw for the free tickets for roundtrip travel in the continental U.S. immediately following the adjournment in the registration area. So, you may want to meander up into that area to see who won the tickets. [*David Martin of Vienna, Illinois, won the free roundtrip airline tickets raffled off at the close of the meeting.*]

I want to thank everyone for coming this morning and hope that everyone has a safe trip back to their destinations. And at this time, I will adjourn the meeting.

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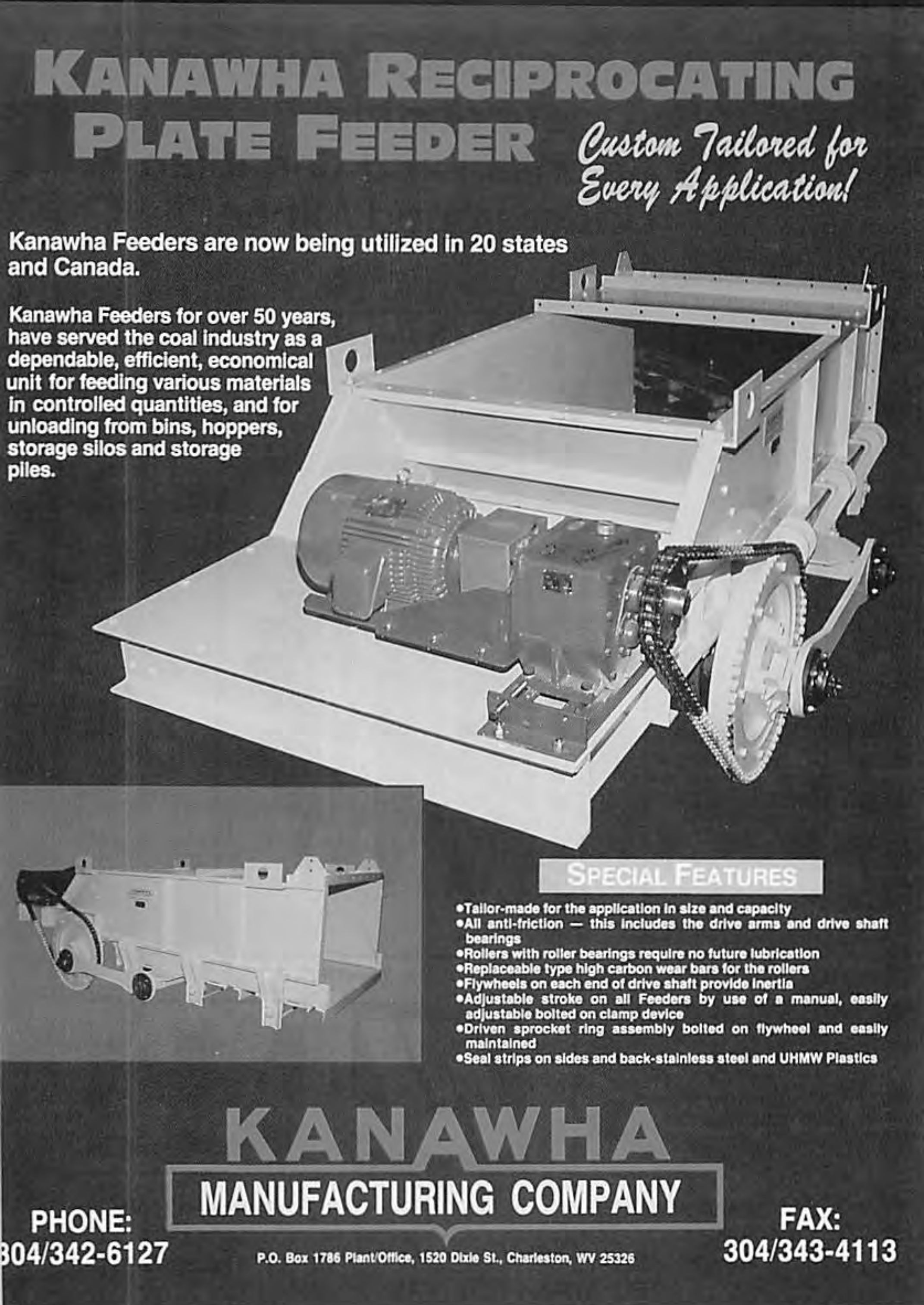
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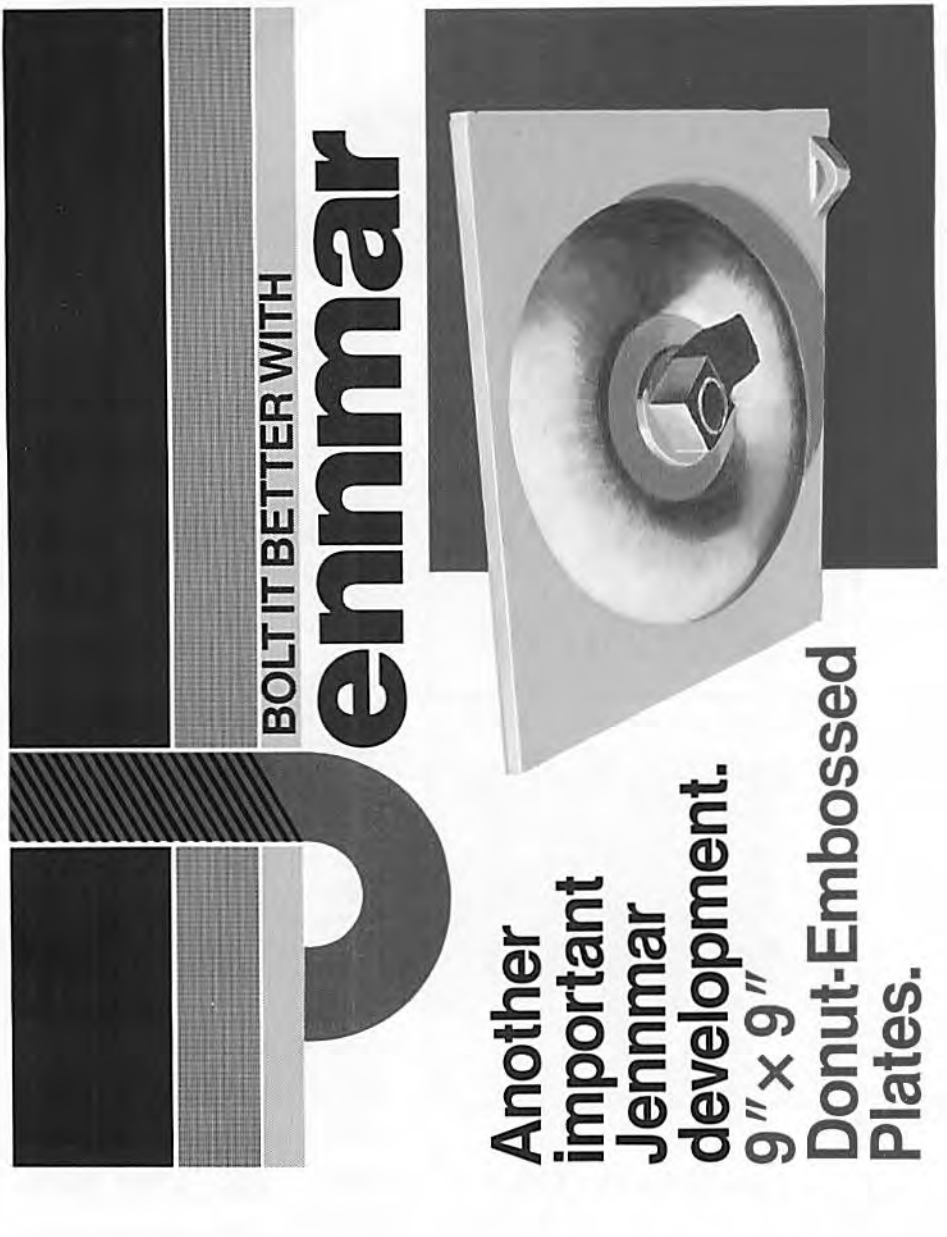
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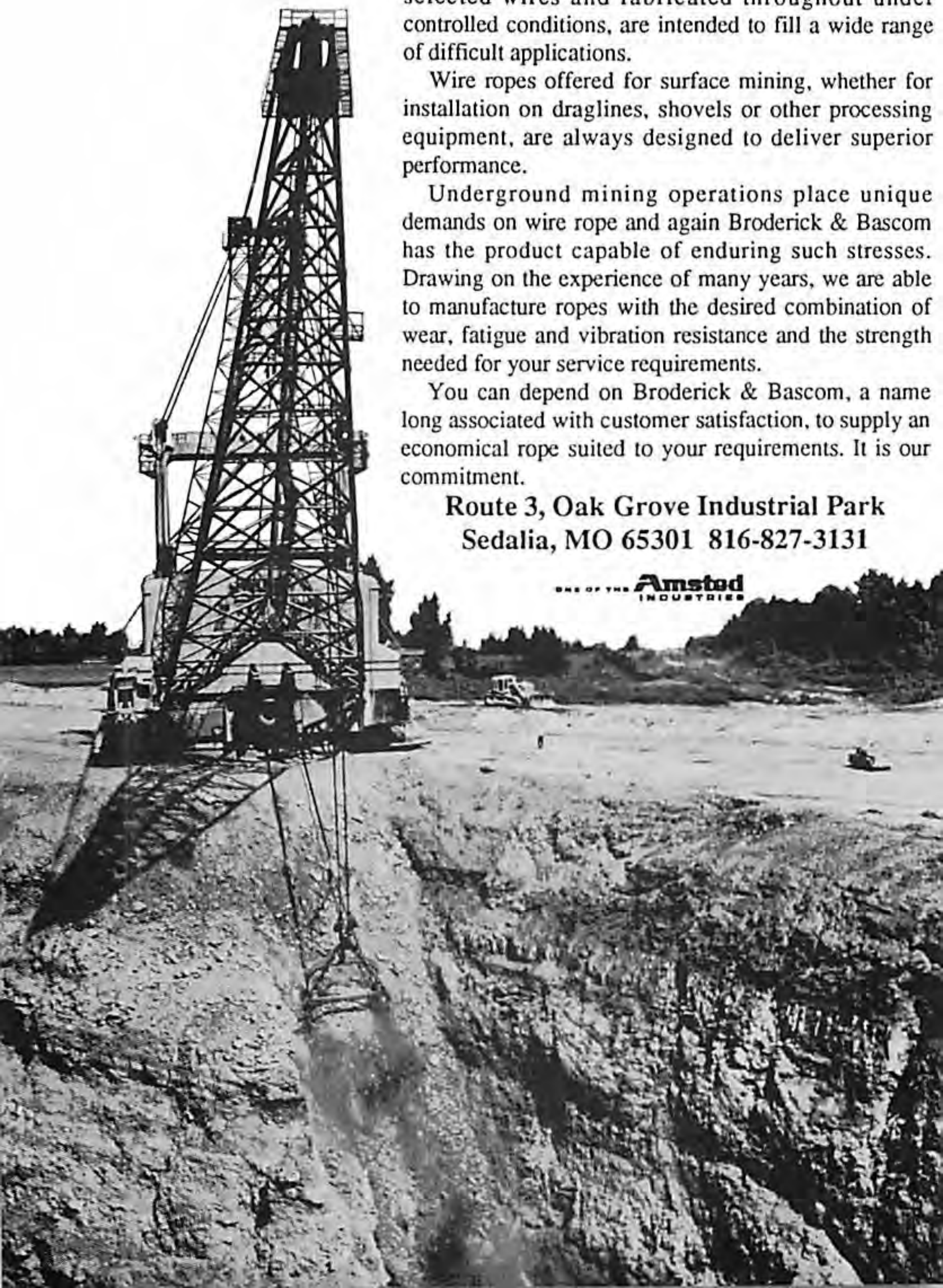

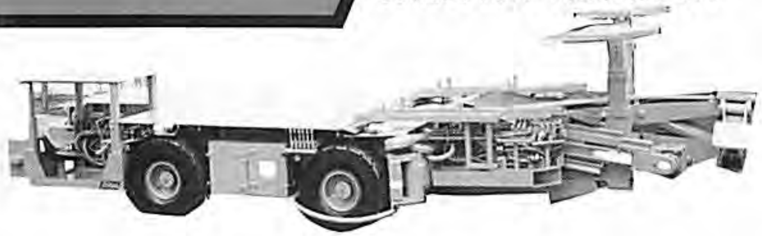

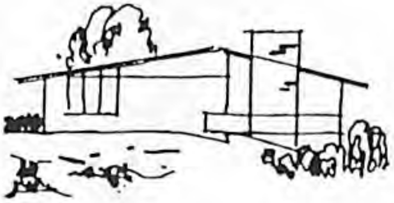

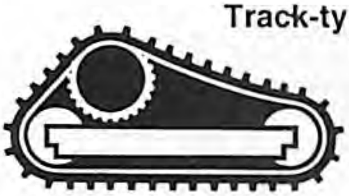

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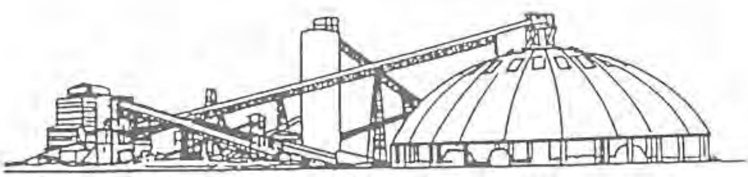

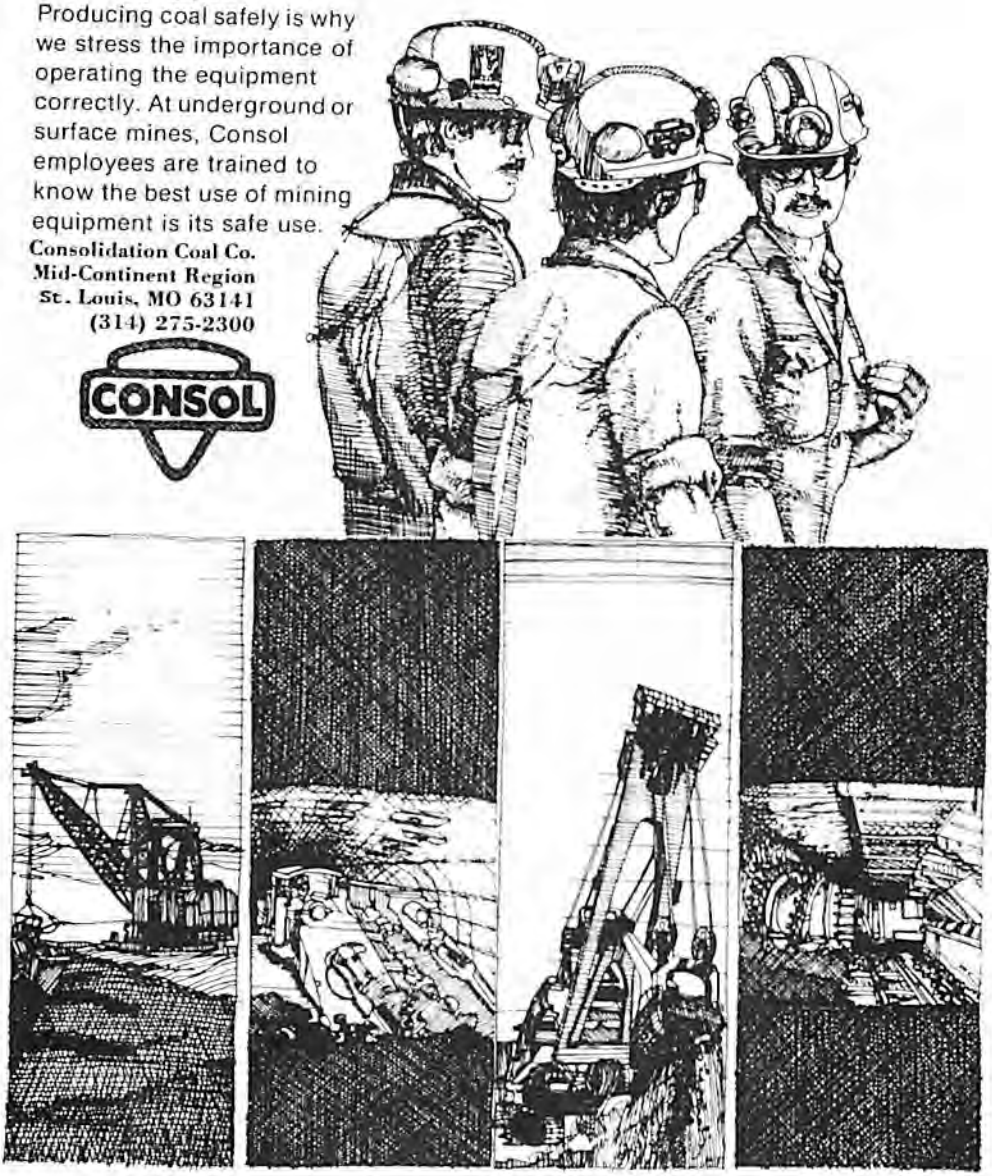

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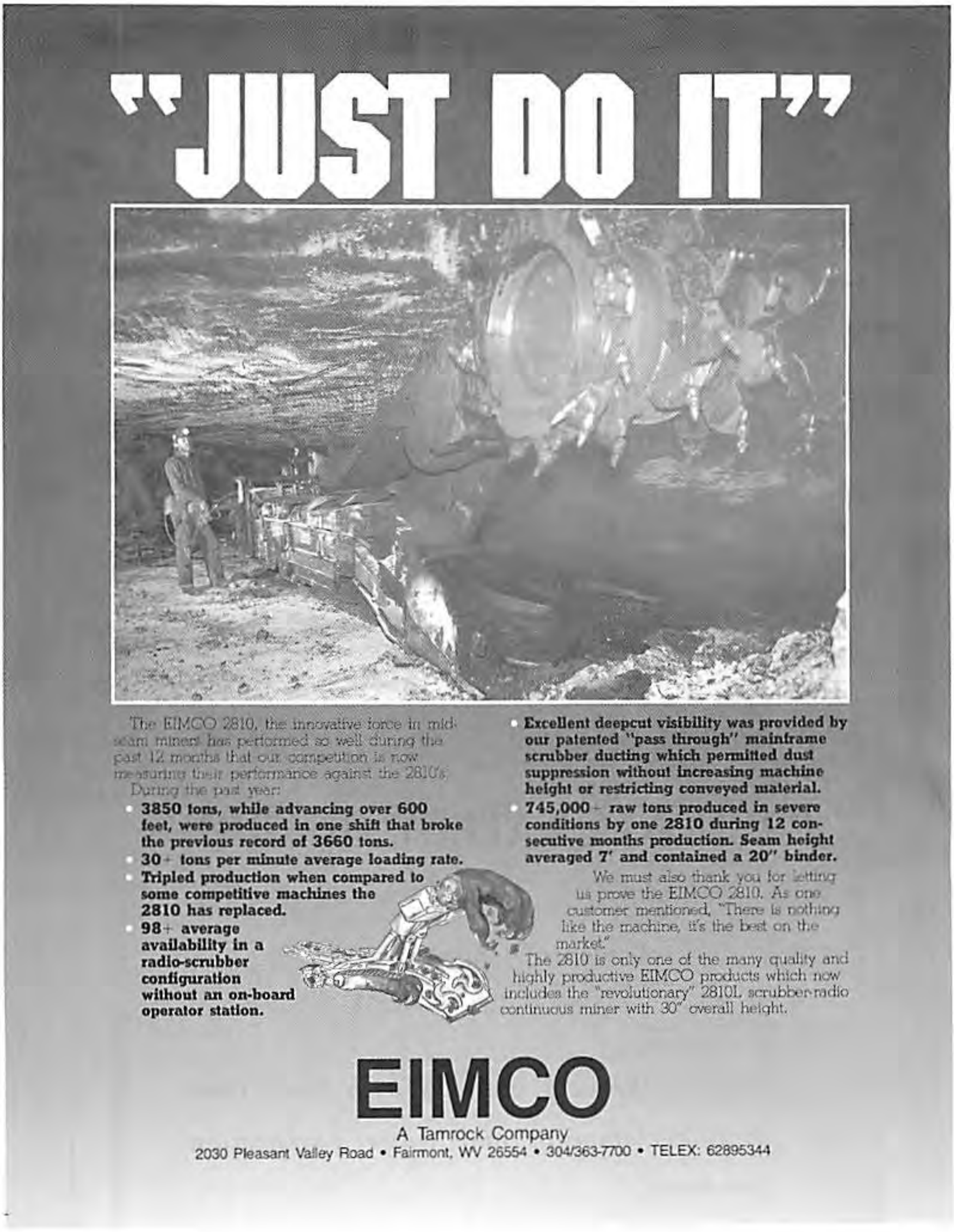
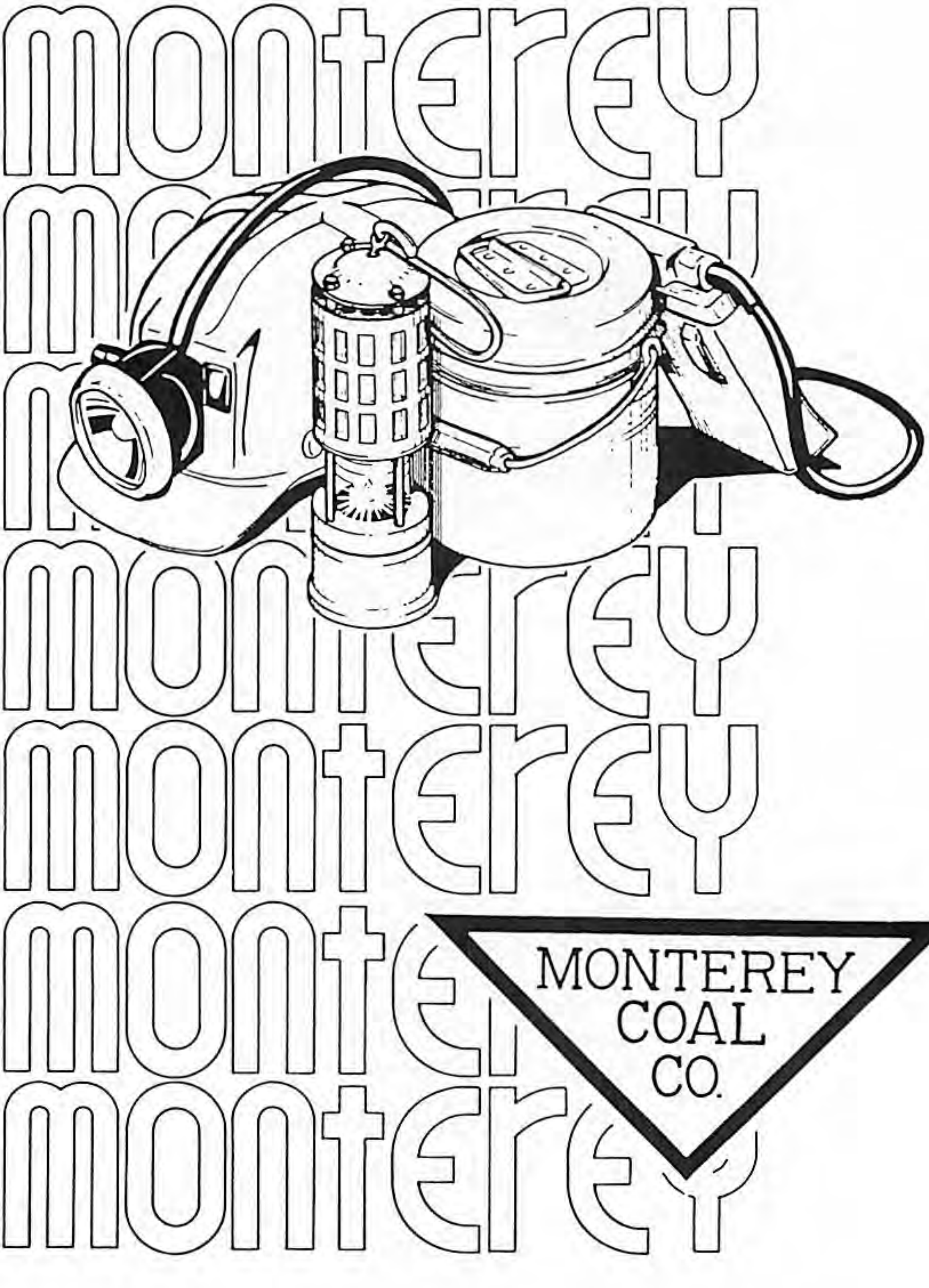

"JUST DO IT"
The EIMCO 2810, the innovative force in mid-seam miners has performed so well during the past 12 months that our competition is now measuring their performance against the 2810's.
During the past year:
• 3850 tons, while advancing over 600 feet, were produced in one shift that broke the previous record of 3660 tons.
• 30+ tons per minute average loading rate.
• Tripled production when compared to some competitive machines the 2810 has replaced.
• 98+ average availability in a radio-scrubber configuration without an on-board operator station.
• Excellent deepcut visibility was provided by our patented "pass through" mainframe scrubber ducting which permitted dust suppression without increasing machine height or restricting conveyed material.
• 745,000+ raw tons produced in severe conditions by one 2810 during 12 consecutive months production. Seam height averaged 7' and contained a 20" binder.
We must also thank you for letting us prove the EIMCO 2810. As one customer mentioned, "There is nothing like the machine, it's the best on the market."
The 2810 is only one of the many quality and highly productive EIMCO products which now includes the "revolutionary" 2810L scrubber-radio continuous miner with 30" overall height.
EIMCO
A Tamrock Company
2030 Pleasant Valley Road • Fairmont, WV 26554 • 304/363-7700 • TELEX: 62895344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MONTEREY
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NAYLOR... The Pipe You Can Count On For Total Service

Whatever your piping needs, you can depend on Naylor to meet both your standard and special requirements.

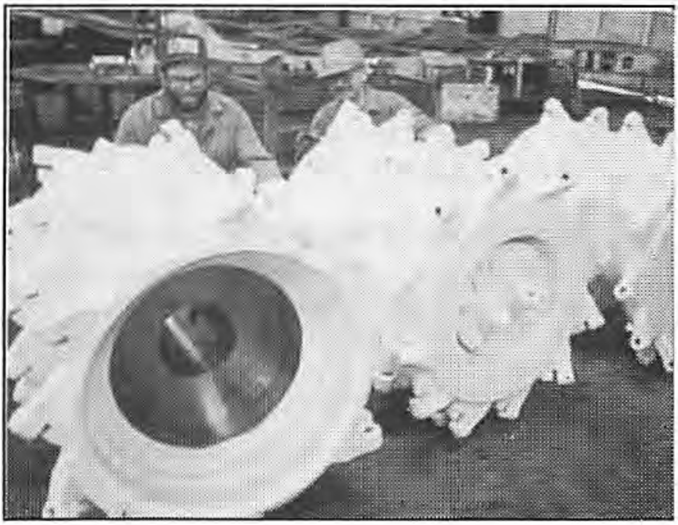
For general service such as water supply, de-watering, compressed air and ventilating, Naylor can provide spiralweld pipe of basic carbon steel in either the lockseam or buttweld construction.

For abrasive service such as dredging, sand and gravel conveying and tailings, product or slurry lines, Naylor can supply spiral buttweld pipe in special analysis, abrasion-resistant steel.

In addition to pipe ranging in sizes from 4" to 72" in diameter and thicknesses from 14 gauge to ½" wall, Naylor offers a complete line of fittings, fabrications and connections including the one-piece positive type Wedgelock coupling. Special coatings and linings to meet your particular requirements round out Naylor's total service.

NAYLOR PIPE COMPANY
1259 East 92nd Street
Chicago, Illinois 60619

Tons of Steel Tons of Coal



At Phillips tons of steel can sometimes mean tons of coal. Our number one goal is to get you back in coal production as soon as possible. By stocking core cutter drums, gear cases and more we can react fast to your emergency needs. This commitment to service is just what you've come to expect from Phillips. It's what you'll find everytime you turn to us.

Phillips
MACHINE SERVICE

Harper Industrial Park / P.O. Box 1245 / Beckley, WV 25802
(304) 255-0537

ADVERTISER PRODUCTS AND SERVICES INDEX

Building Materials and Construction

Contractors and Professional Services

(consultants, engineers, drilling, etc.)

Contractors and Professional Services, *cont'd.*

Electrical Equipment

(supplies, motors, cables, lamps and repairs)

Electrical Equipment, *cont'd.*

Mining and Industrial Supplies

Mining and Industrial Supplies, *cont'd.*

Mining Companies

Petroleum Products and Chemicals

Petroleum Products and Chemicals, *cont'd.*

Power Transmission Equipment

(bearings, drives, pulleys, conveyors)

Preparation Plants and Equipment

(services and parts)

Pumps

(all kinds, pipe valves, fittings, hydraulics)

Rubber Products

(tires, belting and hose)

Rubber Products, ***cont'd.***

Steel and Steel Fabricators

(screens, rail, etc.)

Surface Mining Equipment

Transportation

(railroads, trucking, barge)

Underground Mining Equipment

(equipment, replacement parts and rebuilds)

Underground Mining Equipment, *cont'd.*

Underground Roof Support, Safety and Ventilation

Underground Roof Support, Safety & Ventilation, *cont'd.*

Users of coal

(utilities, industry, etc.)

Other

ADVERTISER ALPHABETICAL INDEX

C, *cont'd.*

D

E

F

G

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I

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L

M

M, *cont'd.*

S

T

W

Z