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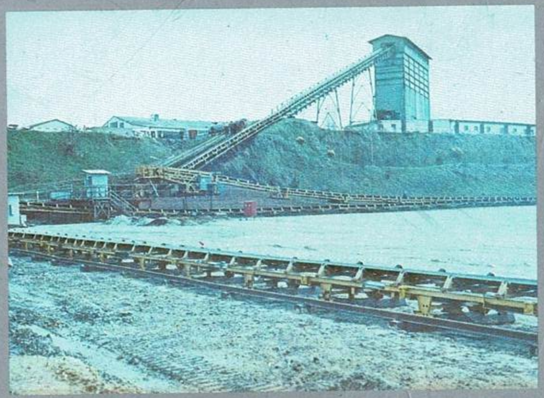
Green Lands

QUARTERLY
SUMMER, 1975



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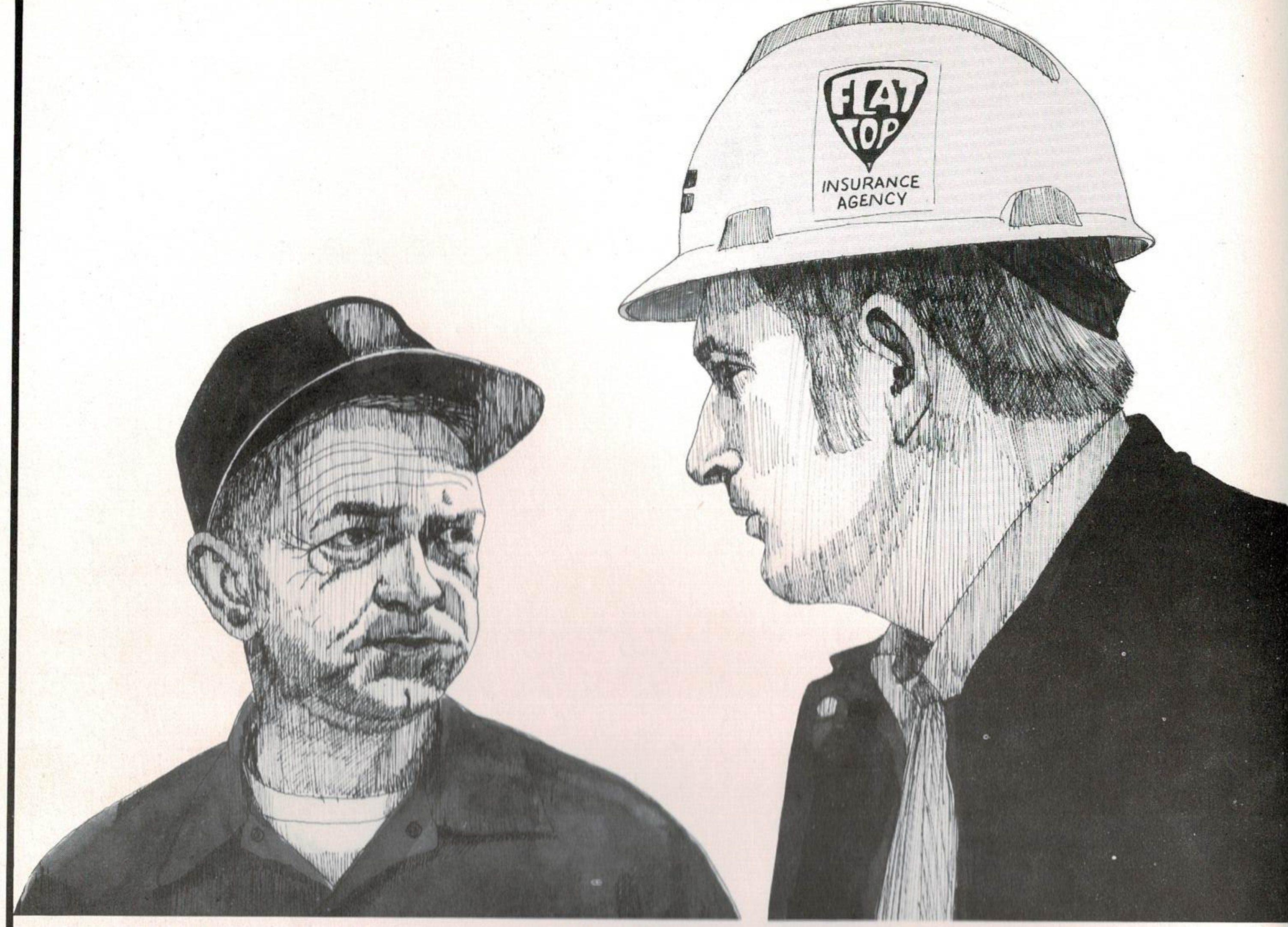

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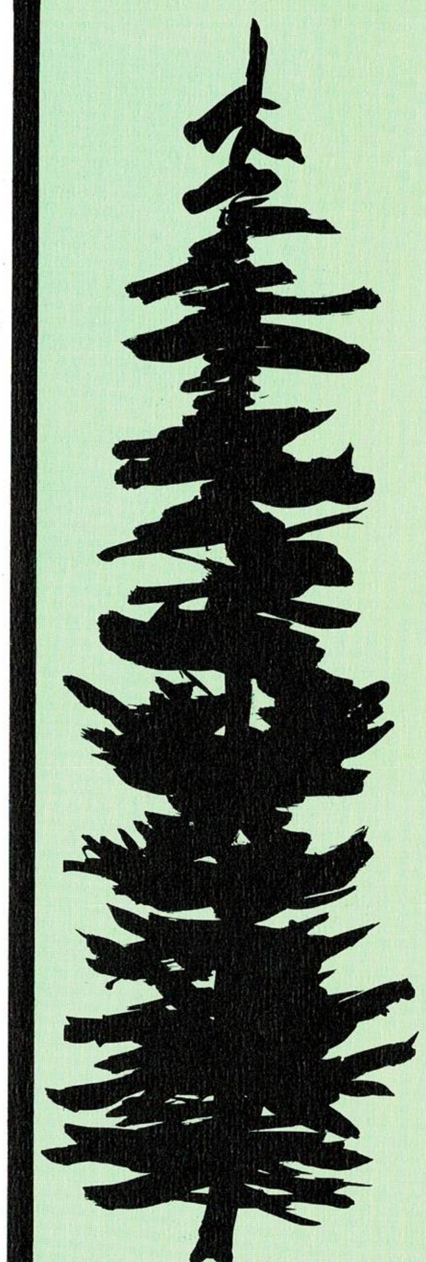
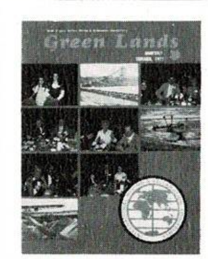
QUARTERLY

Summer 1975

Contents: Summer 1975 **Vol. 5/No. 3**





ABOUT THE COVER

In April, 1975, the West Virginia Surface Mining and Reclamation Association sponsored the first annual International Surface Mining and Reclamation Conference in Dusseldorf, West Germany. This issue of **Green Lands** summarizes the trip and features reprints of papers presented at both technical sessions. A second conference has been scheduled for April 3-10, 1976 in Warsaw, Poland.

International Conference "Complete Success"

The official seal of the International Mining and Reclamation Conference symbolizes the need to "Explore the World of Mining."

In the spring of 1975 the West Virginia Surface Mining and Reclamation Association initiated a unique program to give representatives of the coal industry an opportunity to "Explore the World of Mining." On April 12-19th, the Association sponsored the first International Mining and Reclamation Conference in Dusseldorf, West Germany.

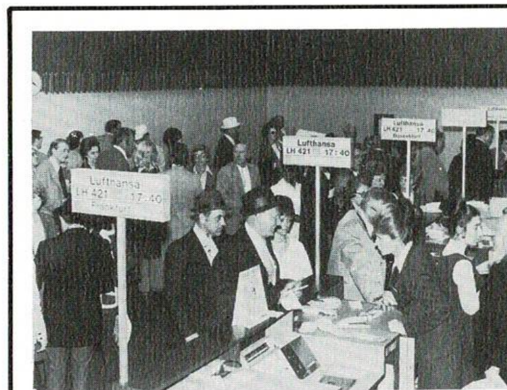
Nearly 200 coal industry people attended the week-long conference which included technical sessions and field trips to mining and manufacturing sites. The conference was designed to investigate the background behind Germany's advanced mining technology.

Interest for the trip was aroused in July 1974, when several members of the Association, accompanied by representatives of the Environmental Protection Agency visited Europe in conjunction with the West Virginia Surface Mining and Reclamation Association's federal grant to study "Longwall Surface Mining." While in Germany, the group visited the famous Brown Coal region near Cologne, where over 100 million tons of coal are surface mined annually from only three pits. They also toured a single-entry longwall deep mine near Walsum, where 22,000 tons are mined daily at a depth of 4,000 feet. In addition the group visited a research laboratory in Essen where studies are being conducted on roof control and a plant in Wuppertal which manufactures longwall supports.

These, as well as many other features, were found to be so interesting that planning was begun for the International Mining and Reclamation Conference (IMRC), which would afford a large number of coal people the opportunity to attend.

Initial contact was made with Lufthansa German Airlines to secure travel arrangements for the conference. The Lufthansa regional office in Pittsburgh was most helpful in coordinating air transportation, ground transportation, hotel accommodations as well as tour guide services. A great deal of cooperation was also received from the German government as well as various mining and manufacturing companies in organizing the presentation of papers and the working functions of the conference.

The Association began the publicity on the conference in December 1974, through its weekly newsletter and announcements to the press. All invitations were in the form of personal letters to coal industry and equipment representatives in nearly every coal producing state. Also, in order to add to the international aspect of the trip, invitations were sent to selected individuals in six foreign countries. Representatives of the various state and federal agencies concerned with coal mining were also given an opportunity to attend to insure a desirable cross-section of government and industry representation.



Some of the 190 delegates begin checking in for Lufthansa Flight LH 421 to Dusseldorf, at the Philadelphia International Airport. Coal industry representatives attending the conference had been transported to Philadelphia via charter flights from Charleston and Pittsburgh.

Due to hotel accommodations and travel arrangements, a limit of 200 participants was established. The initial response from those invited was extremely favorable and assured a near capacity turn-out by mid-January of 1975.

Philadelphia International Airport was selected as the departure point because Lufthansa offered 747 service non-stop to Dusseldorf Airport. Conference participants were transported to Philadelphia via two jet charters; one from Charleston and one from Pittsburgh. Final count at takeoff time showed 190 people from seven states including Pennsylvania, Ohio, Kentucky, Virginia, Tennessee, Alabama and West Virginia.

The seven and one-half hour flight featured cocktails, dinner, a full length movie and breakfast, followed by arrival in Dusseldorf at 6:00 A.M. The first official function was that evening at the Hilton Hotel with a welcoming cocktail party and the "Rheinischer Abend," or traditional German dinner party, featuring a native-dish menu with German beer and wine. Mr. Josef Welzel, Director of the Hemschedt Manufacturing Company in Wuppertal, was most helpful in arrangements for the party and sponsored the social hour. The evening was highlighted with entertainment provided by a nationally famous band comprised of German coal miners. Coal mining is considered a most honorable profession in Germany and the miners take great pride in their work. From this pride, it has become traditional for each mine to have its own band and we were privileged to have one of the finest.

Registration for the conference began Monday morning followed by a kick-off luncheon. IMRC delegates were welcomed to Dusseldorf by an official representative of the mayor's office and the business portion of the conference was underway.

Bergassessor Arnold Haarmann of Montan Consulting Company delivered the opening address, "An Overview of German Deep Mine Technology."

The afternoon technical session featured papers on German surface mining and reclamation techniques, equipment and mining systems, exploration and mine planning and films covering the use of bucket wheel excavators. (The text for all papers given on this day are reprinted in full on pages 18 through 30.) Principal speakers for these sessions were Mr. Ralf Gold, of Dr. Otto Gold Company, independent consulting engineers for geology and mining;

...Nearly 200 Coal People Attend

(Continued from Page 3)

Top: Some of the 120 men who attended the day-long tour of the famous "Brown Coal" region, pile off the busses to their first German open cast mine.

Above: Ralf Gold, of Otto Gold Consulting Engineers, explains the intricate planning involved with large open pit mining. Mr. Gold was one of the main speakers at the opening session of the conference.

Mr. Willi Streck, managing director for the Otto Gold Company; Dr. Karl Benecke, chief mining consultant engineer and Mr. Vic Gaedke, project engineer of the Fried Krupp Company, excavator department.

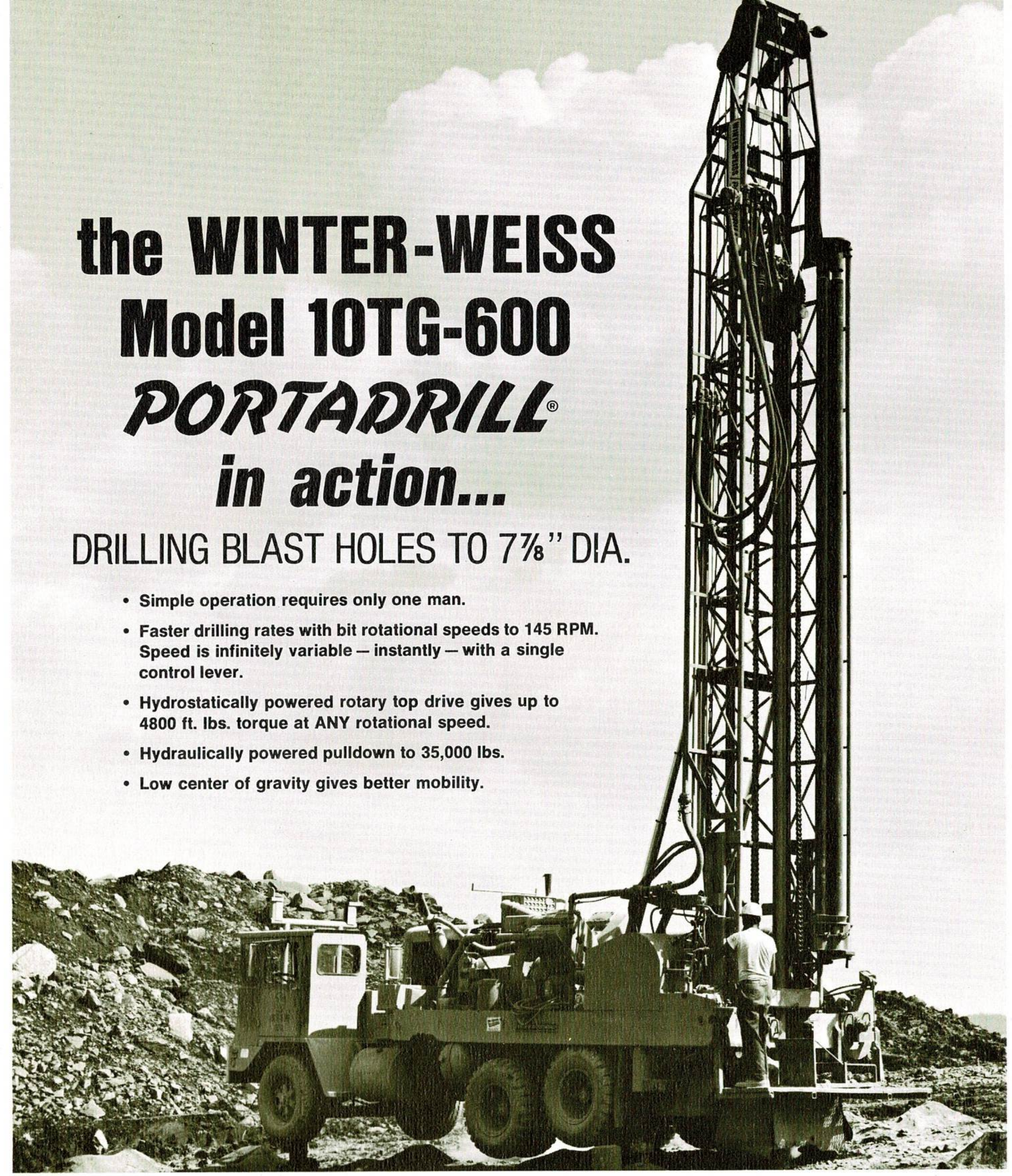
Tuesday marked the beginning of three days of tours and field trips for both the men and women participants. The men crowded into two large buses for what proved to be the most impressive day of the conference. Traveling about 30 miles west of Dusseldorf the group entered the Brown Coal region. Stops were made at several open cast mines including a "small" mine producing **only** 700,000 tons per year. Mining systems utilizing huge bucket wheel excavators and intricate conveyor systems were inspected by 120 men on the tour. Each mine featured direct conveyor feed from the pit to nearby power generating facilities.

The most impressive mine visit was the Fortuna Mine, which provided some staggering statistics. Over 47 million tons of lignite were produced from a single pit in 1974. The pit, which is continually moving forward and reclaiming itself as it goes, measures nearly four miles across and 800 feet deep. Villages, highways, railroads and even rivers are constantly being moved and rerouted in the wake of this massive operation.

Another most impressive feature of the tour included a look at a huge gob pile created by overburden material removed from the initial cut of a nearby open cast mine. Measuring approximately 500 feet high, five miles long and two miles wide, the gob pile would compare with a good sized mountain in Appalachia. However, the pile proved to be more of a construction project than a simple refuse dump. The dump was completely stablized with grass-legume cover as well as trees. It featured a paved, two-lane road complete with guard rail which was constructed all the way to the top, revealing a huge plateau which had just been plowed for agricultural use. Asked how the local people felt about this mountainous addition to their almost completely flat landscape, our hosts revealed that the gob pile has become some what of an attraction for hikers and picnicers because of the panoranic vantage point of the surrounding area.

On Wednesday, the emphasis moved underground in order to view the highly efficient longwall mining systems that have been prefected by the Germans. Five groups of between five and fifteen men were transported to five

(Continued on Page 6)



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. . . Exploring the World of Mining

(Continued from Page 4)

Top: One of the most impressive visits was to the top of this refuse dump. It has been completely stabilized with grass and tree cover and had just been plowed for agricultural use. The dump measured approximately 500 feet high, five miles long and two miles wide.

Above: The two-lane, paved road leading up the refuse dump provided a spectacular view of the surrounding countryside. It has become some what of an attraction for weekend hikers and picnickers because of the panoramic vantage point.

different underground mines in the area surrounding Dusseldorf. After visiting briefly with company officials, members of the groups were taken to the impressive bath house facilities, where they were given work clothes and equipment necessary for the trip underground. Conference delegates soon found some significant difference between mining in the United States and Germany. First of all, the Germans use longwall mining exclusively. There is no room and piller methodology utilized. The mines are much deeper than in the United States, with depths reaching 4000 feet. Also, due to the extreme depth and pressure, the temperature reaches as high as 95 degrees at the working face.

Following two to three gruelling hours of riding the longwall systems and inspecting the mines, each group was treated to a memorable coal mining custom. After the mine tour, visitors were taken to the bath house for a hearty meal, complete with German snops and beer, all before cleaning up. This period provided an excellent opportunity to chat informally with the gracious hosts and learn more about the German people.

For those not wanting to go underground, there was also a visit to the famous Bergbau Museum of Mining in Dusseldorf.

The third day of field trips featured excursions to several large manufacturing plants. Those visited included: Hermann Hemscheidt Maschinenfabrik, underground longwall support systems, Krupp Industries, bucket wheel excavators; Humboldt Wedag, preparation plants, and Woma-Apparatebau, high pressure pumps.

On corresponding days the ladies program featured a sightseeing tour of fascinating Dusseldorf, a bus tour of Bonn and Cologne, followed by a steamer cruise up the historic Rhine River, and a final tour of three famous German castles. Mrs. Hazel Kennedy was kind enought to lend her time and efforts as director of the ladies program. She was invaluable in seeing that the tours ran smoothly.

During the seven-day stay in Germany, evening functions were scheduled for only two nights, in order to allow ample time for exploring the sights and sounds of the host city. Conference delegates found Dusseldorf, boasting a population of nearly 800,000, to be quite an enjoyable city, offering sparkling skyscrapers, ancient churches, remnants of World War II, the beautiful Rhine River and a true taste of cosmopolitan Europe in the 1970's. Restaurants and entertainment spots of every possible description were

(Continued on Page 10)

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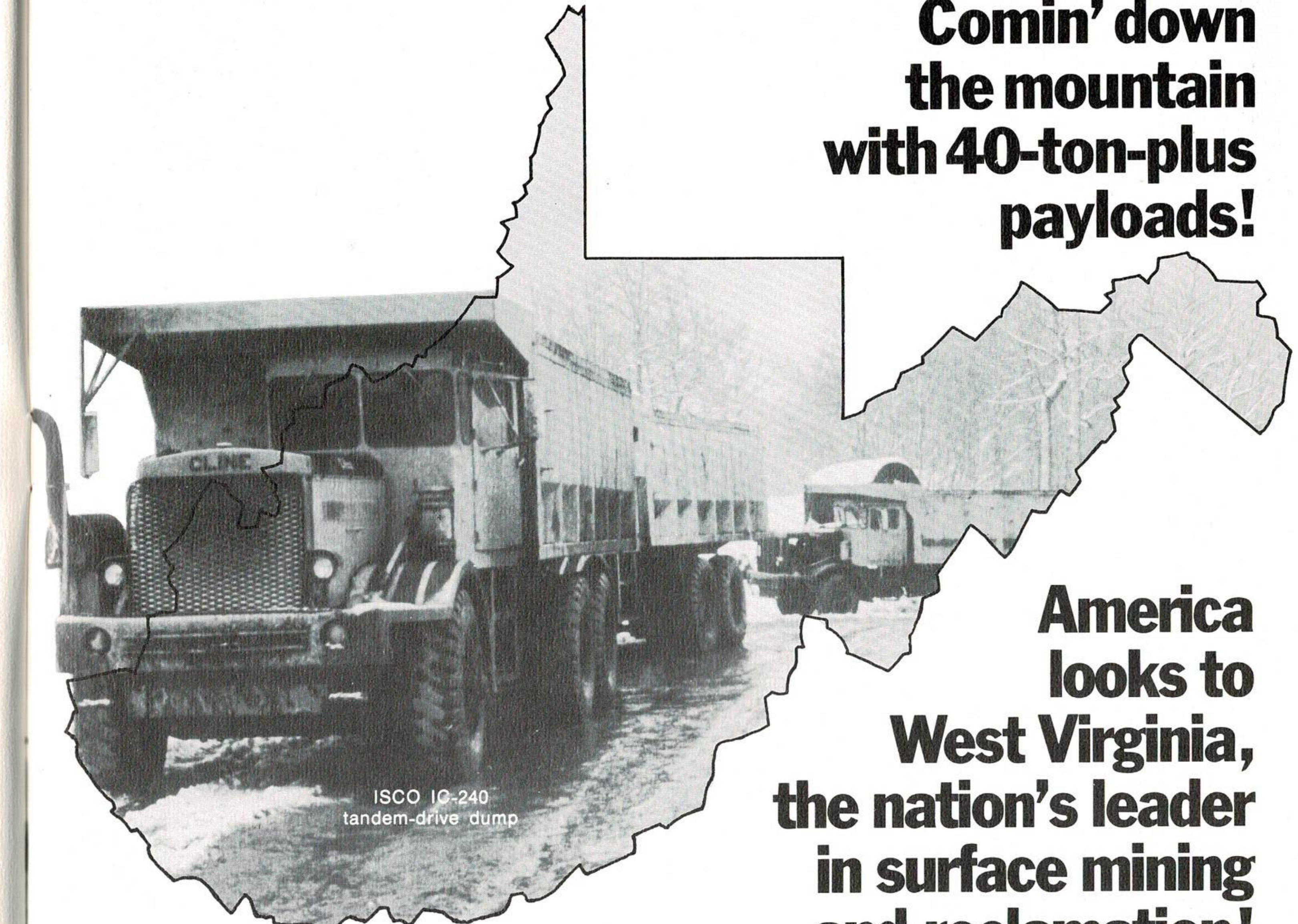

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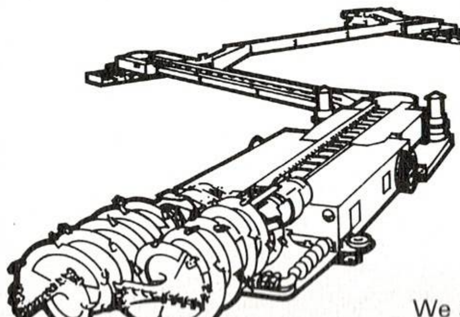

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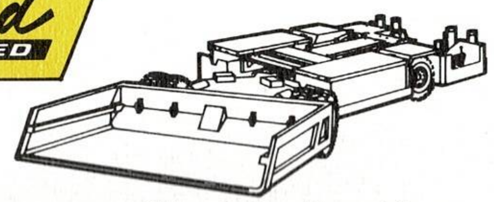

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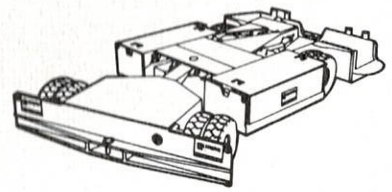

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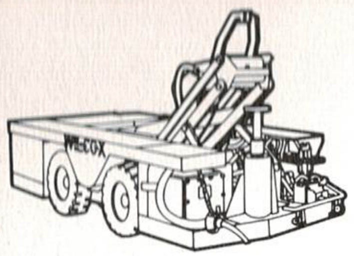

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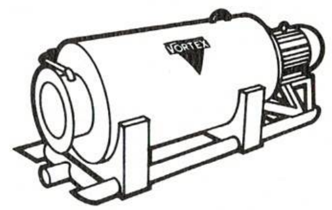
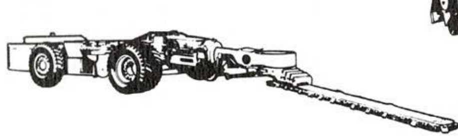
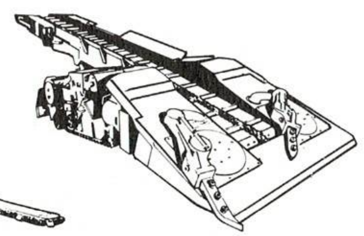
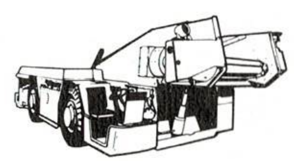


Vortex Sepairator Dust Control Equipment







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. . . Second Conference Is Planned

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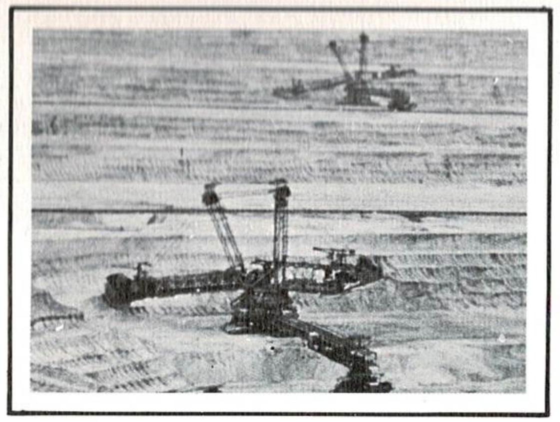

Top: This view at one of the "smaller" mines shows a close-up of a bucket wheel excavator in operation. The cutting boom swings back and forth scooping the overburden onto a conveyor system that transports it to the empty pit behind the operation.

sprinkled throughout the new as well as the "Altstadt" or old section of the city. Possibly the most remarkable thing about Dusseldorf was its similarity to a comparably sized city in the U.S.

The final day of the program began early with the presentation of more papers by German mining officials. Included in the morning session were presentations on deep mine safety by Dr. Zur Rieden, head of the department of training safety and medical services for Ruhrkohle AG (mining company), German deep mine technology by Dr. Helmet Ritter of the West German Bureau of Mines, and the problem of underground mine subsidence in populated areas by Mr. Hugo Weishaupt, General Manager at the Nordsterd Mine. (Summaries of these papers are reprinted on pages 10 and 46.)

Following a luncheon and a free afternoon, the last official function of the conference was a farewell cocktail party in the 1890 Club of the Hilton. The reception was sponsored by International Carbon and Minerals Inc. of New York.

In the morning the group bused to the Cologne Airport for the direct flight and 5:00 P.M. arrival at New York's John F. Kennedy Airport, and connecting flights to the various U .S. destinations.

Conference officials were extremely pleased by nearly every phase of the trip, from start to finish. Ben E. Lusk, President of the West Virginia Surface Mining and Reclamation Association and organizer of the conference termed the venture a complete success.

"For our first attempt at an international trip, we couldn't have been happier," he said. "We received excellent cooperation from our German hosts and the technical aspects of moving 190 people from place to place came off without any problems."

Lusk explained that the response to last year's conference was so good that plans are underway for a second trip in the spring of 1976.

"We have not yet decided between several locations including Austrailia, Poland and a possible return trip to Germany, but a decision will be made soon," he said. "One of our biggest concerns is that, due to the overwhelming response to last year's trip we may not be able to accommodate everyone. We will do everything possible to see that hotel and travel arrangements are made available to all coal industry representatives wishing to participate."

TECHNICAL REPORT

Overview of German Deep Mining

(Editor's Note: The following represents excerpts from a presentation by Dr. Ing. Helmut Ritter, West German Bureau of Mines, before the International Mining and Reclamation Conference in Dusseldorf, West Germany).

"The deposits of the Ruhr coalfield are characterized by the varying dip of the seams and the short length of the panels in the direction of face advance. Out of the 293 faces being worked in 1974, 216 were classified as flat ones, up to a dip of 20 gons (one gon being one degree on the 400-degree circle, thus 20 gons — 18°), 46 moderately inclined — dip from 20 to 40 gons — and 31 in the range from 40 to 100 gons. The usual mining method applied in the collieries of the Ruhr coalfield is the longwall system, on the strike. Caving is practiced in 94 percent of the faces."

"The longwall advancing system is very advantageous in gassy seams. The thickness of the seams being worked ranges from 0.80 to 4 m., with a mean value of 1.74 m. Seams thicker than 4 m, and up to 6 m., are worked in two slices. The length of the faces must not exceed 250 m; the usual length ranges from 200 to 250 m."

In the last 15 years, it has been possible to have much better control of the roof in the faces due to the development and introduction of hydraulic props and powered support. The use of hydraulic support enables high values of specific resistance to be attained. (Specific resistance, or mean load density is defined as "the effective resistance opposed to the strata pressure in the face and distributed over the face area; thus, it is expressed in tons per square meter.")

One of the disadvantages of powered support in that sensitive roof layers are destroyed before reaching the breaking edge by the repeated loading and unloading of the props. If the props are set under a load as near as possible to the yield load, this shortcoming could be weakened or eliminated all together. By doing this, the roof layers are only unloaded for a short period and over a very short distance during the advancing movement of the support. If the roof layers should tend to face prematurely, it is possible for the support lag to be shortened in most faces.

The term "support lag" refers to the time between the exposure of the roof by the coal-getting machine and the setting of the supports. Previously this interval caused delays of up to 6 hours; the support lag has now been reduced to 5 minutes. As the last resort, shield supports may be used. A major advantage of the shield support is that it supports the largest possible area of the roof and reduces the interval between the coal face and the tip of the roof bars to a minimum.

Top: Vic Gaedke, project engineer for the Krupp Industries, explains the mechanics of BWE mine planning to two conference delegates; Al Curry of the Tennessee Valley Authority and Bob.

Above: "Fortuna" is the largest coal mine in the world. Over 47 million tons of lignite were mined from one pit in 1974.

(Continued on Page 14)

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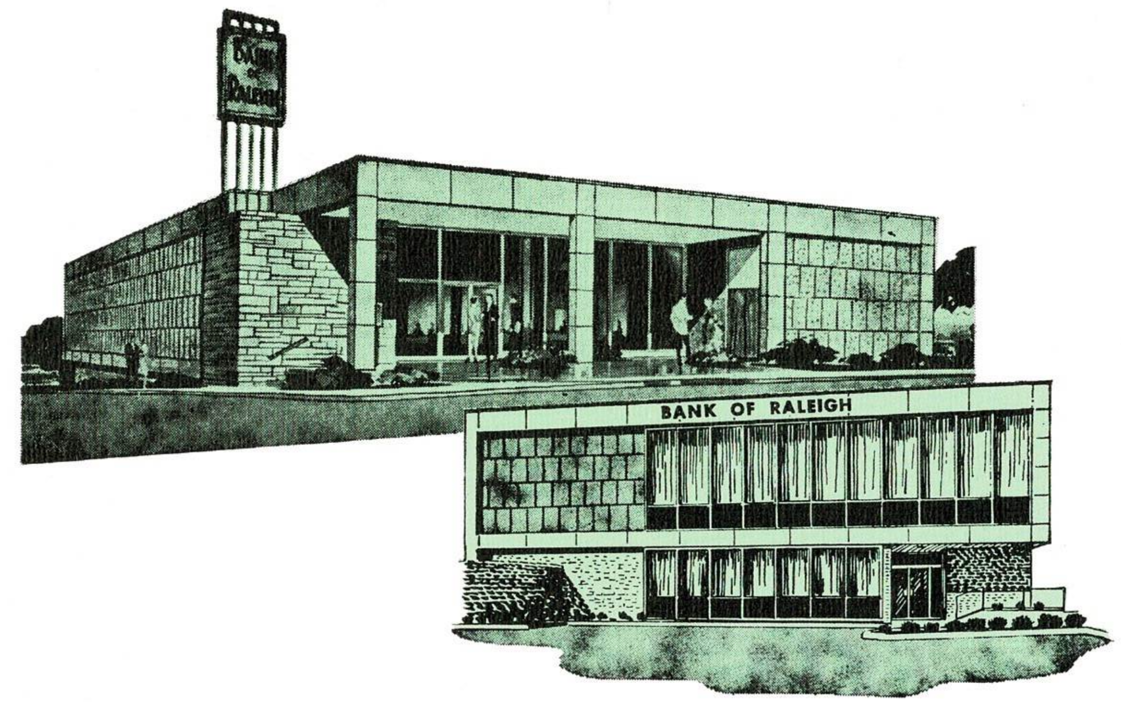

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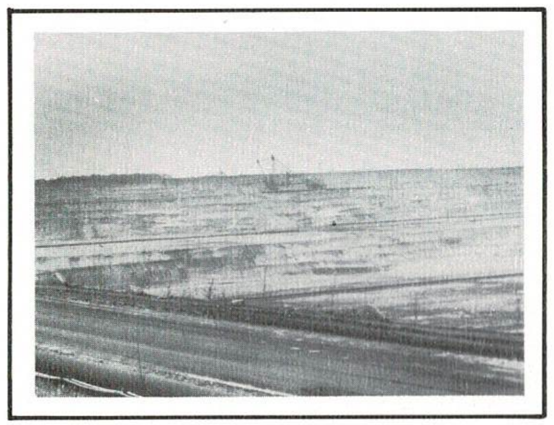
. . . German Deep Mine Technology

(Continued from Page 11)



Top: Vic Gaedke notes the close proximity of the lignite mines to the electrical generating facilities that burn the mineral.

Above: The awesome Fortuna mine, which is continually moving foreward and reclaiming itself as it goes, measures nearly four miles across and 800 feet deep. Villages, highways, railroads and even rivers are constantly being moved and rerouted in the wake of this massive operation.

"Originally, powered supports were designed for flat seams, but recently successful attempts have been made to also introduce them in more inclined formations where the dip exceeds 40 gons (36°). In this range of dip, good roof control is in most cases, easier than in flat seams, provided that longwall on the strike is adopted as working system. In caved faces, however, the line of the coal face should be slightly overtipped, so as to deviate from the line of the full dip by 5 to 10 gons. This, in turn, entails certain problems, not only with regard to the support but also to the face conveyor. As a rule, the support is advanced normally to the conveyer, and the conveyor normally to the face line. Thus, both the support and conveyor would tend to drift downwards towards the bottom gate, unless the conveyor is raised again from time to time, away from the full dip. With this end in view, anchor stations are installed at the upper entry to the face which are intended to secure the face conveyor and the coal-getting machine against the drifting forces acting upon them and to enable the conveyor to be raised against the dip. The anchor stations consist of heavy support chocks, connected by a beam by means of a hydraulic mechanism." It is hopeful that in the future this method will make it possible to reach in more inclined seams the same output per faces in flat seams.

There are more problems in other fields, the solutions of which will be vital for the future of the industry. The first problem is the drainage of gate-roads. "The high strata pressure acting at depths beyond 800 m. calls for a relatively large initial cross-section of the gate-roads. Also for reasons of ventilation, large cross-sections are required. Thus we are compelled for the time being to drive gate-roads of arched shape, with cross-sections ranging from 16 to 20 m^2. In general, the degree of mechanization of these operations is still very low, and therefore they are a bottle-neck in highly mechanized faces, because they cannot keep pace with the advance on the face; on the average, the rate of advance of the headings is restricted to about 6 m., although some cases, 10 m. per day are achieved using selective heading machines."

The prevention of coal bursts is a problem faced by coal miners in West Germany. The Research Center of the West German Coal Mining Industry has developed promising methods of preventing rock bursts. Dangerous stresses ahead of the face can be reduced by drilling large diameter holes.

High gas content of the seam is another problem, with methane content usually averaging out to about lo m^3. As a result of this, the rate of face advance and the output per face can be restricted by gas emission and the high ventilation velocities required to dilute the gas. In accordance with regulations, "the air velocity in the face must not exceed 4 m/second, and in principle, one percent is admissible upper limit for the CH_4 content of the air current."

The environmental conditions or the "underground climate" is another important problem. "Our regulations give definition of the term "underground climate" which is characterized by temperature and humidity of the air. Certain limit values of the underground climate must not be exceeded. This implies that in deep mines where rock temperature between 50-55°C are measured, it is necessary to install air cooling plants or to reduce the working time of the personnel employed in the hot zones. At present, not less than about 30 percent of our faces are classified as "hot working places" with temperature in excess of 26°C. The working time of the personnel occupied at these places must be reduced to 7 hours."

The final problem is protecting against dust. A high percentage of the total expenses borne by the accident and professional diseases fund is accounted for by miners injured by dust and the indemnities fund for them. The problem of dust may very well be the most serious safety problem underground. Preparation must be made to deal with this in the future.

"Silicosis is caused by quartz, christobalite and tridymite. The maximum admisable fine dust concentration in the mine air is 4.0 mg/m^3. In coal mines these figures are long term values; they are valid for exposure to dust over a period of 5 years. There is no denying that great efforts are still required in order to reach these limit values and to improve the environmental conditions underground. One of the most difficult problems is the suppression of dust in the coal face, if it is impossible for water infusion to be practiced. This is the case in seams with argillaceous surrounding rock which would swell by absorption of water and lead to bad roof or floor conditions.

In conclusion "I should like to mention a special feature of our safety measure in the field of mine fire and explosion prevention. All roadways in our collieries must be "pasted", which means that the dust is fixed by atomizing solutions of high salt content which act as a binder. In many roadways the use of non-inflammable support is compulsory. (Belt conveyors in particular must be made of non-flammable material.)"

Top: Conference delegates receive the benefit of expert explanation from Dr. Karl Benacke, chief mining consultant engineer for Krupp, which manufactures the bucket wheel excavators. From the left: Bill Anderson, Lawson Hamilton, Joe Orlandi, Dr. Benecke and Trip Hamilton.

Above: This small river which borders on the Fortuna mine has been rerouted five times. Also, approximately 80% of the water in this river is mine water being pumped out of Fortuna.

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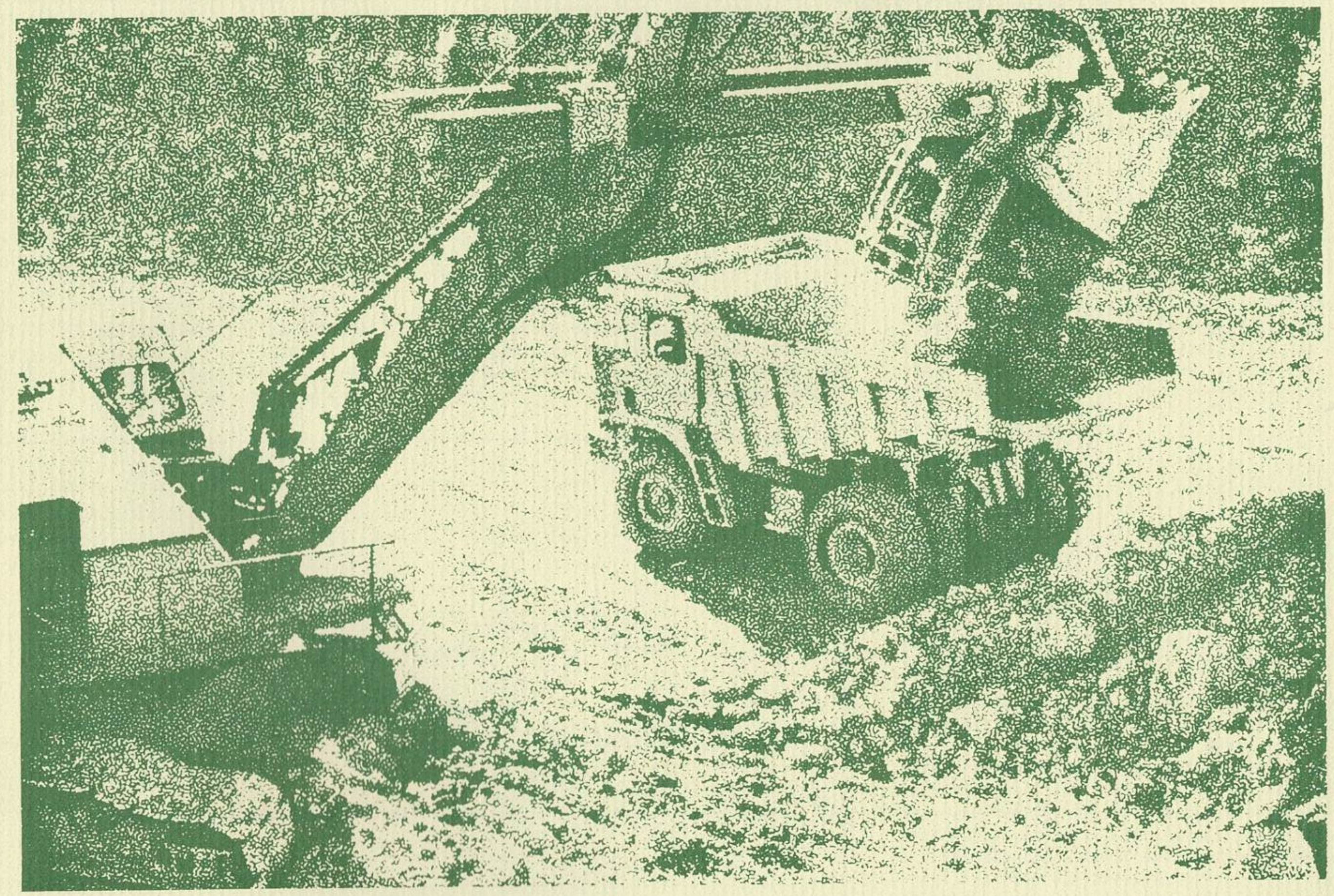

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German Techniques In Surface Mining and Reclamation

Presented before the first International Mining and Reclamation Conference, April 14, 1975, Dusseldorf, West Germany.

by

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Consulting Engineers
In Mining and Geology

... EQUIPMENT AND MINING SYSTEMS

When Germany is mentioned in connection with surface mining, this always refers to the extraction of low grade lignite in big opencast mines. As can be seen from figures of world lignite production since 1913 (see figure 1.1), the German lignite mining industry has always held a dominating position, notwithstanding the fact that the percentage has considerably decreased after World War II. In 1913 Germany's share in the world production was 67 per cent, whereas it attained only 44 per cent in 1973. However, it is certainly of interest to learn that in the course of these 60 years world production increased from 142 million to 907 million tons, i.e. an increase of more than 500 per cent.

Considerable masses of overburden had to be removed in the opencast mines for attaining these production figures. It is estimated that in Germany 318 million cu yd of overburden had to be removed in 1929; the corresponding figure for 1938 amounts to 484 million cu yd. In the Federal Republic of Germany 327 million cu yd of overburden were extracted in 1973 in order to produce 131 million tons of lignite.

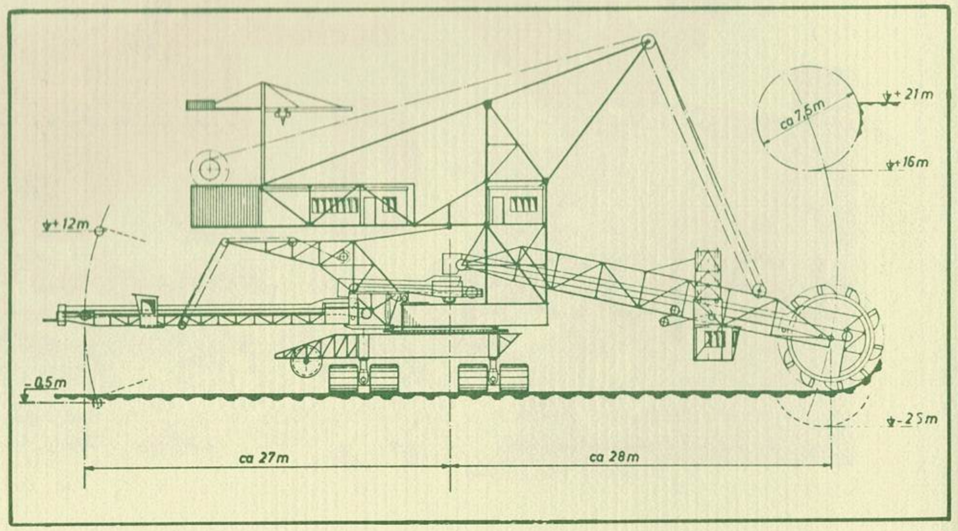
Assuming an overburden to lignite ratio of 3 to 1 and a specific weight of overburden of 2 tons per cu yd, 6 tons of overburden have to be excavated, transported and dumped for producing 1 ton of lignite. It is therefore evident that the handling of overburden is one of the most important elements of economic lignite mining.

Before World War II output per man and shift varied between 10 and 30 tons. In 1973 the average OMS was 68 tons in West Germany, in the Rhenish opencasts near Cologne this figure was considerably higher, their output amounting to 87 tons.

In the past lignite was extracted from many small opencast mines with a maximum production of about 5 million tons per year. Nowadays this is quite different. In West Germany for example, 11 major openpits are presently in operation, the production of only five of these—located in the Rhenish basin—amounted to 113 million tons in 1973. "Fortuna" is the biggest openpit and in 1973 produced 47 million tons of lignite which required the removal of 101 million cu yd of overburden.

These high production figures were only feasible due to the development of special equipment and of an adequate mining system.

Because of the special mining conditions, which will be reverted to later, the bucket wheel excavator (BWE) was developed rapidly during the last few decades and now represents a machine of high efficiency.



The bucket wheel excavator digs with six to 12 equally sized buckets which are mounted on a wheel periphery. This wheel is mounted to the end of a boom which can be moved up and down, and slewing of the boom is achieved by rotation of the super-structure. The extracted material flows continuously via a transfer point to a discharge belt system. BWEs are mostly mounted on crawlers and electrically driven.

The idea of the BWE, i.e. of the continuously digging wheel, dates back to the beginning of the 19th century. Interestingly enough one of the first patents describing the use of a BWE was issued in the United States in 1881. Only in the thirties the German lignite mining industry started to develop the BWE.

Prior to this period, overburden and lignite had been extracted by bucket chain excavators. Bucket chain excavators were used in combination with trains and with overburden conveyor bridges. By application of these mining systems the annual output per mine attained a maximum of about 26 million cu yd of overburden and 5 million tons of lignite.

After World War II the development of the opencast mining technique tended towards large-scale lignite opencast mines, and consequently the industry demanded equipment of higher capacity, thus paving the way for the BWE. Up to now we have had at least five generations of BWE, starting with a capacity of some 1300 cu yd per day, via 40,000 and 80,000 cu yd per day to presently employed excavators of 130,000 cu yd capacity per day. The fifth generation with a daily performance of 260,000 cu yd and operating weight of 14,500 tons is actually under construction and will be ready for operation in late 1975 in a lignite mine producing about 33 million tons annually.

The BWE (fig. 1.2) digs with 6 to 12 equally sized buckets which are mounted on a wheel periphery. This wheel is mounted to the end of a boom which can be moved upward and downward. Slewing of the boom is achieved by rotation of the superstructure. The extracted material flows continuously via a transfer point to a discharge belt system. BWEs are mostly mounted on crawlers and electrically driven.

Shape and material of bucket teeth are selected according to the characteristics of the overburden.

The BWE can be laid out for very specific mining conditions, and especially the following parameters can be varied:

- diameter of bucket wheel
- length of bucket wheel boom
- discharges per minute
- revolutions of the bucket wheel
- number of buckets
- size and shape of buckets
- shape and material of bucket teeth and lips as well as possibly a precutting device
- discharge system of buckets
- drive power of bucket wheel and thereby the break-out force
- number of belts in BWE itself
- width and speed of these belts
- length of discharge boom
- discharge or loading system
- number and lay-out of crawlers according to ground pressure
- kind of drive (hydraulic, electric, or diesel)
- extent of high and deep cut operation.

From the large number of parameters, it can be concluded that due to dimensioning every BWE to the specific conditions prevailing in the openpit, two BWE will seldom be alike. In principle, the BWE can either be utilized in block excavation or in lateral block excavation, as well as in bench excavation, although the latter is no longer applied nowadays. The BWE will always be capable of removing the material horizontally in slices. In other words, the BWE always makes selective mining possible at any rate, i.e. extraction of overburden, lignite, and partings in separate digging operations.

The development of the BWE during the last few years was not confined to its application in lignite mines; on the contrary, it has proved as mining equipment of multiple use and of high efficiency, utilized in the following fields:

- in phosphates in Morocco and Spanish Sahara
- in tar sand in Canada
- in frozen material in USSR
- in iron ore and pellets in Mauritania and Canada as reclaimers
- in overburden of a copper openpit in Zambia
- in tough pottery clays in Germany
- in quartz sands in California
- in coal as reclaimers and blenders
- in chalk and diatomites in Germany and Belgium.

The special development of the BWE has to be considered under the special conditions prevailing in European lignite deposits. This means that considerable overburden thicknesses of up to 500 ft. as well as lignite thicknesses of up to 165 ft. are frequent and that the material is homogenous and comparatively soft. Furthermore faults and fractures occur frequently which can be handled easily by BWE.

The economic limitations for the operation of a BWE are:

- The handled material must be homogenous. Boulders and concretions above a certain percentage will lead to excessive stoppages and consequently to excessive costs. If the percentage of boulders is low, they can be handled economically by other means.
- Excessive stoppages and slow-downs are experienced if the lump size of material admissable for the corresponding size of BWE is exceeded. The performance of the big BWE is considerably affected when rocks larger than 20 to 24 inches are encountered. They do not only plug the chutes and transfers but will damage the belts, too.
- Limestone, tough marl and sandstone cannot be dug economically. But the old axiom "hands off wheels where drilling and blasting begin" may not be true any longer especially during the last few years when the drilling and blasting techniques have been improved enormously in combination with new explosives. Therefore above all, it should be examined whether a control of lump size might be exercised by a systematic blasting operation, attaining hereby a material which could easily be extracted by BWE at optimum cost.

WORLD LIGNITE PRODUCTION
(in million short tons)

	1913	1929	1938	1950	1960	1970	1973
GERMANY	95 (67%)*	191 (74%)	213 (74%)				
W. GERMANY				84 (55%)	105 (49%)	119 (47%)	131 (44%)
E. GERMANY				151	225	228	271
EUROPE	137	243	259	319	525	659	673
USSR	3	4.5	21	84	158	160	169
ASIA	----	----	----	2	7	18	18
AFRICA	----	----	----	----	----	----	----
AMERICA	0.8	7	4	9	7	10	18
OCEANIA	0.8	3	6	10	19	29	29
WORLD TOTAL**	142	257	290	424	716	876	907

* Percentage of World Total **Total may not add due to rounding

As can be seen from figures of world lignite production since 1913, the German lignite mining industry has always held a dominating position, notwithstanding the fact that the percentage has decreased considerably since World War II. However, it is of interest to note that in the course of these 60 years, world production increased from 142 million to 907 million tons (a more than 500 percent increase.)

As a consequence of the use of BWE, different material handling systems and mining techniques have developed during the last few decades. As the BWE operates continuously, new kinds of transportation had to be found moving the large masses continuously, too. In the decades before World War II the material was mainly transported by trains. Simultaneously with the considerable expansion of the mine size belt, conveyors gained ground in preference to trains.

In general, the transport distances in lignite mining vary approximately between two and seven miles. If large masses are to be removed, only belt conveyors will be the appropriate equipment for covering these distances economically. If distances exceed approximately seven miles, train operation could still be preferred, as is shown by the example of the so-called north-south-track in the Rhenish Lignite District.

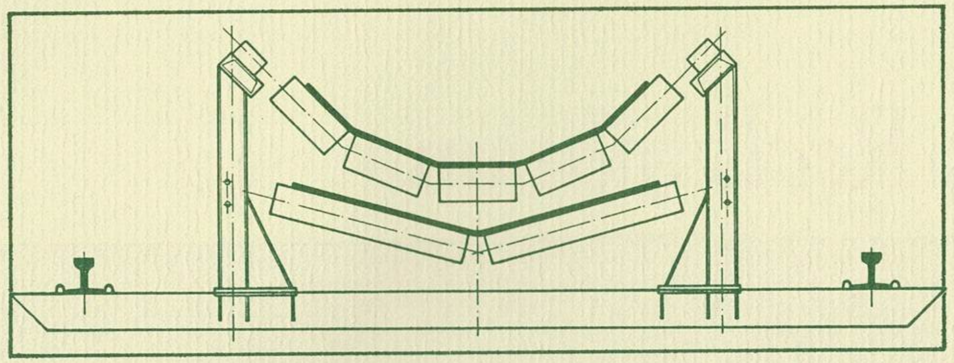
By means of this track large masses are transported over a maximum distance of 20 miles either to outside dumps, mined-out areas or power plants. However, the operation of this track is mainly being maintained for forming an interconnected transport system between mines, briquetting plants, power plants, mined-out areas, and reclamation areas.

The longest conveyor belt system in the world with a length of 60 miles was built by Krupp in Spanish Sahara. This installation is used for transporting phosphates from the mine to the port and is laid out for about 11 million tons p.a. in the eighties. Yet, opinions differ considerably as to the economy of this transport system.

The latest development of a conveyor, being currently applied in Germany, consists of a steel sleeper and a steel frame with the idlers. The carrying idlers are preferably "garland" idlers, anchored with the steel bar and easily exchangable.

The belt moved over carrying and return idler consists of rubber, reinforced by steel or nylon chords. A conveyor section varies in length from 300 to 3000 yards and consists of the self-contained drive, the conveyor section itself, and the tail section including transfer points. There exists stationary and shiftable conveyor sections. Shifting is normally done by using auxiliary equipment as tractor or crawler (actually pipe layers) fitted with a special shifting device which locks onto the head of the shifting rail. Shifting device and conveyor are raised slightly to reduce ground friction and the tractor then is traversed along the conveyor to shift it over the step distance. In this way conveyors can be shifted 6 to 15 feet in one step.

The self-contained drive and tail section are shifted independently but at the same rate as the intermediate conveyor section. In case of high-capacity conveyors, the heavy drives and tail sections are mounted on crawlers, rails, or hydraulic walking pads to move under their own power. In the opencast, the conveyor sections may be extended over a maximum length of two miles. The lay-out of a conveyor is determined in accordance with the theoretical maximum capacity of BWE, and belt width, belt speed, drive capacity depend on it. Length and gradient of conveyor section are other factors for determination of drive capacity.



The latest development of a conveyor, currently in use in Germany, consists of a steel sleeper and a steel frame with the idlers. The carrying idlers are preferably "garland" idlers, anchored with the steel bar and easily exchangeable.

Conveyors offer a further advantage by the fact that they can carry material without difficulties over slopes of 30 to 40%. In special cases and by means of so-called "belts for operating abrupt slopes" even inclinations of 100% will be overcome.

In train operation, the maximum inclination is four percent, however this is only admissable for light charges and produces enormous wear. On the other hand, rail lines steeper than two per cent are rare in opencast mines.

In all mining systems conveyors in combination with BWE play the most important part for transportation and dumping of lignite and overburden respectively. According to the mining conditions prevailing in each case, different mining transport techniques are applied. The BWE in a combined operation with conveyor belts and stackers proved very successful in German and European opencasts.

While the lignite is transported along the benches by conveyor belts to the processing plant, the overburden is carried by belts to the stacker on the opposite side around the mine. It is the stacker's task to refill the mined-out area with overburden arriving in a constant flow due to continuous extraction and transportation. Thus the continuous removal, refilling and rehabilitation of overburden is achieved.

In principle, the stacker is a special conveyor that fulfills the task of taking up the overburden masses from the bench conveyor to dump them according to a reclamation plan. The stacker consists mainly of the substructure with chassis, two booms and the steel structure with the counterweight. Independent of one another the charging and discharging boom are sluable and can be lifted and lowered. In most constructions, both booms are connected in the stacker itself by one or several conveyor sections and transfers. The stacker can spread the overburden by high casting operation as well as by deep casting operation and can also discharge from different heights which is of significance for the compression of soils. By slewing the discharge boom, it is possible to distribute the overburden more or less evenly avoiding the formation of deep ridges and enabling the stacker to provide for its own working surface.

Applying the transport system with the combination of BWE/conveyor/stacker, a certain disadvantage arises from the fact that the overburden has to be transported over long distances around the opencast. Durng the last few decades, considerations have always been concentrated on finding a solution for eliminating this disadvantage by transporting the overburden straight across the mine.

In this respect, overburden conveyor bridges have proved very successful, especially in East Germany. In principle, such conveyor bridge is a special conveyor, too, in as far as it receives the overburden masses from the excavators, carries them across the opencast and dumps them directly in the mined-out area. In the East German mines the extraction of overburden is done by bucket chain excavators which are linked with the conveyor bridge. According to overburden thickness and number of benches, three or more bucket chain excavators can be in operation at the same time. The material is fed onto the bridge at various points, the overburden is then transported by several belt conveyors. On the dumping side, the bridge is equipped with several discharging points. The bridge which moves on rails or crawlers, can transport the overburden over a distance of up to 2200 feet. A bridge was set into operation in 1972 and can transport up to 260,000 cubic yards p.d. over a maximum distance of about 2000 feet. In East Germany a new conveyor bridge started full operation in October 1974. It is 2200 feet long and has an operating weight of 16,500 tons. Overburden thickness of up to 200 feet can be extracted in one operation. Owing to the special mining conditions prevailing in East Germany, conveyor bridges have become the preferable equipment for overburden handling there. The basic preconditions for the use of conveyor bridges are an even sedimentation of overburden and lignite, i.e. thickness of overburden and lignite is almost steady, as well as a homogenous and very soft overburden. However, it has to be pointed out that this mining system is rather inflexible and complicated.

The principal disadvantages are:

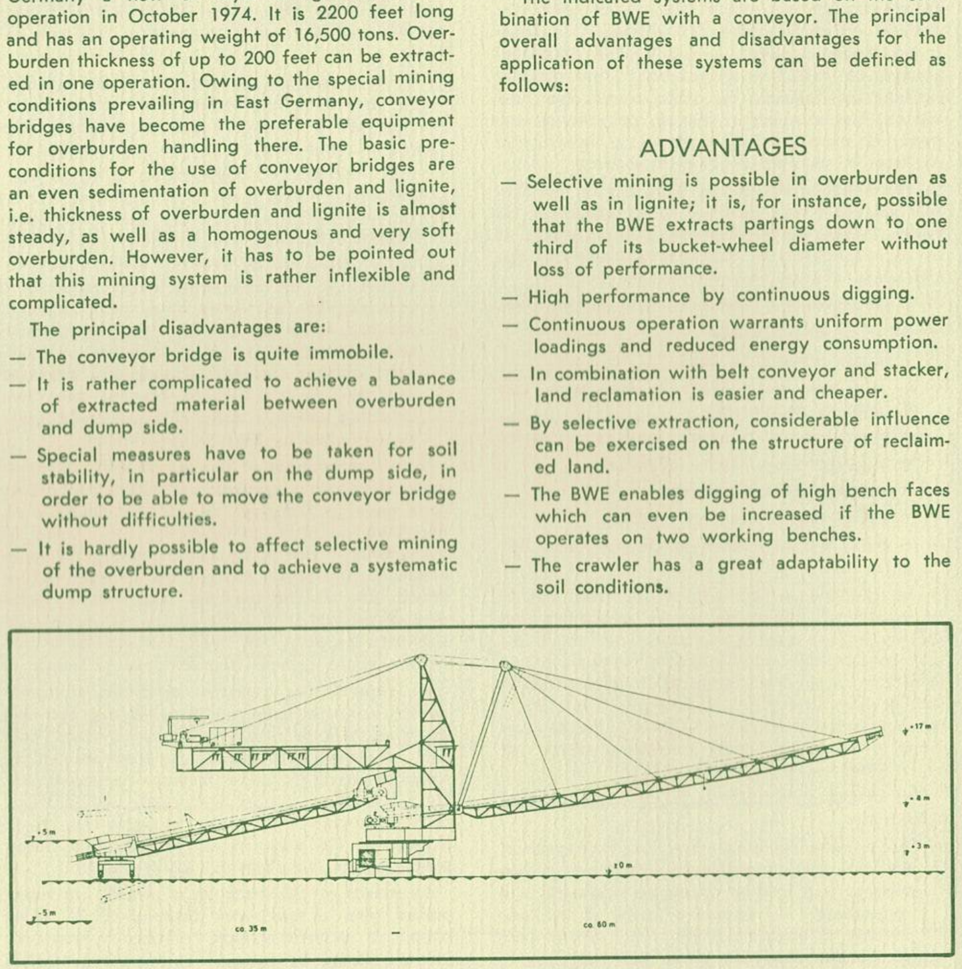
- The conveyor bridge is quite immobile.
- It is rather complicated to achieve a balance of extracted material between overburden and dump side.
- Special measures have to be taken for soil stability, in particular on the dump side, in order to be able to move the conveyor bridge without difficulties.
- It is hardly possible to affect selective mining of the overburden and to achieve a systematic dump structure.
- In a separate operation the topsoil has to be removed, transported, and refilled—resulting in higher cost for land reclamation.
- The opencast has to be drained thoroughly as otherwise the bridge could be endangered by sliding or by lack of soil stability.
- The bridge moving on rails will be applicable for gradients of 0.5% only, whereas for instance the BWE can be operated down to gradients of five percent without any problems.

Another possibility of avoiding the long distance around the opencast is the use of BWE equipped with a long boom and being able to cast back the extracted overburden directly. Without affecting the boom, the bucket wheel can be slued and also be moved up and down. The distance to be covered by this equipment can be approximately 460 ft or more. This distance can be further increased by linking the BWE with a so-called belt wagon, equipped with a long discharging boom. Contrary to the stacker, the two booms of the belt wagon itself cannot be slued independently. A certain flexibility is, however, achieved by the sluable discharging boom of the BWE which can be operated without affecting the bucket wheel boom. This equipment offers the possibility of transporting and direct casting of the overburden over distances of more than 800 feet. However, these two systems of direct casting are only advantageous if certain overburden and lignite thicknesses are prevailing. They are only applicable if overburden thickness does not exceed about 160 feet. They offer the advantage that the overburden can be extracted selectively and that the dump can be built-up systematically.

The indicated systems are based on the combination of BWE with a conveyor. The principal overall advantages and disadvantages for the application of these systems can be defined as follows:

ADVANTAGES

- Selective mining is possible in overburden as well as in lignite; it is, for instance, possible that the BWE extracts partings down to one third of its bucket-wheel diameter without loss of performance.
- High performance by continuous digging.
- Continuous operation warrants uniform power loadings and reduced energy consumption.
- In combination with belt conveyor and stacker, land reclamation is easier and cheaper.
- By selective extraction, considerable influence can be exercised on the structure of reclaimed land.
- The BWE enables digging of high bench faces which can even be increased if the BWE operates on two working benches.
- The crawler has a great adaptability to the soil conditions.



The stacker is a special conveyor that performs the task of taking up the overburden masses from the bench conveyor to dump them according to a reclamation plan. The stacker mainly consists of the substructure with chassis, two booms and the steel structure with the counterweight.

DISADVANTAGES

- Limited application in case the overburden material is rocky, contains sandstone and limestone strata or boulders. Efforts have been made during the last few years to overcome this disadvantage by special construction of the buckets, by use of pre-cutting devices, by a better shape and material of the teeth, and by increasing the driving power.
- Comparatively high preventive maintenance in order to avoid stoppages. The BWE is a comparatively complicated machine requiring more maintenance and higher workshop control.
- The combination BWE/conveyor belts/stackers has, of course, a lower availability. According to our experience, the rate of utilization of the BWE varies between 60 and 80 percent of its operating time.
- More detailed exploration and planning work has to be done if BWEs are to be utilized. Optimum results will always be achieved with BWE where large quantities have to be removed over long periods. Therefore it is necessary to make an exact investigation of overburden and lignite and to consider in the mine plan that the BWE has a lifetime of 20 to 30 years and involves high initial capital cost. Furthermore, a BWE is laid-out according to the specific mining conditions and offers hardly any possibilities for improvisation.

Based on our experience, some examples concerning the BWE application are indicated in the following. These examples shall give an idea of the complexity of lignite mining conditions, of the lignite quality, and of the equipment to be selected.

A feasibility study and a preliminary project were elaborated for the development of the lignite deposit of Elbistan (southeast Turkey) with reserves of about 3 billion tons. The overburden to lignite ratio is about 2 to 1, the average overburden thickness amounting to 230 feet and the average lignite thickness to 120 feet. The heat value of the lignite is 2100 Btu per pound on an average. The overburden consists of a material which is extractable by BWE.

On account of the considerable thickness in overburden and lignite, the use of BWE, conveyor belts and stackers was the only solution. Three alternatives were analyzed videlicet for an annual production of 8, 12 and 16.5 million tons. In this case, the influence of the economy of scale was remarkable. If the unit costs for the alternative of eight million tons are assumed to represent 100, the costs for the alternative of 12 million tons decrease to 80 and to 65 in case of a production of 16.5 million tons. During planning of the mine, special consideration had to be paid to land reclamation since the topsoil is used intensely for agriculture. With the proposed equipment, the overburden can be rehabilitated easily and at low costs.

For the Megalopolis deposit in Greece, a feasibility study and a mining project has to be elaborated. The deposit which is presently being mined, has an overburden to lignite ratio of 0.5 to 1 with an average lignite thickness of 110 feet. The reserves of this deposit amount to approximately 700 million tons. The lignite seam shows a number of irregular partings. The marginal heat value of the lignite amounts to 1650 Btu per pound only (despite the low heat value of this lignite, the power plant has been working perfectly for years without supplementary oil firing), and this is why provisions for special equipment had to be made in the planning, i.e. for equipment that warrants a neat separation of the partings. For an annual production of five million tons, three BWE were planned. The lignite and the partings are transported by the belt either to the power plant or to a stacker, respectively. Scrapers were planned for removal, transport and redeposition of topsoil.

The opencast Neurath in the Rhenish lignite basin was scheduled for an annual production of 660,000 tons. The deposit has an average overburden to lignite ratio of 1.7 to 1, and the thickness of the two lignite seams varies between 7 and 70 feet. Besides, two partings, attaining up to 20 feet each, had to be considered in the planning. The lignite has a heat value of about 3300 Btu per pound and is supplied to an industrial plant.

Taking the partings into account, three BWEs were scheduled for overburden and lignite extraction. Transportation to the stacker and to the lignite bunker, respectively, is effected by two conveyor lines. Lignite is carried from the bunker by special trucks over 12 miles to its destination. The topsoil is extracted by BWE and transported by one of the two belts to the stacker. The working bench of the stacker is located on a higher level so that overburden and partings can be dumped in deep cast operation, and high cast operation is employed for discharging the topsoil of seven to 14 foot thickness.

With these comments on the equipment employed in lignite surface mines and with the short description of its application in Turkey, Greece, and West Germany, we tried to point out that BWE and conveyors offer all qualifications for optimum utilization in large and small surface mines.

Conference delegates discuss the economics of mining with the bucket wheel excavator. From the left: Milford Jenkins, Bob Long, B. Ray Thompson, Ralf Gold, Mike Kennedy and Bill Anderson.

... ECONOMICS IN BWE MINING

The lignite deposit of Ptolemais in Northern Greece has a strongly faulted geological structure; individual seams are parted by layers of center reject. Lignite mining therefore has to proceed in selective operation, with separate removal of reject strata down to 25 cm (10 inches) thickness and lignite strata as thin as 50 cm (20 inches).

It was for this and other reasons that, initially, only pits of medium output were planned in the Ptolemais area.

The first open pit, the Main Field, went into production in 1958. It had been planned by Krupp, orignally as a train haulage operation, with a yearly lignite output of 2.2 million tons. In 1963 the owners started to convert this pit to conveyor haulage, at the same time increasing the yearly schedule lignite output to 5.1 million tons. This target was already exceeded in 1969, however, and since then the Main Field has been producing 6.6 million tons of lignite per year, which means that overburden and center reject have to be stripped at an annual rate of about 20 million bank meters^3 (26 million bank cubic yards). Maximum depth of this pit is 85 m (280 feet.)

This output is achieved by five bucket wheel excavators of different sizes, associated with two boom stackers of which each is able to handle and dump the volume of material excavated by two excavators. The fifth BWE can meanwhile dig the center reject and dump it directly into the worked-out pit with the aid of a belt wagon. It is thus possible in this pit to have a maximum of five excavators working in overburden and reject strata at the same time.

Since 1971, a second open pit, the Kardia mine, has been under development in the Ptolemais region. It has been planned for a yearly lignite production of about 6.6 million tons, and a maximum depth of 120 m (395 feet). The mine uses six bucket wheel excavators of equal capacity. All transport of overburden, center reject and lignite within the pit is handled solely by belt conveyors. Two boom stackers of identical capacity serve to dump the overburden and center reject, each stacker designed to receive the material from maximum three BWEs.

The planning now under way for a third pit in the Ptolemais area, the South Field Mine, envisages an annual lignite production of about 22 million tons. To achieve that output, it is intended to use wheel excavators of considerably higher capacity than those at the Main Field and Kardia open pits. Their output rates will be about three times as high as those of the earlier excavators.

The ratio of overburden + reject to coal at the Main Field is 3.85 bank cubic yards of overburden + reject per ton of coal.

The total output was achieved by the five BWEs in a total of 29,705 yearly net digging hours, which means 5941 hours per BWE per year or, compared with 8760 annual calendar hours, means 67.8% utilization of the annual calendar time while digging for a great part of the time in selective operation.

Dumping

Overburden + center reject: 25.80 million bank cubic yards = 45.65 million tons.

This dumping rate was achieved by the two boom stackers in a total of 12,740 yearly operating hours, averaging 6370 operating hours per stacker per year, or 72.7% utilization of the available annual calendar time.

The higher net operating time percentage of the stackers is due to the fact that, on an average, each stacker receives the overburden or reject from two wheel excavators, while these two BWEs will not necessarily dig always at the same time.

For transport of all excavated materials, only belt conveyors are used at the Main Field. Trains merely take the lignite from the edge of the pit to the power plant at surface level.

Bulk Handling

Conveyors	52.36 million tons of overburden + reject + coal
Average distance	2.0 miles
Handling rate	104.7 million tons × miles
Trains	6.71 million tons of coal
Average distance	1.87 miles
Handling rate	12.55 million tons × miles.

It is obvious from these figures that the handling output in conveyor transport is considerably higher than in train operation, not only due to the slightly greater average distance, but mainly on account of the much greater volumes of material that have to be handled by the belt conveyors.

A major criterium for assessment of an open pit operation is the power consumption of the equipment.

The total power consumption in 1971 was 54.07 kilowatt hours. Referred to the total stripping and ...ining output of 52.36 million tons, this equals about 1.033 kilowatt hours per ton or, for 6.71 million tons of lignite production the power consumption was 8.06 kilowatt hours per ton of lignite.

Comparing the power consumption within the handling system, it is found that 0.343 kilowatt hours are required per ton-mile by the belt conveyors, while trains only require 0.142 kilowatt hours per ton-mile. This lower relative consumption in train service results also from the fact that the trains only run on horizontal ground while the conveyors have to overcome gradients in hauling the material up to surface; part of the higher energy consumption is therefore power required to lift the load.

A comparison of costs alone — including capital cost, financing charges and operating cost — for trains versus conveyors shows an entirely different picture, however:

The following figures are based on a conversion rate of 30 Drachmae to U. S. $1.00

Train operation	$0.07 per bank cubic yards × mile
	or $0.07 per ton × mile
Conveyors	$0.05 per bank cubic yards × mile
	or $0.03 per ton × mile

These figures show that, as regards to handling volume, the train operation is more expensive by an average 40%; as regards to tonnage, it is 133% more expensive than belt conveyor operation.

Total production cost per ton of lignite was Drachmae 34.41 or $1.14 in 1971.

A breakdown of costs by percentages is seen from the following tabulation:

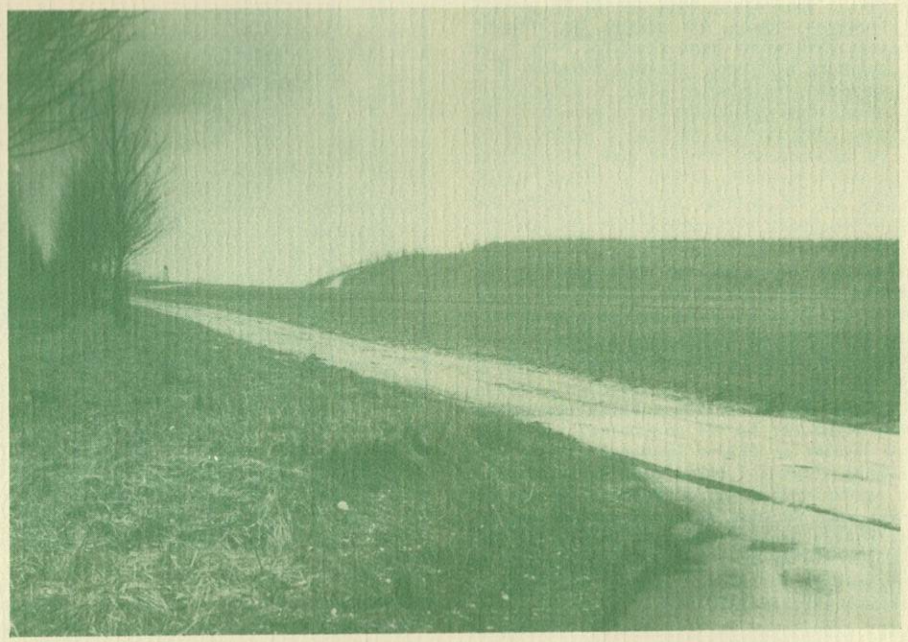
The price per ton of lignite was about $1.66 in 1971. By 1974 it had risen to $2.21 per ton which was an increase of 33% in four years—due to rising wages and general inflation. Assuming that production costs rose at the same rate since 1971, the $1.14 per ton of lignite in 1971 would be $1.52 per ton in 1974. This is about $0.29 per 1 million BTU at 2610 BTU/lb. of lignite. If imported oil had been used to fuel the power station instead of the lignite, the cost would be $1.90 per 1 million BTU at 17,450 BTU per pound. The cost of imported fuel oil, delivered to the power plant, was about $66.54 per ton in 1974.

For purposes of comparison, let us look at some figures from the Neurath mine, a small open pit operation in the German lignite district of the Rhineland.

The ratio of overburden + center reject to coal is 1.54 bank cubic yards per ton of lignite.

Production costs per ton of coal, delivered to the storage bins at the pit boundary, is Deutsche Mark 6.25 per meter tons equal to $2.64 per ton of lignite at a conversion rate of Deutsche Mark 2.30 to U.S. $1.00. This would be $0.39 per 1 million BTU (Deutsche Mark 3.47/million kilocalories) at 3240 BTU per pound. Compared with the 1974 production costs at the Main Field mine in Greece, the German figure appears high. The reasons are:

- Smaller equipment units due to considerably lower lignite production;
- Higher wages than in Greece, especially in view of the high cost of social services; and
- Slightly higher overhead expenses.



What was once spoil from the initial cut of a near by open cast mine, is now productive farm land.

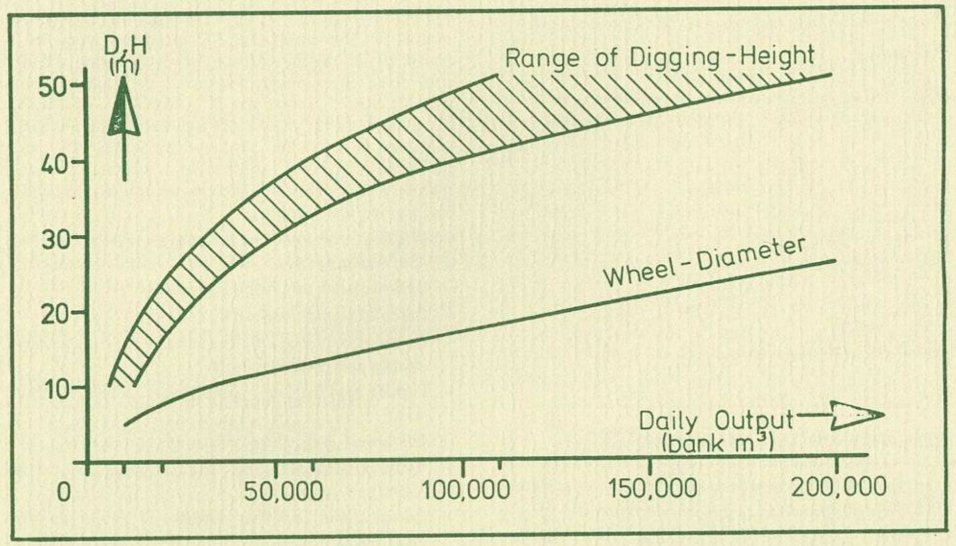
. . . DEVELOPMENT OF BWE SIZES FOR LARGE-SCALE MINING

With a daily output of 20,000 bank meters^3 (26,000 bank cubic yards), the bucket wheel excavators at Kardia are still among the small units. Up to the early 1950's, this output rate was about the maximum BWE capacity attainable. Thereafter, however, the development of actual high-capacity BWEs began with a machine for 40,000 bank meters^3 (52,000 bank cubic yards) per day in 1952. This concept for the first time made use of an entirely new design, an excavator unit with telescopic discharge bridge and loading unit, which will be explained in fuller detail below. From then on, progress was fairly swift and straight from 60,000 to 110,000 and now even 200,000 bank meters^3 per day (80,000 to 145,000 and now 260,000 bank cubic yards). The first such giant wheel excavator will go into actual service at the Fortuna Garsdorf pit early in 1976. An even larger unit, having a daily capacity of 240,000 bank meters^3 (315,000 bank cubic yards) has already been ordered for the new Hambach open pit operation.

The size of that unit, however, will be the end of BWE size development for the time being, as there are no plans under way just now for future pits requiring still larger excavating equipment.

Completely new design concepts were necessary in that development, starting with the BWE of 20,000 bank meters^3 (26,000 bank cubic yards) daily capacity. Thus wheel diameters were tripled from 7.5 m to 21.6 m (25 to 71 feet), the digging height was increased 25 times from 20 m to 50 m (66 to 165 ft.), and buckets even increased 10 times in size from 0.6 to 6.3 meter^3 (0.8 to 8.2 cu. yd.) Bucket wheel drive ratings rose accordingly, from about 350 kilowatt to ten times as much, 3300 kilowatt (470 to 4430 horsepower.)

Service weights of the excavator units are now 12 times as high as in the earlier designs, they developed from about 920 to 11,300 metric tons. To carry the increasing service weights and still keep ground pressures within reasonable



New design concepts were necessary in order to develop larger BWEs. Thus wheel diameters were tripled from 25 to 71 feet, and the digging height was increased 2.5 times from 66 to 165 feet, and buckets were increased 10 times in size from 0.8 to 8.2 cubic yards. Bucket wheel drive ratings rose accordingly, from about 470 HP to 10 times as much, 4430 HP.

limits, the crawler area had to be suitably enlarged. Nevertheless, slightly higher ground pressures had to be accepted with increasing excavator output.

Ground pressures of the excavator units designed for a daily production around 20,000 bank meters^3 (26,000 cubic bank yards) were quite low as 1 kp/cm^2 (14 psi). This corresponded to a crawler area of 98 meters^2 (1050 feet^2). The giant wheel excavator now under construction for a daily output of 200,000 bank meters^3 (260,000 cubic bank yards) needs a total crawler area of 665 meters^2 (7150 feet^2) to keep the groundpressure to 1.7 kp/cm^2 (24 psi). This area is equal to a square of about 26 m (85 feet) edge length or to the area of a circle with a diameter of 29 m (96 feet).

If the permissible ground pressure were only 1 kp/cm^2 (14 psi), a wheel excavator of this size and weight would demand a crawler area of 1.7 × 665 = 1130 m^2 (11,000 square feet.)

These considerations do not yet allow for the fact that such an increase in crawler area would automatically entail a further increase in service weight of the machine. Crawlers themselves would become larger and heavier, and the same would happen to the undercarriage. Finally the superstructure, too, would have to be a heavier design as the larger crawler area leads to a corresponding increase in wheel boom length, a decisive factor for the service weight of a bucket wheel excavator.

The problem of having to accommodate large crawler areas obviously led from a two-crawler design to a multi-crawler undercarriage. So far the highest service weight carried by a two-crawler undercarriage has been 745 metric tons. The excavator in question had a total crawler area of 680 square feet and even then it reached a ground pressure around 17 psi.

The two-crawler assembly was already combined with a three-point system of support — the stablest load support arrangement. However, in that case the three points of support are loaded unequally since one point is located on the one-point side (crawler with one support point) carrying half of the total load, while the two other points of support (two-point side, two points on one crawler) only have to bear a quarter of the total load each. Both crawlers are thus equally loaded. The real advantage of this two-crawler design merely lies in the fact that the two crawlers can move relative to one another around a fictive horizontal axis and can therefore adapt better to uneven terrain than an entirely rigid two-crawler track assembly where treads of the two crawlers are always in a common plane.

The change-over to the multi-crawler design remained this equalization between the crawlers, but additionally distributed the total load evenly on the three points of support, which represent the corners of an equilateral triangle. Such assemblies may have three, six, or even twelve crawlers forming groups of one, two or four under the three points of support. Each point is thus carried by a crawler assembly and all assemblies are equal in crawler area. In the twelve-crawler undercarriage of the BWE for 200,000 bank meters^3 (260,000 bank cubic yards) daily capacity, for instance, the area of an individual crawler is about 55.5 m^2 (600 square feet). Those are the largest individual crawlers known to date in actual practice.

Apart from this three-crawler concept, which alone made it possible to provide sufficiently large crawler areas, on the other hand the development of equalized crawlers was a pre-condition for the necessary increase in average ground pressure. Contrary to the rigid crawlers, the track wheels of these new crawlers are mounted in a system of bogies and equalizers, whereby the crawler track can adapt to every unevenness of the terrain and the load is therefore spread over the entire length of the crawler track at all times.

In case of a rigid crawler, depending on the degree of ground uneveness, only half of the total crawler track or even less might have to carry the total load, with consequent increase in ground pressure under the loaded section.

Bucket wheel designs, too, underwent a further development and improvement. This led from the cell-type wheel to a cell-less wheel with rigid chute, and then to the cell-less wheel with interior cone. The main advantage of the cell-less wheel is the improved bucket emptying process. Material excavated by a cell-type wheel passes from the actual bucket through the cell compartment to the means of onward transport, the bucket cell thus acts as a chute. Bucket ds-charge and passage of material through the chute can only reach their optimum during the short span of time when, in rotation of the wheel, the axial cell walls are at an angle which is steeper than the natural slope angle of the excavated material. Where sticky material is involved, the cell-type bucket wheel is therefore not very suitable.

Such sticky material might clog the cell and therefore block the bucket emptying process. The cell-type wheel therefore only has its advantages in free-flowing material such as dry sand or the like, where the cell is filled with material in addition to the bucket and the digging rate is thereby increased.

In a cell-less wheel, material is emptied from the buckets straight onto a rigid chute, or in the cone-type wheel onto the interior cone which rotates at the same time as the wheel, giving the material an added impulse in the direction of onward conveying. Optimum bucket discharge is therefore independent of the position of the chute or cone — contrary to the cell acting as a chute in the cell type wheel — and discharge takes place over a greater portion of the wheel periphery. If a cell-type and cell-less wheel rotates at equal speed, the available emptying time of the cell-less wheel is therefore greater. The cell-less wheel is more or less independent of the consistency of the material dug by the buckets, and is more universally applicable. Even in extremely sticky ground conditions, the cell-less wheel is preferable and its bucket emptying characteristics may be further improved if the bucket bottom is replaced by chain mats.

When the cell-less wheel moreover has an interior cone, rotation of the cone has an added self-cleaning effect and largely prevents chute blockage.

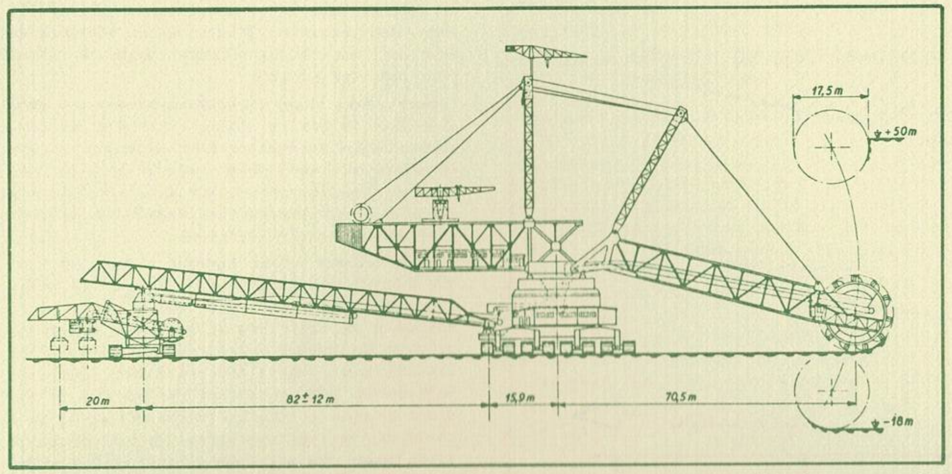
In the development of large bucket wheel excavator units, a further prerequisite increase has been reliable on haulage of the excavated material. A BWE designed for 200,000 bank meters^3 (260,000 cubic bank yards) per day has an hourly output of 15,900 bulk meters^3 (20,800 loose cubic bank yards); this means that every minute about 265 bulk meters^3 (345 loose cubic bank yards) have to be reliably hauled off. The overhanging discharge conveyor boom is no longer adequate for this duty, because its point of discharge has to be moved continually in the digging process. This aspect led to a wheel excavator concept with telescopic discharge conveyor bridge and loading unit the latter, and therefore the point of transfer to the means of onward transport (train or belt), can remain in unchanged position for a longer period at a time. The arrangement ensures a reliable transfer to the means of onward transport.

This separation of the actual excavator and loading unit, first developed for a wheel excavator of 40,000 bank meters^3 daily capacity (52,000 bank cubic yards), is the design commonly used these days for large and giant wheel excavators.

As we have seen in the beginning, there is a certain connection between the digging output and digging height of bucket wheel excavators. In some deposits, the need may exist for a digging height greater than that which would correspond to the required digging capacity. Such applications show the advantages of a wheel excavator design with telescopic bridge and loading unit.

The BWE and loadng unit can then travel on different bench levels, for added increase of the vertical working range of these excavators. The loading unit always moves at face conveyor level, while the BWE is stationed on an intermediate bench below or above the conveyor level.

The vertical digging range may then be increased once again by making use of the cut below grade provided in some BWEs as an additional facility. A giant wheel excavator at the Fortuna Garsdorf mine, of 110,000 bank meters^3 (145,000 bank cubic yards) daily capacity, thus attains a total digging height of 107 m (350 feet).



With the development of larger bucket wheel excavator units, a prerequisite for a capacity increase was necessary for the haulage of the excavated material. The overhanging discharge conveyor boom was no longer adequate, because its point of discharge had to be moved continually in the digging process.

Out of that total, 25 m (80 feet) are excavated in deep cut below grade, 52 m (170 feet) are the actual digging height of the excavator, 16 m (54 feet) are removed in digging from a higher intermediate bench and 14 m (46 feet) from an intermediate bench below conveyor level.

The development of giant BWE sizes is directly connected with the large open pit operations of Rheinische Braunkohlenwerke AG (RBW). At the largest pit — Fortuna Garsdorf — Rheinbraun at present, operates six bucket wheel excavators of the capacity class ranging between 100,000 and 110,000 bank meters^3 per day (130,000 to 145,000 bank cubic yards). The Fortuna mine has therefore become the world's largest open pit operation.

At the moment two BWEs of 200,000 bank meters^3 (260,000 cubic bank yards) daily capacity are under construction at the Fortuna mine, so as to further increase the production at this pit. The overburden-to-coal ratio will increase in the near future when the pit goes deeper down with growing overburden thickness.

Another even larger open pit is in the planning stage in Germany at Hambach. The two first bucket wheel excavators have already been ordered for this forthcoming new operation, with a daily capacity of 240,000 bank meters^3 (315,000 bank cubic yards) each.

Annual savings of foreign exchange for oil imports, by replacing oil with lignite for thermal power stations, will be 2300 million D-Marks ($1000 million).

The rain and fog of West Germany make it difficult to see the details of the massive Fortuna mine. The power plant in the back ground is nearly four miles away.

... EXPLORATION AND MINE PLANNING

As already pointed out, a detailed exploration of a lignite deposit is the only guarantee for an effective mine planning and an optimum layout of BWE. In the following, the characteristics and the extent of an exploration for lignite are indicated on the basis of a specific, yet typical project.

Within the frame of regional prospecting of Turkey for lignite, which was started in 1966, the basin of Elbistan, located in Southeastern Turkey was considered lignitiferous, and in 1967 five wildcat drills were sunk there. The very first drilling yielded almost 165 feet of lignite. Following this result, the drilling program was extended in view of determining the lignite potential in the basin of 400 square miles. As a result of 55 drills with a total of about 30,000 drill feet, a minable deposit was located in a partial basin northwest of Elbistan, extending over an area of about 50 square miles. In 1968 this area was further explored by about 100 drills of 1 mile spacing, with the purpose of determining the following factors which are decisive for lignite extraction.

- Thickness of lignite and overburden as well as their properties
- Delimination of lignite deposit
- Calculation of reserves
- Correlation of seams by means of determining micro and macro fossils
- Lignite quality (ash, water, heat value, sulphur, etc.)
- Thickness and composition of partings
- Hydrogeological and hydrological investigations
- Composition of the foot-wall down to the bed rock.

After compilation of these data we could select the minable lignite fields out of the large deposit with reserves of about 3,500 million tons. A stripping ratio of up to 3 to 1 was regarded as an economic guideline for a viable mining operation due to the competing primary energies in Turkey at this time. The deposit was divided into three partial fields, videlicet Afsin, Collolar, and Kislakoy, as can be seen on the cross section. These three fields were now compared in order to select the most favorable field for starting the first opencast.

Apart from these factors, numerous others, as for example the consistency of overburden, hydrological conditions, and the nature of the surface must be taken into account.

A comparison of the three opencast mining fields had the following result:

Mainly due to its lignite quality, its high ash content, and its difficult dewatering conditions, the Afsin mining field takes the third place.

When comparing Collolar and Kislakoy, the latter is the more favorable one in view of:

- its smaller depth of opencast and thickness of overburden
- its more favorable hydrological conditions
- its more favorable conditions with regard to the opening up and the location of an outside dump.

The lower overburden thickness, the smaller quantities of opening-up masses, and the considerably smaller amount of overburden to be transported to the outside dump present for Kislakoy a considerable economic advantage over Collolar.

After this evaluation of the three mining fields Kislakoy was selected as the first field to be mined.

After this decision about 490 boreholes were sunk in the area, comprising approximately five square miles in order to delimitate the lignite field and to determine the hydrological conditions.

From the drill cores, more than 15,000 samples were taken and analyzed. In addition to analyses carried out with regard to water and ash content, the heat value of 4,000 samples was determined, and numerous elementary analyses, analyses on the fusing behavior of the ash, and ash-analyses were made. The results which had been derived from the drilling work and from the chemical analyses were evaluated and processed by means of a computer whereby the entire mining field was divided into 12 subsections.

In summary, the exploration of the Elbistan deposit consisted of the following activities:

- 645 boreholes in the basin of Elbistan, 489 of these in the Kislakoy field. Lignite was thoroughly cored, hanging and foot wall were cored in about five per cent of boreholes, drill cuttings were fully logged.
- 16,460 samples were analyzed for water and ash content.
- Approximately 5,000 determinations of heat value were made.
- 123 samples were selected for elementary analysis, ash analysis, and ash fusing behavior.
- 13 wells were sunk and lined for hydrological observations (two for extensive large-scale pump tests).
- Six drillholes with typical strata of overburden were sunk to take samples for soil-mechanical tests.
- geological mapping:
  scale 1: 100,000 regional geology
  scale 1: 25,000 surrounding basins
  scale 1: 10,000 area surrounding the deposit.
- Topographic surveying of drill locations 1 : 10,000 on photo maps, preparation for surveying of 1 : 5,000 and 1 : 1,000 in parts of the area.
- Numerous water analyses of surface water and groundwater.
- Water gauge observations over longer periods.
- Investigations of spores and pollen and determination of micro and macro fossils for correlation of seams and determination of age of other sediments.

The evaluation of these data made it evident that partings in the lignite seam had to be included in the mine planning. The following factors were decisive for the selection of equipment:

- Soft lignite
- Soft material of overburden (non-consolidated sediments)
- High lignite and overburden thickness
- Maximum depth of opencast of about 436 feet.
- High annual production varying between eight and 16.5 million tons.

For facilitating the preliminary mine planning, for determining the equipment capacity, and for elaborating the feasibility study, the Kislakoy field was divided into four main sections.

A possible increase of the lignite production had to be taken into consideration during mine planning.

In general, the opening-up of an opencast mine is undertaken with the same equipment as required later on for mining of lignite. The overburden masses removed during the opening-up must be dumped outside the mine on a so-called "high dump". Therefore it is expedient to undertake the opening-up in a place of small overburden thickness and small opencast depth so that only small overburden quantities have to be transported to the outside dump. It is further to be considered that a distance as short as possible between the place of opening-up and the outside dump is provided for.

After termination of the opening-up which runs over several years, lignite exploitation will start. Even after the start of lignite exploitation, part of the overburden masses must be transported to the outside dump. As soon as the stage of dumping inside the mine area is reached, the normal surface mining operation begins, i.e. excavators for overburden removal and excavators for lignite mining are operating into the planned direction, and inside dumping follows progressively.

The Kislakoy field of a length of 4.4 miles and a medium width of about 1.2 miles extends from the north to the south and is directly connected by a "corridor" with the Collolar field.

With regard to the opening-up, the following considerations were made for the Kislakoy field:

- Certainly the low ratio of overburden to partings to lignite of 1.59 to 0.30 to 1 is in favor of an opening-up in the center.

Reasons against an opening-up in the center are:

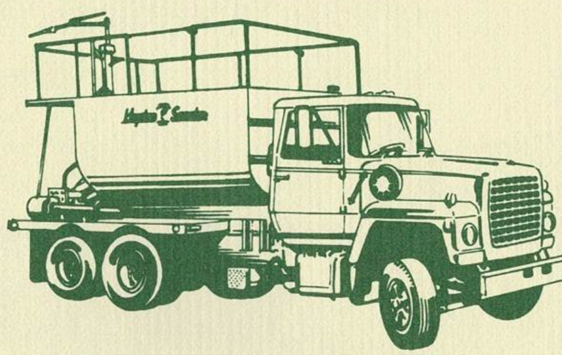
- The great opencast depth of 395 feet
- The necessity to transport 210 million cubic yards of overburden to an outside dump at a distance of 2.5 miles
- Considerable additional costs incurred by the fact that all equipment would have to be transported from the northern rim of the mine field to the initial opening-up place in the central part
- Increased installation costs on account of the required additional length of conveyors, etc.

For these reasons it had to be abstained from an opening-up in the central part of the mining field.

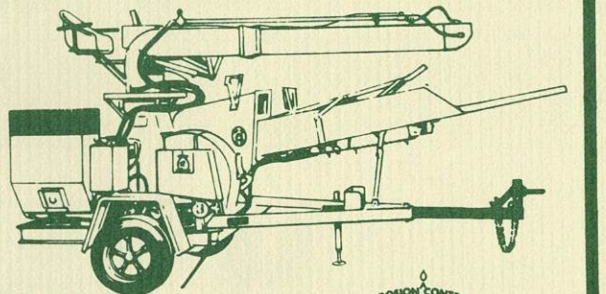
Reasons against an opening-up of the mining field Kislakoy in the south are:

- The high ratio of overburden to partings to lignite in the southern section, amounting to 2.8 to 0.2 to 1
- The great opencast depth of nearly 440 feet
- The long distance to the site where outside dumps can be located
- The later transfer of the entire opencast equipment from the northern rim of the mine to the opening-up of "corridor" and Collolar field.

Against an opening-up in the northern part of the mining field is certainly the unfavorable ratio of overburden to partings to lignite = 2.7 to 0.08 to 1.

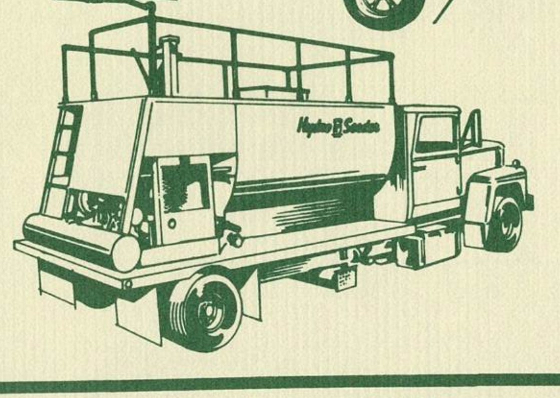


Finn Titan Hydroseeder
Holds 2250 gallons of water and 8000 lbs. of seed, fertilizer and/or lime (or 1000-1200 lbs. wood fiber).



Finn Mulch Spreader
Offers high production performance; spreads up to 15 tons of straw mulch per hour, distances up to 85 ft.

EROSION CONTROL EQUIPMENT



Finn Super Hydroseeder
Holds 1300 gallons of water, 4000 lbs. of seed, fertilizer and/or lime (or 500-700 lbs. wood fiber).

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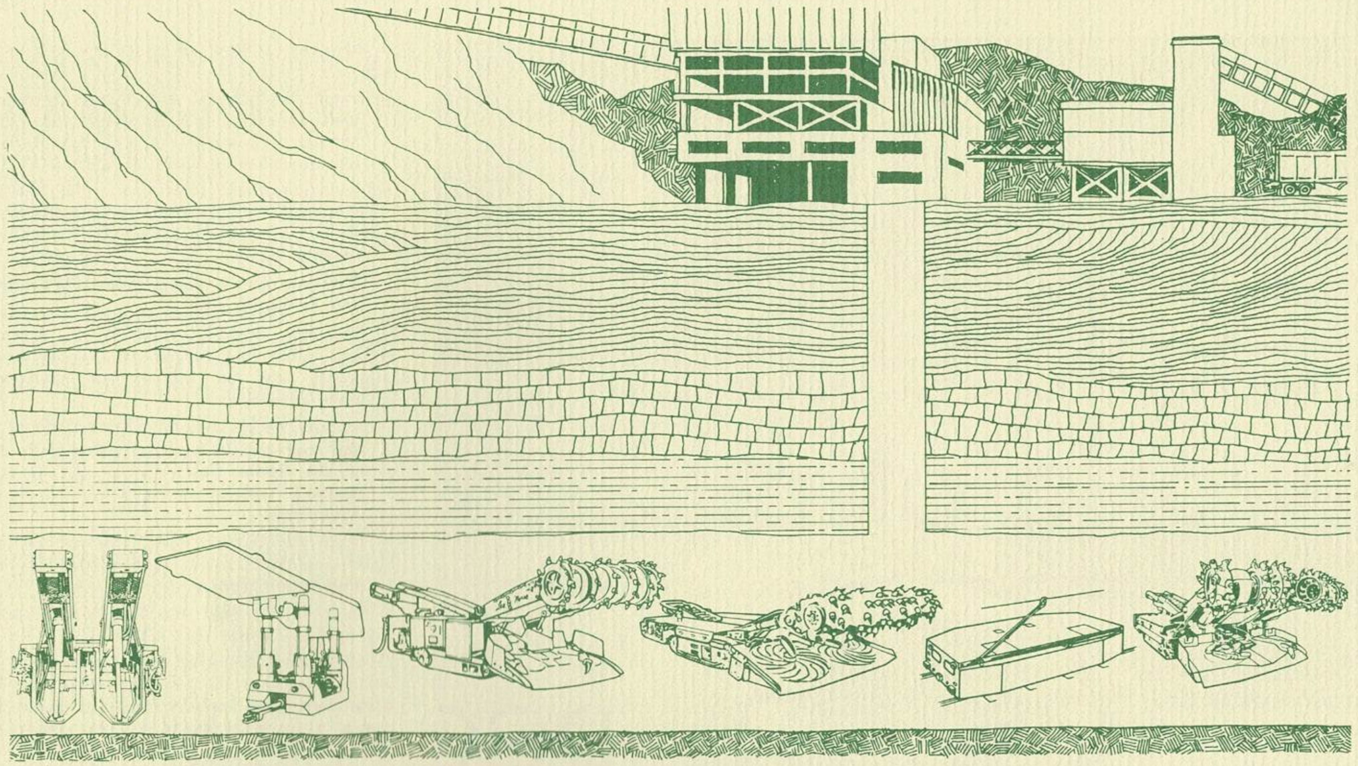

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However, in favor of it are the following factors:

- Small overburden and lignite thickness as well as small opencast depth of 195 feet. Therefore it would not take long before lignite exploitation could be started
- A comparatively small amount of overburden masses (92 million cubic yards) are to be transported, over shortest distance (1 mile), to the outside dump
- Only one lignite seam, practically no partings and no faults
- Favorable mining conditions in overburden and lignite, thus simple working conditions and ample time for training and instruction of mine personnel
- In case the opening-up of the Kislakoy opencast mine is undertaken in the north, mining of the lignite field can be carried on continuously without having to transfer the whole equipment
- From the Kislakoy field, one can proceed to mining the Collolar field without an expensive new opening-up.

For these reasons it was suggested to start mining of the Kislakoy field in the north.

After termination of the opening-up during which according to our calculations 92 million cubic yards have to be transported to the outside dump, exploitation starts in the so-called swinging operation, i.e. the excavator fronts are swung clockwise and advance later on parallel towards the south.

In the southern section of the mining field, again swinging operation will intially be applied, and subsequently the so-called "corridor" will be excavated in parallel operation towards the mine field of Collolar. As the ratio of overburden to partings to lignite deteriorates again here, it is required to add a complete set of equipment for overburden removal, consisting of a bucket-wheel excavator, belt conveyors, and a stacker in order to maintain the annual production of 22 million tons.

With reserves of the field amounting to 630 million tons (470 million tons plus "corridor" with 160 million tons), the life of the mine would be about 38 years, based on an annual output of 16.5 million tons.

The whole basin of Elbistan is more or less intensely cultivated by farming, therefore considerations as to replanting of the outside dump and to reclamation of the mined-out area had to play an important part.

These considerations are a necessary precondition for evaluating a lignite deposit which is to be mined by BWE and conveyors, and finally assessing the economic feasibility including the lignite processing plants.

The detailed mine planning is carried out after the capacity of the mine has been decided upon and prior to ordering the main equipment. It consists of the following principal parts:

— **Opening-up of mine**

The important elements are:

- Design of most favorable opening-up shape
- Time schedule for setting into operation of equipment
- Planning of conveyor lines
- Division into benches
- Detailed plan of dump site.

The opening-up of an opencast can take several years. Durng this period the capital is partly invested, yet not a single ton of lignite is produced and no revenue is obtained. Therefore, great care has to be exercised when planning the opening-up in view of saving time and money. At present, a large-scale opencast, envisaged for an annual production of about 55 million tons, will be opened-up near Cologne. The mean depth of the mine will be of approximately 1,200 feet, that means about 2.6 billion cubic yards of overburden will have to be removed. In other words, about six to eight years will be needed for opening-up.

— **Lay-out of equipment**

The important elements are:

- Height of benches
- Selective mining in overburden or lignite (partings)
- Stability of slopes
- Ground pressure for equipment
- Properties of overburden, lignite, and partings
- Capacity of conveyors, stackers, and BWE
- Stability of dumped overburden.

— **Detailed planning of exploitation**

The important elements are:

- Length of benches
- Possible installation of a combined conveyor for lignite and overburden
- Mine plan for BWE/conveyor/stackers
- Consideraton of varying lignite quality within the seam
- Possible separate extraction of clay or gravel
- Determination of all auxiliary equipment for the mine
- Planning of river deviations, relocation of villages, re-routing of highways and roads, etc.

The planning elements mentioned so far are interdependent of each other in that way that every aspect of planning is being examined for its effect on the layout of equipment and on the cost. Detailed annual plans of operation are set up for at least ten years from the start, and rather exact predeterminations normally exist for the remaining period which ends either by exhaustion of reserves or by wear of equipment. For instance, critical phases of the operation which might result from faults or from a change in the stripping ratio are analyzed and it is examined whether or not they will influence the output of equipment and consequently the lignite production.

In general, the processing plants are laid-out for a specific lignite quality. Therefore, if variations of lignite quality occur within the seam, the mine planning would have to consider these variations and would have to make the necessary provisions in order that lignite of constant quality is supplied to the processing plant. In some cases it will even be necessary to sink shafts in various parts of the deposit and to drive tunnels from there in order to take large samples for industrial tests and to obtain exact data for the specifications of the processing plant.

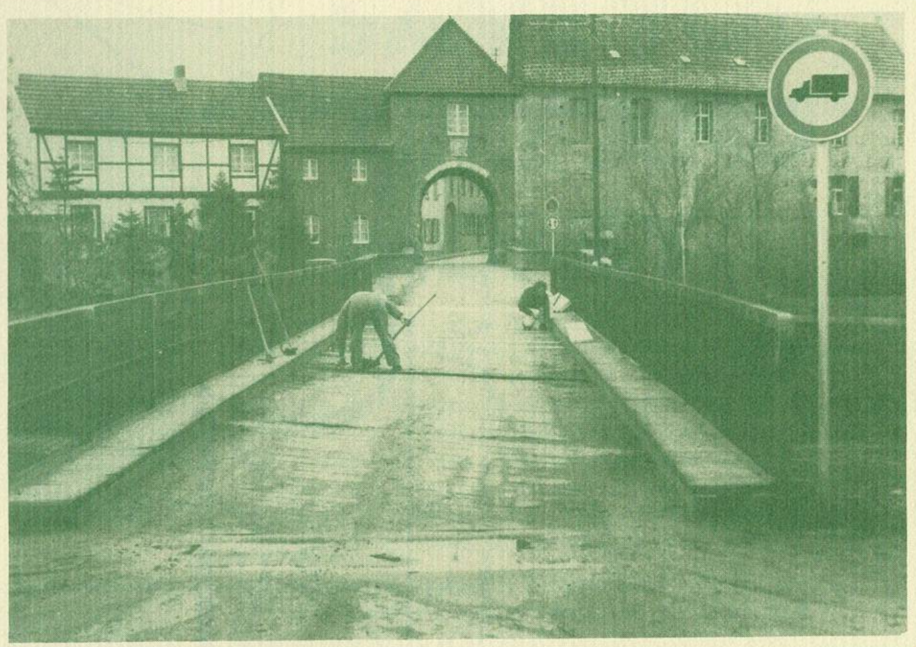
— **Groundwater control**

The important elements are:

- Planning of dewatering wells and pumping system for lowering the water table
- Planning of a drainage system to discharge the pumped water
- Calculation of the water inflow and draw-down and its effect on the surface
- Drainage of pit bottom in view of eliminating residual water and surface water
- Determination of drainage for disposal and possible consumption of surplus water.

In lignite opencasts with considerable depth, the problem of drainage is quite significant for securing the lignite production and for the general safety of the mine. In the Rhenish Lignite District, for instance, between 1,000 and 2,000 gallons of water have to be pumped off for producing one ton of lignite. Here, too, exact knowledge of the hydrology and hydrogeology has to be combined with an exact planning of drainage in order to arrive at optimum cost and time for depressing the water table prior to opening up the mine.

However, planning of the opening-up, planning of exploitation, and planning of drainage are not the only elements that a detailed mine plan consists of. Another integrated part of the mine planning is the reclamation plan, to be explained later.



German workmen repair a small wooden bridge leading into a village that is as ancient as the country side.

. . . RECLAMATION AS AN INTEGRATED PART OF MINE PLANNING

The most important elements of a reclamation plan are:

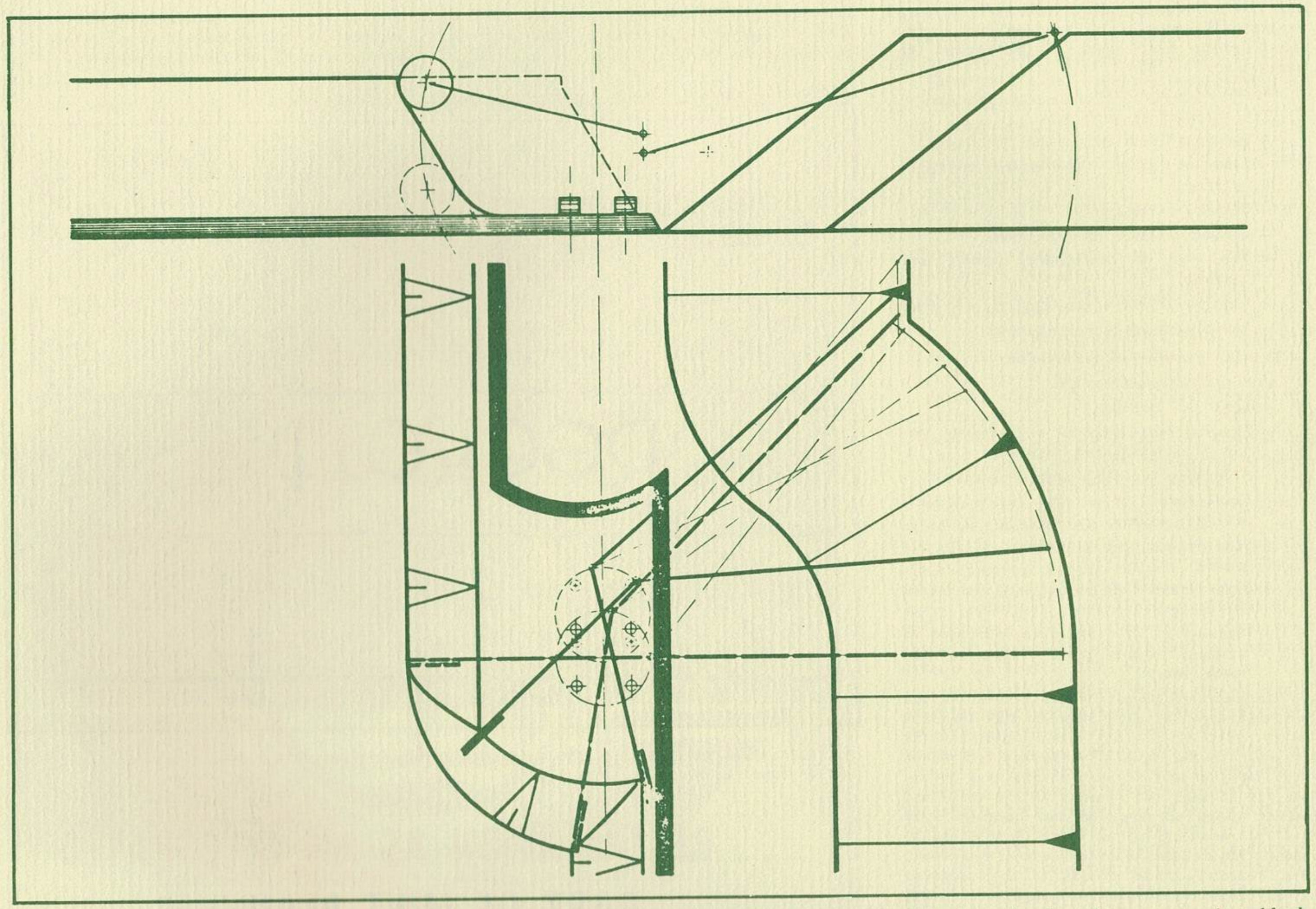
- Investigation of topsoil and subsoil strata for acidity, toxic elements, etc. with regard to utilizing them for recultivation.
- Site and structure of outside dump, taking into account type of soil, slope, criteria of drainage, avoidance of erosion, as well as composition and spreading of topsoil.
- Revegetation of outside dump.
- Structure of inside dump according to type of soil, suitability of soils from the overburden for topsoil, compaction of inside dump by differing casting heights of stackers, possibility of dumping garbage and industrial waste.
- Revegetation plan for mined-out area.
- Land use planning before and after reclamation.
- Planning and design of the remaining pit, i.e. either a lake with a recreation area or a water storage could be envisaged, or the pit could be used as protection against floods or could be refilled with waste or with overburden from other mines.

In addition to the plan of operation for the entire opencast, the reclamation plan has to indicate in detail to which extent the exploitation of lignite affects the environment. This applies in particular to Germany, a country with a comparatively small extension and a large population. Probably for this reason Germany can offer experience of long years with regard to recultivation of mined-out areas after extraction of lignite by surface mining.

It was not before the early twenties that government, farmers, and mining industry discussed recultivation of mine areas. "This should be done by taking all necessary steps in order to provide that in the terrain used for mining operations the original situation is restored."

It was then proved by statistics that from 1880 to 1921, about 38,000 acres of soil used for farming and about 8,600 acres of soil used for forestry had been required for lignite extraction. However, it was a great surprise to learn at the same time that of this area, 19,500 acres (52 per cent) had been recultivated for farming and 2,500 acres (29 per cent) for forestry. In this connection, it is worth mentioning that—with the exception of a single paragraph in the Mining Law which dealt with the subject in general terms only—before 1922 no special law did exist with regard to land reclamation and that the operators carrying out land reclamation before, did so on a voluntary basis. Yet a flood of new laws, orders, and regulations has been issued since then. These are very severe, however, and are handled with enormous expertise and bonafide by mining authorities and operators. Land reclamation and environmental protection only turn out to be a problem for all concerned if new mining projects are discussed in public by politicians electioneering.

It has to be admitted that the decisions to be taken in this sector are of utmost significance for the society even though they are sometimes quite painful. Owing to the fact that in Germany we have no surplus in energy of any kind, we are forced to exploit the domestic primary energies to their limits which will always result in a



The above is a wheel excavator with direct casting discharge boom. It removes up to 100 feet of overburden above a seam in a block width of 115 feet, cutting four horizontal slices of 25 feet height each.

compromise between economic necessity and environmental protection. It is above all West Germany, which had to accept this compromise after World War II thus rendering successful pioneers' work in land reclamation of lignite mining areas.

This does not only apply to the Rhenish District but also to the Helmstedt District and to the Hessian and Bavarian District.

Due to a continuous dialogue between mining industry and state authorities in the last 25 years, laws and regulations have always been modifed on account of new scentific results and new requirements of the legislative authorities.

Very detailed regulations have for example been issued in the state North-Rhine-Westfalia for the Rhenish Lignite District. These stipulate that only topsoil or loess, the latter occurring in various layers of the overburden, are to be utilized for agricultural recultivation, either separately or as a mixture. On the other hand, gravel and clay must never be employed as constituent of arable soil. Before topsoil is being spread, it has to be warranted that sufficiently permeable material (sand and gravel) is placed in order to allow for water seepage. The thickness of this layer should be in the range of six feet. Clay and lignite are not to be constituents of this layer. Besides, the surface of the dump, prior to spreading of topsoil, has to be built up in a way that detrimental water accumulations cannot form. Therefore this surface should have the same contour as the recultivated area. The dump should not be compacted. If dumps show excessive compaction, they have to be loosened before the topsoil is spread. When spreading the arable topsoil, importance has to be attached to the fact that horizons disturbing the water seepage will not form, nor inclusions of fine gravel or clay or compactions.

Regulations may vary in the individual districts according to water, soil, and climate conditions, however, the provisions by the law are as follows:

— Separate removal of topsoil
— Separate extraction of subsoil from the overburden which may be used as topsoil layers, in other words, sometimes segregations of overburden
— Restoration of land by backfilling, compacting where advisable, and grading of topsoil and suitable parts of overburden which are best able to support vegetation
— Revegetation according to approved reclamation plan
— Disposal of mine wastes, lignite processing wastes, or other liquid or solid wastes according to approved reclamation plan
— Elaboration of a detailed plan of operation for reclamation and revegetation (temporarily or permanently)
— Elaboration of an environmental impact study dealing with the effects of a mining project on traffic, towns, surrounding industries, water supply, water and air pollution, off-site areas, safety, etc.
— Revegetation on outside and inside dump has to start immediately after reclamation to avoid unwanted compacting and overgrowth of weeds.

If for instance loess is dumped by stackers, drop of material should be low in order to avoid compaction which might affect plant growth. This example only applies to the recultivation of agricultural areas. For areas to be utilized for forest land, regulations are different with regard to properties of soil, spreading, etc.

Credit has to be given, above all, to the permanent endeavors of the mining industry for the fact that in the Rhenish Lignite District, a new landscape has been created that is more abundant and more beautiful than it had been before lignite mining took place. In the area of about 1,000 square miles, a systematic landscape planning has been carried out for mined-out areas. In total, approximately 90 million plants have so far been set, 62 million of these after the war. About 60 different kinds of leaf-wood have been planted.

Every year between two million and two and a half million trees and bushes are planted for which very special types of soil had to be "developed". It has proved for instance, that a mixture of sand, gravel, and loess with a thickness of 12 to 16 feet is quite appropriate for a reforestation. The soil will receive the missing contents of humus and nitrogen by a simultaneous sowing of lupines, thus warranting a loose soil structure, sufficient oxygen content, and diversity of mineral nutrients.

In total, 26,200 acres have been recultivated in the Rhenish Lignite district up to 1973 of which 38 per cent (9,950 acres) were recultivated for agriculture, 48 per cent (12,560 acres) for forestry, and 14 per cent (3,660 acres) for other purposes. In 1973 the mines and plants covered 14,000 acres. The total surface of artificial lakes amounts to 1,180 acres, and 1,960 acres have been made available for infrastructure and

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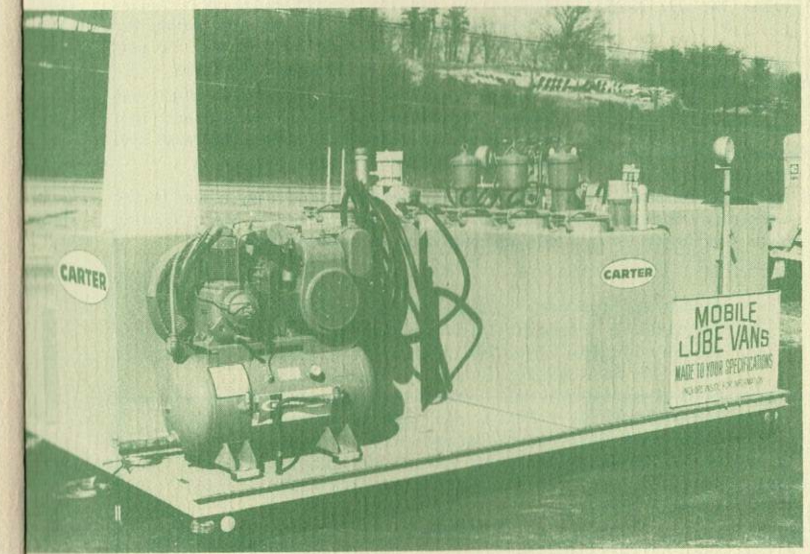

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housing. In 1974 alone, about 730 acres of previous opencast terrain could be turned into usable land again.

New methods had to be developed for these purposes. The BWE, and subsequently the stacker, first fulfill the task of building up a proper structure and an adequate compaction of the dump; then the grader gives the final contour to the surface. Immediately afterwards, vehicles with planting equipment start to plant trees or bushes. Such planting machines are operated by three men and can set 10,000 plants per day.

Here in Germany, environmental protection is one of the great issues of the federal government and the state governments, and amendments are being issued all the time. Nevertheless, a relationship of confidence has established between the state authorities and the mining industry in the course of years, and this relationship must be called detached and objective. Another advantage is offered by the fact that in practice, the mining operator deals with one state authority only, viz. the competent Bureau of Mines located in the district. The Bureau of Mines for their part will consult other authorities, institutes, associations, etc. in cases where they need support for taking the decision.

If a company wants to open up a mine, a long-term plan of operation has first to be submitted to the Bureau of Mines for approval. This plan must contain operational details extending from the opening-up to the exhaustion of the lignite field. Details concerning land use planning before and after exploitation, type of equipment, groundwater control system, methods of land reclamation, etc., have to be indicated. As regards, special problems like planning of traffic, drainage, urbanization and housing projects, general safety, revegetation, etc., the Bureau of Mines may require additional plans of operation. In a committee which is presided by the Bureau of Mines, the mining projects will then be negotiated, and the permit will finally be granted here. Members of this committee are representatives of the state government, municipalities, water and traffic departments, the state geographical survey, the farmers' association, the industry, and the bureau of land management. The committee is also obliged to listen to representatives of groups which have been formed ad hoc by citizens who might feel affected by the project in some way. According to the environmental problems involved and depending on the intensity of public relations activities of the applicant, the procedure of permit takes between one and five years.

After starting with the exploitation, the operator has to submit a detailed plan of operation every year, with this annual plan, the Bureau of Mines can control the activities of the operator. Besides, the opencasts are inspected regularly by representatives of the Bureau of Mines. In case of violations the Bureau of Mines can impose penalties and corrections and may in case of noncompliance request the close-down of the operation.

For some reason it is not easy to compare the German laws and regulations for land reclamation with the Surface Mining Control and Reclamation Act:

— First, the mining conditions here differ from those in the States,

— Secondly, conditions are also different with reference to climate, soil, water, biology, land and socio-economics,

— Thirdly, large-scale mines start in untouched regions of the US whereas in Germany the public in the mining districts has been familiar with mining for generations.

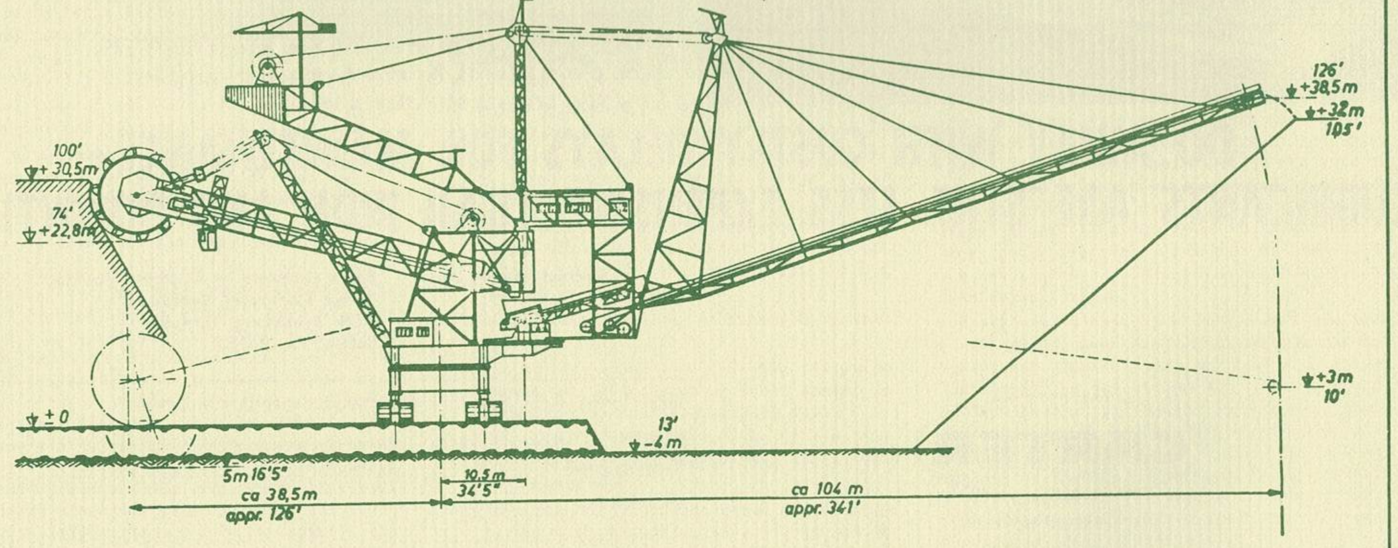
In the United States the discussion on the new mining law seems to be handicapped by the fact that different groups stand for extreme views, ranging from energy supply without any environmental protection to the absolute prohibition of surface mining. An analysis of the Congressional Bill H. R. 25, dated January 14, 1975, of the White House comment, including 27 critical and important changes dated February 6, 1975, and of the critical and substantive concerns stated by the National Coal Association, prove that the differences in opinion are still quite significant.

With regard to land reclamation itself, we consider the conditions stipulated in Section 515 to be almost totally acceptable although too little allowance has been made for the totally diverse mining conditions prevailing in the Western and the Eastern States. On the contrary, it seems that the procedural problems like citizen suits (Sec. 520), notice and hearing procedures (Sec. 513), interim program for federal enforcement (Sec. 502), surface owner consent (Sec. 716) and several ambiguous terms in the bill contain a high amount of uncertainty which will hinder the start of many new projects and which will finally jeopardize the increase of the US coal production. Last not least, it appears that the competences between federal and state agencies have not precisely been defined yet so that the corrsponding laws are still pending, thus increasing the prevailing uncertainty. The solution is to find a reasonable compromise between environmental overkill and energy supply at any sacrifice.

The example in Germany shows that it takes a lot of time before such compromise can be achieved in practice. Therefore, it is necessary to make things easier for the industry during the transition period when starting to apply the new laws, and to grant an adequate lead time.

Furthermore, we are convinced that the German techniques for surface mining and land reclamation may contribute when the new laws are enacted in the States.

The BWE for instance could play a part in the future U. S. coal production if the following mining conditions were prevailing:



The above drawing depects a bucket wheel excavator with a stacker boom for direct- casting. The wheel boom and stacker boom have different slew centers—the slew center of the stacker boom is located on the projecting end of the wheel boom. In this manner, dead counterweight for the wheel boom may be omitted; the function of that counterweight is taken over by the stacker boom together with the counterweight of the latter.

— Greater overburden thickness

— Several seams, which imply selective mining

— Considerable increase in size of opencast mines and thus increased removal of overburden

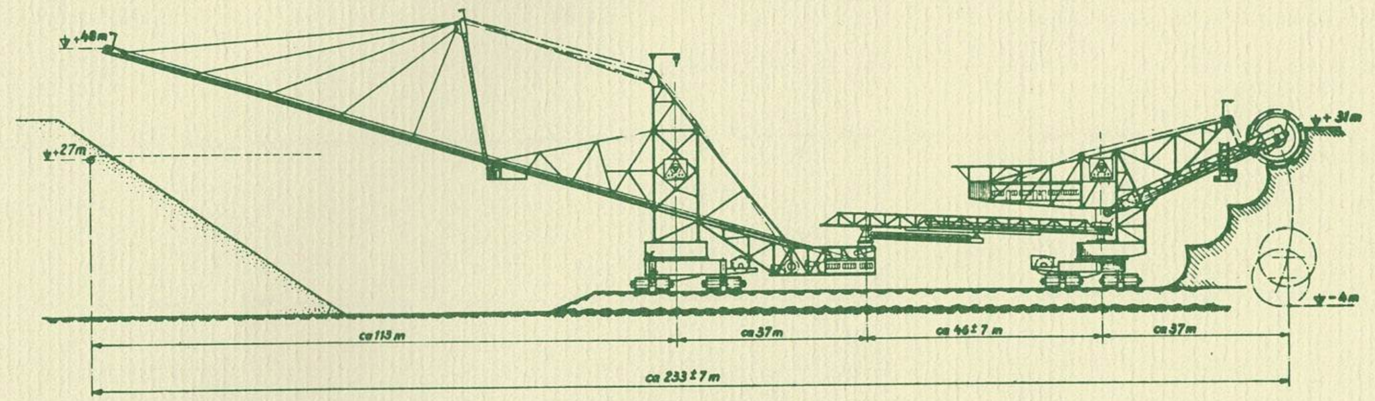
— Stringent land reclamation acts

— Provision of higher lignite reserves for gasification and power plants

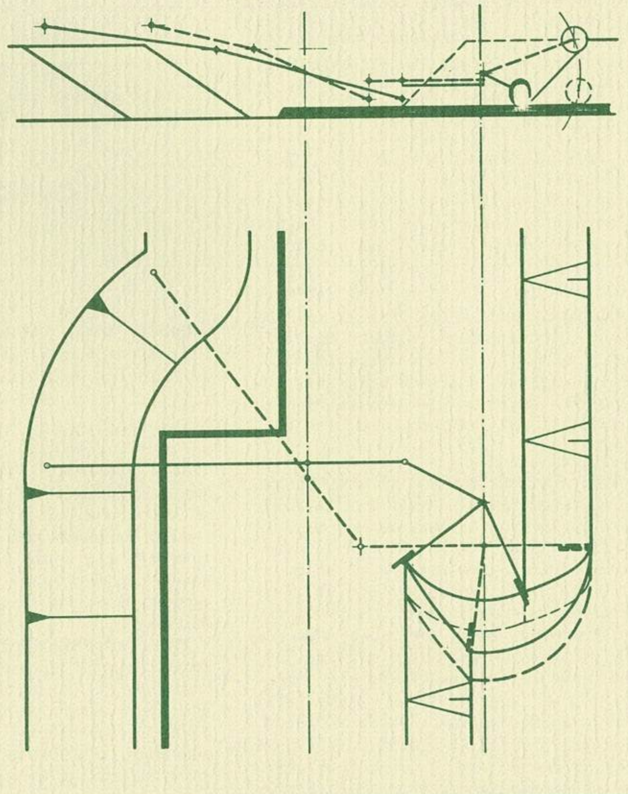
— Mining of coal fields with a less favorable stripping ratio.

Since two mines never are alike, every project has to be scrutinized individually. It is, after all, always a question of cost and economy whether BWE/conveyors or dragline/shovels or both systems in combination are to be employed.

In this respect the new laws for surface mining and land reclamation will require new solutions and new systems, and the search for such new techniques will be a challange to the mining industry and to every engineer.



Another direct casting concept is shown here. A bucket wheel excavator is equipped with a telescopic discharge bridge, with its end resting on a belt wagon with an overlong stacker boom. The advantage of this design is that the position of the stacker boom is independent of the slew movement carried out by the wheel boom, as shown in the adjoining drawing.



... SURFACE MINING TECHNIQUES FOR DIRECT CASTING

In the United States, coal deposits with moderate overburden cover are being mined with optimum success by draglines using the strip mining technique. The most common dragline type has a working radius of about 90 m (300 feet) and, when digging a block width of about 35m (115 feet) permits direct casting of overburden up to about 25m (80 feet) thickness above the coal seam into the worked-out pit. If the overburden thickness is more than 25m (80 feet), the essential advantage of a dragline operation with direct casting of the entire stripped overburden is lost because part of the overburden then has to be rehandled. This is due to the working reach of the dragline which, like any other type of machine, has its inherent typical limits of application.

Where the optimum dragline reach of 25 m (80 feet) is significantly exceeded, a bucket wheel excavator may be used with advantage as an additional stripping unit, working in conjunction with a double-wing stacker bridge.

A dragline would operate as usual, stripping the overburden up to 25m (80 feet) thickness above the coal. The overburden above this limit, up to maximum about 25m (80 feet) would be removed by the bucket wheel excavator. In this manner, a total overburden thickness of 50 m (160 feet) could be excavated. The BWE transfers its excavated material to a conveyor bridge of appropriate span which bridges the working range of the dragline. The bridge rests on two crawler trucks, one running at excavator level and the other on the dump. From the conveyor bridge, material is delivered through a movable loading saddle to a balanced double wing stacked whose two wing conveyors carry the material away from the saddle in opposite directions.

The material can thus be cast simultaneously or alternately in deep and high dumping. Deep dumping onto the dragline dump at the same time creates a level surface for crawler travel of the conveyor bridge.

It is an inherent advantage of the stacker operation that it produces an almost level dump surface without significant assistance of bulldozers, with such level surface being a prerequisite for recultivation of the mined-out area.

The overburden above 50 m (160 feet) thickness is in that case also stripped by bucket wheel excavators. If the digging height of such a BWE is 25 m (80 feet), this would result in a total digging height of about 75 m (240 feet). The BWE transfers its overburden to a shiftable excavator face conveyor which takes it along the bench to a connecting conveyor at the end of the pit. The connecting conveyor serves to bridge the working range of the dragline and of the other BWE with conveyor bridge. The overburden is then taken to a dump face conveyor and onward to a boom stacker by means of a travelling tripper; the boom stacker casts a high or deep dump as required.

The system of BWE, conveyors and boom stacker is the most common arrangement in German lignite mining operations. It has the advantage that it can be repeated in any number of tiers, depending on the open pit depth. In the example just described, it would also be possible to add a second or third system, if the total overburden thickness requires such an addition.

The combination possibilities shown here for a dragline and bucket wheel excavator can also be applied in conjuncton with a stripping shovel replacing the dragline. The shovel would have to be appropriately selected, however, so that its overall height fits the clearance under the conveyor bridge.

Apart from the combination of dragline or shovel with bucket wheel excavator, the BWE itself can be designed as a direct casting machine as well. It removes up to 30 m (100 feet) of overburden above a seam, in a block width of 35 m (115 feet), cutting four horizontal slices of 7.5 m (25 feet) height each. As is seen in the illustration, the discharge boom describes slewing movements relative to the wheel boom. The overburden from each excavated slice is therefore cast on the dump within a certain slew range. This relative movement is an inherent design feature. The wheel boom and stacker boom have different slew centers. The slew center of the stacker boom is located on the projecting end of the wheel boom. In this manner, dead counterweight for the wheel boom may be omitted; the function of that counterweight is taken over by the stacker boom together with the counterweight of the latter.

The overburden is stripped in four slices of 7.5 m (25 feet) thickness each. A certain position of the stacker boom is associated with each of the four slices. The belt wagon may retain its position during excavation of one slice at a time, while the travel movements of the BWE are compensated by its telescopic discharge bridge.

It is a major advantage of this equipment combination that a large coal reserve can be exposed over the entire bench length in a full block width.

Trip Hamilton and Larry Garbart inspect the excellent vegetation on reclaimed mine spoil. This area was stablized with grass/legume, as well as, tree cover.

TECHNICAL REPORT

DEEP MINE SAFETY

(Editor's Note: The following represents excerpts from a presentation by Dr. Zur Nieden, head of the Department of Training, Safety and Medical Services at Ruhrkohle AG, before the International Mining and Reclamation Conference in Dusseldorf, West Germany).

Describing safety from the point of view of his company, Nieden stated that safety and protective measures at work give rise to many questions, and that is why two services are set up at each mine. One is connected to the fight against accidents and the prevention of catastrophies' or to fight against individual accidents due to more or less unforeseeable events. The second service is responsible for all protective measures.

"It is not only the question of dust control in order to avoid silicosis, but also a question of reduction of noise, lighting of the workplace and improvement of the climatic conditions; all of these factors which must be taken into consideration in order to improve the situation at work, to protect the health of the miners and to humanize the environmental working conditions," he said.

In order to protect the personnel and the mines from disaster like fire and explosions, they have about 40 mine rescue corps with about 3,000 unpaid members who are equipped with gas protection apparatuses and other special devices. In addition, each mine is provided with a full-time physician.

According to Dr. Nieden, four focal points for improving safety at work are:

1. Safety should be planned early in the program and on a long-term basis, independent of daily events. The program should evolve around the necessities, demands and specific problems of each individual mine.
2. Adequate information should be available to the miners. The safety department should inform the management of the mines, the supervising personnel and the work council, concerning accidents or illnesses, and also inform them of any interfering environmental influences and relate if new measures being introduced are a success or failure.
3. It is vital to act on detected defects in the mines immediately and to keep in mind the aspects of safety already in advance in a preventive manner in the planning and preparation stage. It is the job of the central departments to see that safety standards are transformed into practical instructions and that safety conditions are inserted into work techniques.
4. Continual inspection and supervision is a must in order to obtain precise information concerning the conditions and equipment in the mines.

In order to implement safety and protective measures into the enterprise as a whole, a safety committee should be set up in each mine, consisting of a mine manager, technical directors, operating managers, president of the works council and his deputy, and the heads of safety and protective services in the mines.

A new employee should be given all safety information by the supervisor upon his first day of work. Charts, diagrams and numerical records should be available concerning accidents. Instructions on newly developed safety devices on equipment and the handling of tools and apparatuses should be issued to the men. The personnel on the whole should be kept up-to-date by a company publication concerning safety problems.

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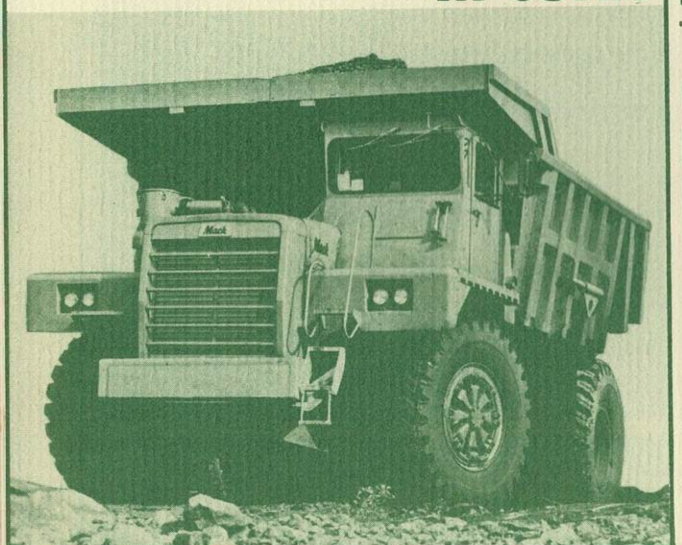

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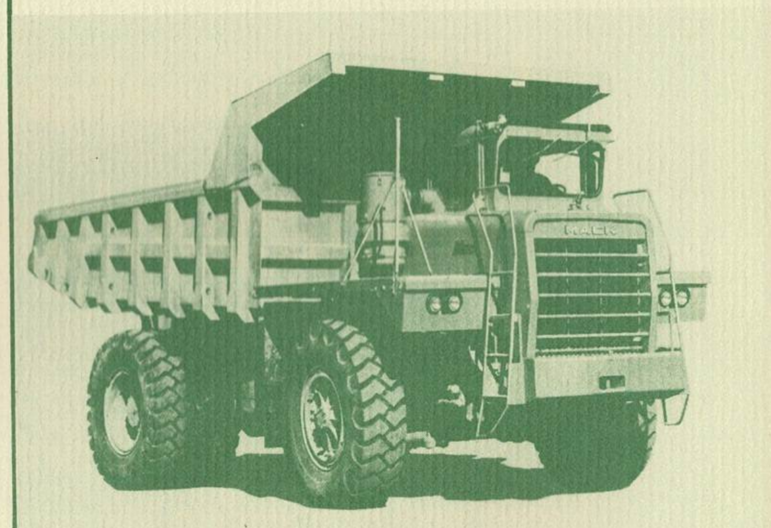

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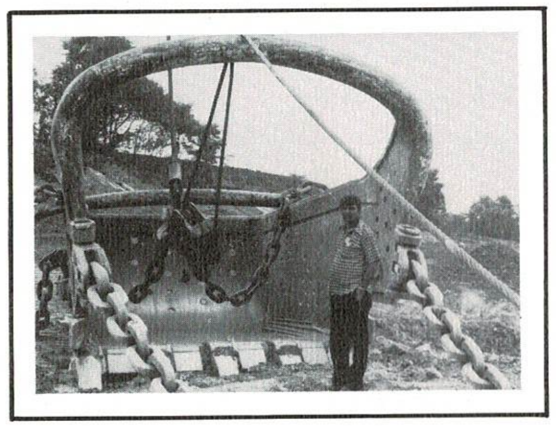
Restripping Eliminating Abandoned Mine Scars



Above: Rockville's Vice-President Joe Elliott stands beside the bucket of the state's largest dragline, now operating in Preston County.

Right: Rockville Mining Company expects to recover approximately 22,000 tons of coal per month from this area that was originally mined over 10 years ago.

Highwalls and spoil piles left over from abandoned surface mining projects in West Virginia are being eliminated at a rapid rate, but ironically the environmental improvements are being achieved through expanded mining, rather than increased reclamation.

Ben E. Lusk, President of the West Virginia Surface Mining and Reclamation Association, explained that this seemingly contradictory situation is made possible by what the coal industry calls "restripping."

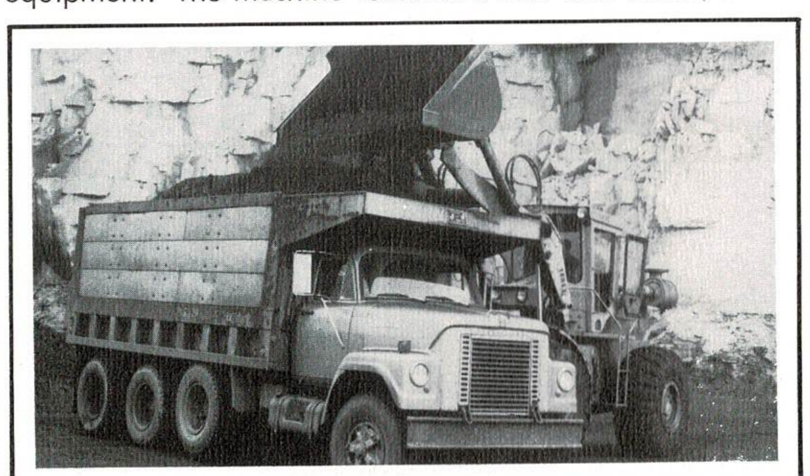
"Restripping simply means going back to extract coal from an area that was previously surface mined," he said. "Many of our operators are finding it feasible to go back to these areas and recover coal that was left when it became too uneconomical to mine in past years."

Lusk noted that the recent trend towards restripping is based on several factors, but the most significant is economics.

"With energy shortages and rising demand for coal, prices have gone up in recent months. This increase in prices has increased the coal-to-overburden ratio and allows miners to recover more coal than was previously possible," he said.

Rockville Mining Company in Preston County is heavily involved in restripping and has purchased the state's largest dragline in order to achieve its production and reclamation goals. Through the use of a new Marion 7500 dragline, Rockville is able to recover coal that was once considered unminable and is eliminating miles of 10 to 15-year old highwalls.

The company made a $4 million total investment to purchase and erect the dragline, as well as supporting equipment. The machine features a 200 foot boom, 2 and 5/8 inch hoist and drag cables with a maximum suspension load of 110,000 pounds. The drag's 22 cubic yard bucket is removing over 100 feet of overburden in order to reach 48 inches of the Upper Freeport coal seam.



Joe Elliott, Vice-President of Rockville, explained why the Marion 7500 was purchased. "The area we're restripping was originally mined to a depth that could no longer be mined economically with conventional equipment. Therefore, in order to recover this coal, it became necessary to invest in a larger machine," he said.

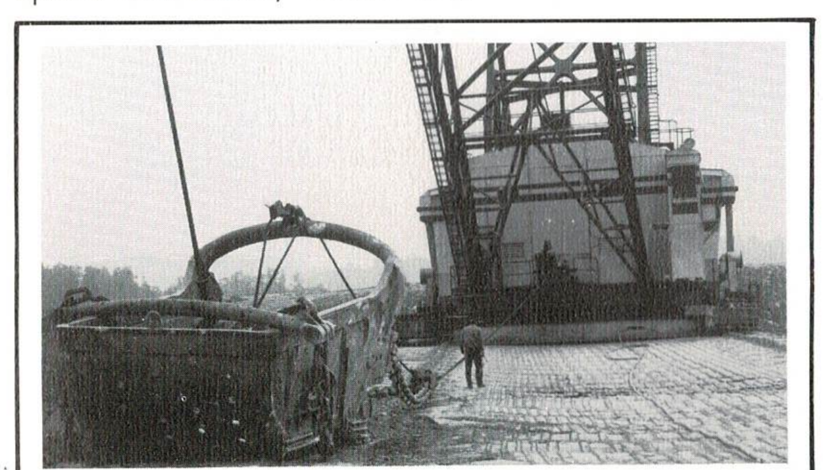
Rockville expects to recover approximately 22,000 tons of coal per month from an area that has already been mined. Because of an excessive amount of sandstone above the coal seam, they are using two 45 cubic yard scrapers to remove and stockpile top soil in order to insure good revegetation and stabilization.

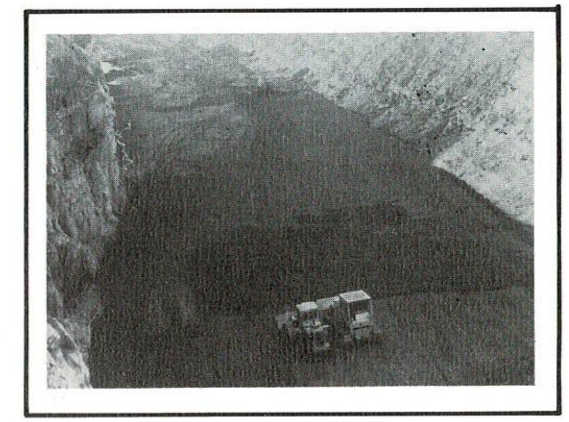
Ben Greene, Chief of Reclamation for the Department of Natural Resources, is obviously pleased with the increase in restripping.

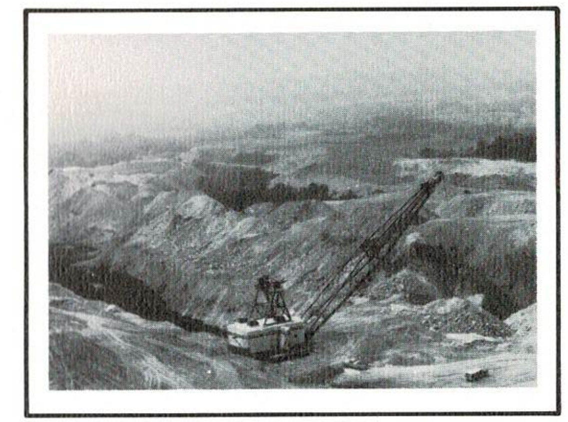
"It is certainly a healthy trend," he said. "Reentering an inactive area allows the operator full environmental control before, during and after mining. Due to our modern day standards, we are now receiving a higher degree of reclamation through restripping."

Greene also explained that due to larger equipment, new methods and accessibility, restripping is a great benefit to the state's Special Reclamation program that would normally be responsible for reclaiming such orphaned lands.

"The operators are totally eliminating the old highwalls, where we could not do so in most cases through Special Reclamation," Greene said.







Top: Chief of Reclamation, Ben Greene, says of the restripping, "It is certainly a healthy trend. Reentering an area allows the operator full environmental control during and after mining."

Left: The drag's 22 cubic yard bucket is removing over 100 feet of overburden, which is mostly thick sandstone, in order to reach 48 inches of the Upper Freeport coal seam.

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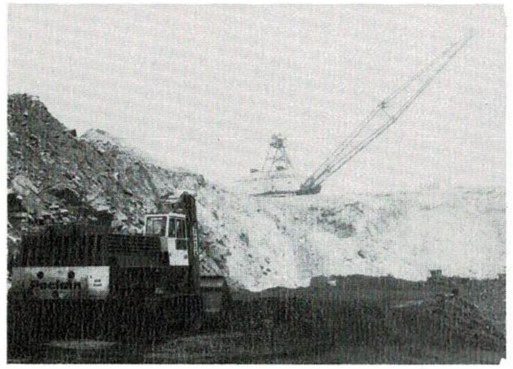

The new machine features a 200 foot boom, 2 and 5/8 inch hoist and drag cables with a maximum suspension load of 110,000 pounds.

(Continued from Page 35)

A recent survey by the Reclamation Division shows that since March of this year, the trend towards restripping has been significant. Of the 95 permits issued, 35 (36.8%) are recuts, and of the 5,900 acres permitted, over 2,000 acres (35%) were previously disturbed by surface mining.

However, the most significant factor is that on the restripping permits issued since March 20th of this year, 164,802 linear feet or 29.3 miles of highwall will be totally eliminated. This figure promises to be substantially higher by the end of the year.

Lusk explained that restripping provides a twofold benefit for the industry, as well as the state.

"First of all, we are able to recover coal deposits that were once considered unminable and, secondly, we are eliminating and reclaiming old, abandoned surface mines that have scarred the mountains for as long as 30 years or more," he said.

A third advantage has to do with the overall amount of land disturbed each year. Lusk explained that early indicators are predicting a small increase in West Virginia's surface coal mine production this year, but because of trends toward restripping, there will not be a proportionate increase in overall land disturbance.

"We will be producing more coal, but actually disturbing less untouched land," he said.

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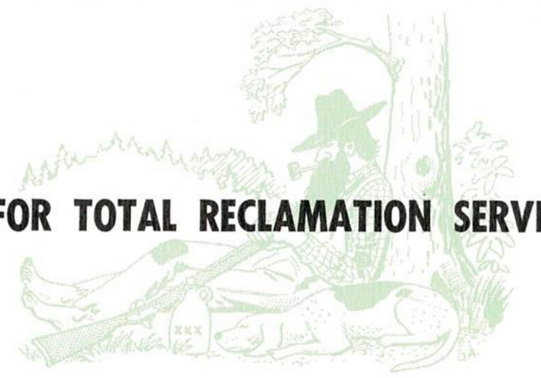

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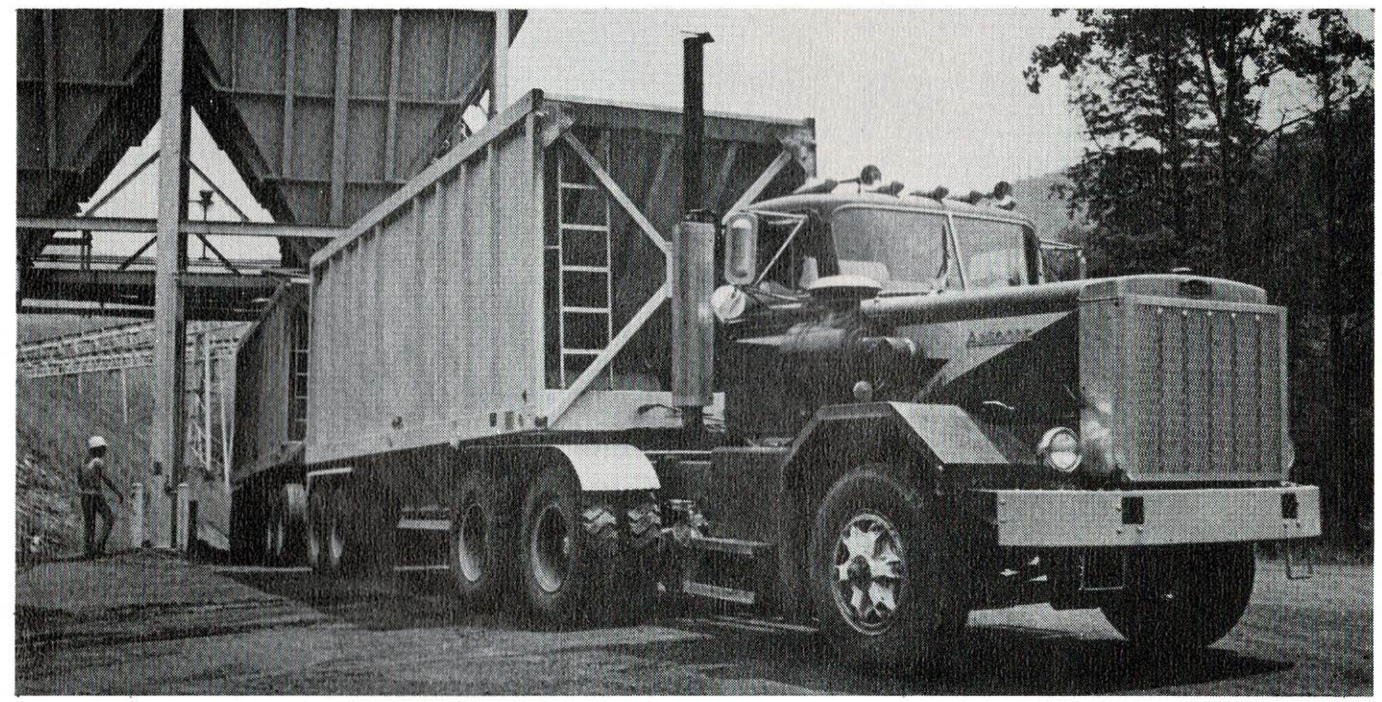

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WVSMRA Technical Program Features Fall Seeding

Above: William T. Plass, principal plant scientist for the United States Forest Service, first became interested in fall seeding in 1971. He recommended the species Balboa Rye, Abruzzi Rye and wheat for cover crops and has experimented with them on Ford Coal Company property in Cabin Creek and Sewell Coal Company mines near Richwood.

Right: The afternoon portion of the conference was a demonstration of the new Estes one-way spreaders for lime and bark.

The presentation of "An Overview of Fall Seeding in West Virginia" highlighted the Association's Fall Technical Conference, held at the Ramada Inn in Beckley, West Virginia on August 14.

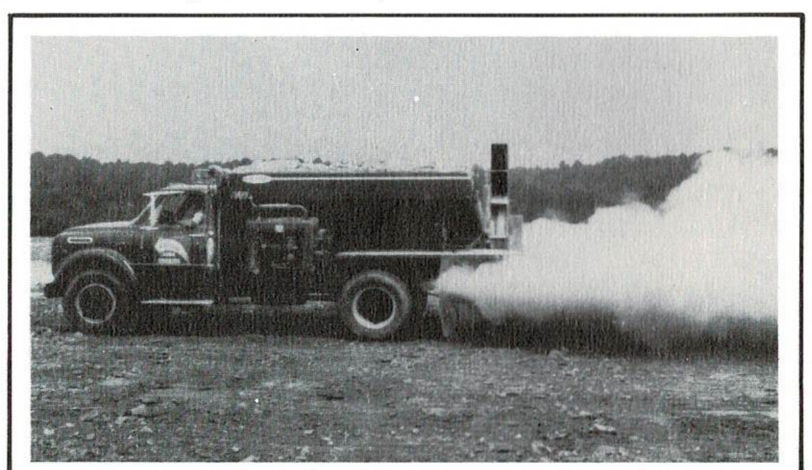
Over one-hundred industry representatives turned out for the meeting, which was designed to disseminate the most current information available on improved reclamation and mining methodology. The one-day format, which proved so successful last spring, was used again, in order to encourage more technical and field personnel to attend.

Featured during the morning session were William T. Plass, principal plant scientist for the United States Forest Service, and Wayne Everett of the Soil Conservation Service, who divided the fall seeding discussion between southern and northern West Virginia.

According to Plass and Everett, fall seeding has many advantages, the most important being the immediacy of stabilization and a decrease in soil erosion.

Plass first experimented with fall seeding in 1971. In his trials, he used many cover crops including Balboa Rye, Abruzzi Rye, wheat, Field Broma, Timothy, a combination of Red Top and Timothy, Wild Russian Rye and Annual Rye Grass. The species were first tried in small test plots and then those showing promise were tried on mine sites. Plass recommended the species Balboa Rye, Abruzzi Rye and wheat and has experimented with them on Ford Coal Company property in Cabin Creek and Sewell Coal Company mines near Richwood. He used 40-60 pounds (or one bushel) per acre.

Approximate dates for fall seeding are from August 15 through October 1. However, for successful seeding at this time of year, certain precautions are recommended.

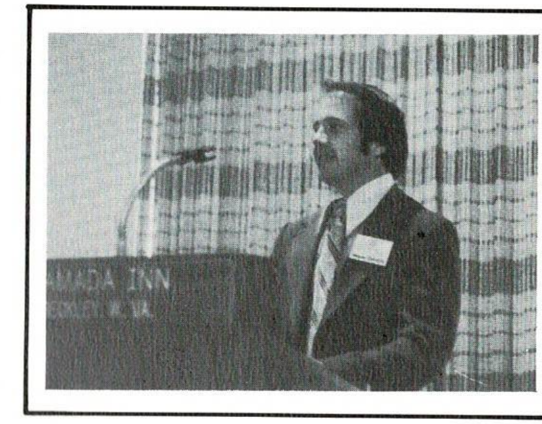


Everett noted that the soil should be freshly graded before seeding, the seed planted should be of high quality and the soil should be fertilized with higher rates of nitrogen and normal phosphate. The area should then be retreated in April or May.

Plass explained a new approach to seeding techniques which emphasizes the use of pure live seed, making it possible to determine the number of seeds per pound. Overseeding can be avoided by considering pure live seeds per square foot rather than acre. An estimate to aim for is approximately 100-150 pure live seeds per square foot. Different mixtures for reclamation seeding are noted in the SCS Technical Guide which is available at any district conservation office.

Larry Miller of Mountaineer Euclid, Inc., followed the fall seeding program and discussed new mining methodology utilizing the "backhoe." This excavator, which has been in the coal fields for years, has recently been revived and put to use by Roy "Chick" Lockard of Grafton Coal Company. An outstanding feature of this excavator is that a 3-yard backhoe is able to load coal as quickly as a 6-yard front-end loader. Miller listed other advantages of the backhoe, which included: the loading of cleaner coal with lower ash content; the ability to strip overburden without additional aid; the flexibility to dig drainage ditches, build ponds and maneuver in areas unaccessible to a dozer.

The final presentation was a field demonstration of the Estes one-way spreaders for bark and limestone by Don Estes, held at the Piney Creek Coal Company operation near Sullivan in Raleigh County. This was followed by a meeting of the Association's Board of Directors.



Above: Wayne Everett of the Soil Conservation Service explained the precautions recommended for successful fall seeding. These suggestions included freshly graded soil before seeding; use of high quality seed; and fertilization of the soil with higher rates of nitrogen and normal phosphate.

Left: Some of the 100-plus people in attendance check the effectiveness of the spreader. The demonstration was conducted at the Piney Creek Coal Company operation near Sullivan in Raleigh County.

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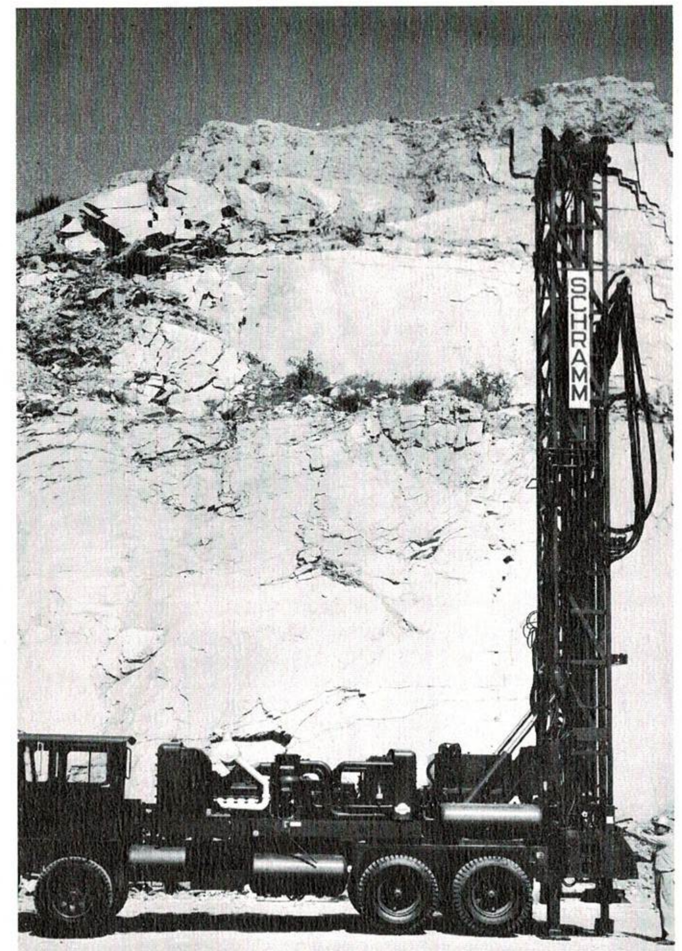

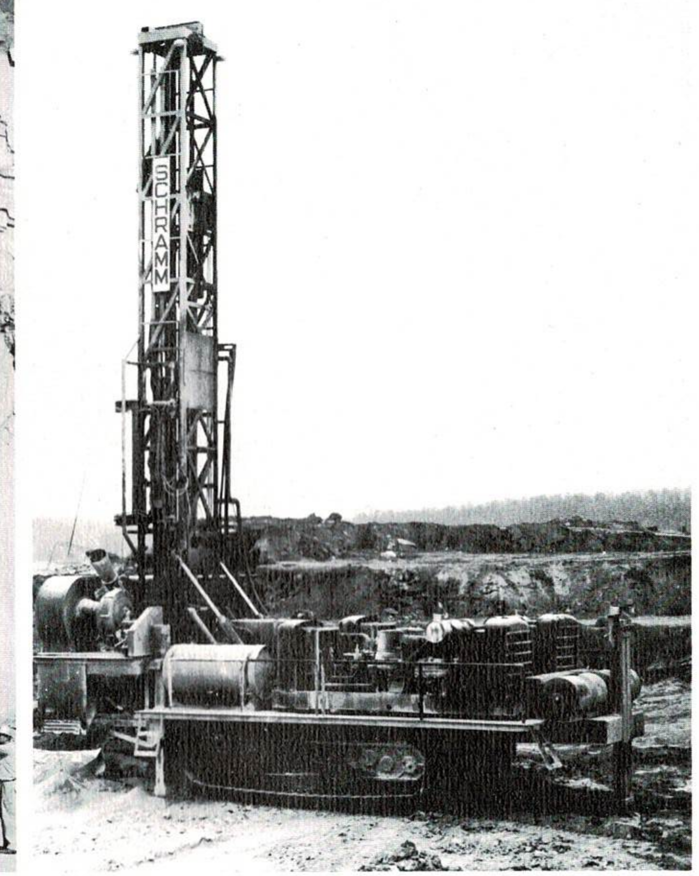

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Experts Study Reclamation Through State-Wide Evaluation Tour


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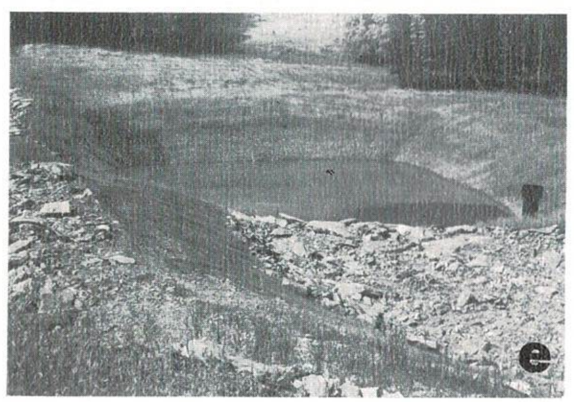
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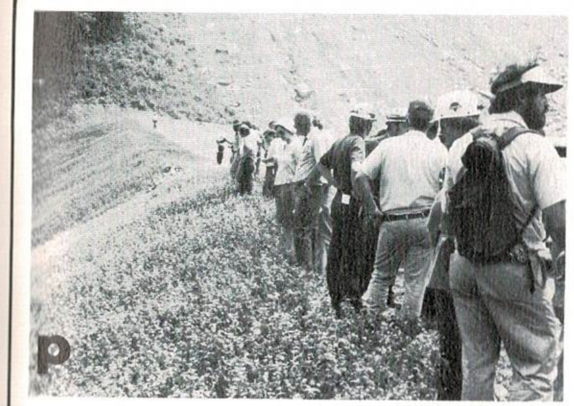
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a Ira S. Latimer, director of the Department of Natural Resources and Roy "Chick" Lockard, vice-president of Grafton Coal Company, discuss Braxton County's coal reserve on Grafton Coal Company's Frametown operation.

b New mining methodology utilizing the "backhoe" is demonstrated on Grafton Coal Company property. Chick Lockard revived this excavator, which had been on the coal fields for years and uses it instead of end loaders to load coal and as the primary stripper.

c Ken Faerber of Hobet Mining and Construction Company, Inc. and Eddie Williams of Willco Reclamation, Inc., discuss helicopter seeding on a Grafton Coal Company permit.

d This site of the Allegheny Mining Corporation, located near Mt. Storm is an excellent example of grass/legume Crownvetch and Kentucky 31 Tall Fescue.

e Reckart Mining Company, Preston County was the first Company in West Virginia to receive a permit having a certified drainage system. This area was recently seeded using oats as a nurse crop.

f Frank Glover of the Soil Conservation Service inspects the DR-5 in the Permit Booklet. on Ford Coal Company Property.

g H. L. Kennedy (extreme right), chairman of the WVSMRA Board, DNR representatives and other members of the tour discuss permits on Ford Coal Company property.

h Gene Matthis of Island Creek Coal Company and Elmer "Hitler" Underwood examine revegetation efforts on this Island Creek Coal Company permit, in Nicholas County.

i Hobet Mining and Construction Company's mountain-top removal site, in Nicholas County, shows excellent use of rye grain as a quick cover crop or outslopes. The group noted that there was a good grass/legume under story development for a late spring seeding.

j Jim White, vice-president of Pioneer Fuel Corporation; John Sturm, WVSMRA; and Joe Parker, Assistant Chief of the Division of Reclamation, discuss the use of various mining equipment.

k Hydroseeding the outslopes of a valley fill was demonstrated on Cannelton Coal Company near Welch. A French drain (rock core) is shown in the center of the valley fill.

l A sediment control structure, located on a Cannelton Coal Company permit is designed to control runoff from the surface mining operation. The depressions in the soil from the dozer cleet marks, make excellent areas for seed to germinate and grow.

m Elmore C. Grimm of the USEPA and Pete Pitsenbarger, Assistant Chief of the Division of Reclamation, discuss future land use on Cannelton Coal Company property near Welch, West Virginia.

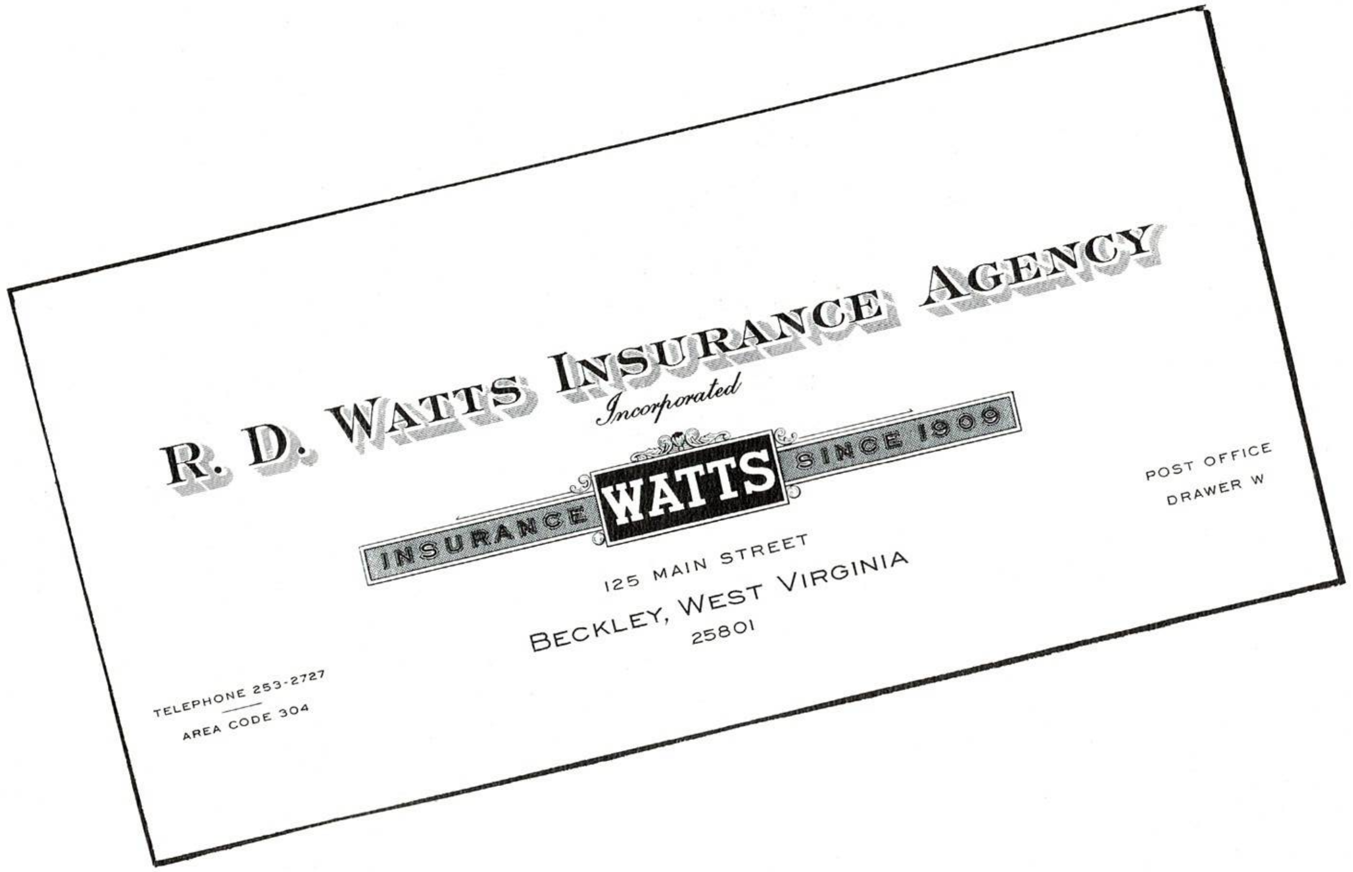
n This area, once a mountain-top removal, is the proposed site of the Welch County High School.

o Before beginning each evaluation, the group would meet with the local inspector and company officials to review the operation.

p The initial phase of this valley fill has been completed on this Pocahontas Fuel Company property. A cover crop of Buckwheat was used on the valley fill outslope.

q The Princess Susan Coal Company on Kelly Creek in Kanawha County utilized the "haul back" mining methodology developed in 1972 on this permit, and demonstrates the type of reclamation efforts now being employed in West Virginia on steep slope operations.

r The area below the road on this Princess Susan Coal Company permit is all fill slopes, not uncontrolled outslopes spoil as it may appear. The rock drain at the extreme left runs up through the fill area to the tree line. This type of drainage acts as a filter for silt-laiden water.



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TECHNICAL REPORT

Influence of Underground Mining In Densely Populated Areas

Top: Getting a birds-eye view of German open cast mining, from the left: Kent Ratliff, A. S. Cappellari, Bill Anderson, Frank Allara and Buck Harless.

Above: Many of the small towns and villages in the Brown Coal region were just as a visitor would expect. Ancient, well-kept and relatively unchanged.

(**Editor's Note:** The following represents excerpts from a presentation by Hugo Weishaupt, General Manager, Nordsterd Mine, before the International Mining and Reclamation Conference in Dusseldorf, West Germany).

Looking first at some figures concerning the size of the underground mining on the surface, the Geisenberg Refinery, built in 1938, has subsided 20 feet since then, and the surface has subsided 30 feet. The complex includes a power plant, 130 tanks and 250 miles of pipeline which handles pressure up to 3000 psi.

"The actual amount of vertical subsidence does not necessarily affect the industrial facilities, but of greater importance is the intensity of the horizontal forces which occur in connection with the underground mining. A horizontal stress of 0.5 percent means that a 30-foot-long pipeline has an elongation of 1.5 feet. A conventionally built pipeline would not withstand such a stress."

Due to the large proportions of the refinery, several steps must be taken to protect against subsidence damage. This begins with the general layout of the mine, designing it to allow minimum disturbance. By using longwall mining with or without stowing or backfill and mining sequence to minimize surface damage, the creation of various single subsidence turoughs, independent of each other, can be avoided.

"The next step is to pre-calculate the influence of the underground mining on the surface to be expected. This way it is learning in advance where the most serious stresses can be expected and how they can be controlled. As a result, preventive measures can be taken."

"Due to different subsidence rations, the changing pitch of the railroad tracks must be eliminated by either lowering or building up the track beds. There is a positive "by-product" in case of such a situation. Railroad crossings can easily be eliminated by lowering or lifting the tracks."

Subsidence damage to regular roads or highways is relatively small. If bridges are built in these areas the abutment foundations should be designed to allow flexibility. Subsidence also affects apartment buildings and other dwellings. The modern layout of single houses should be used because if geological conditions (such as faults) do not allow large area subsidence, houses may tilt or even be destroyed.

Underground Operation

"A successful coordination is only possible if underground mining methods are available which allow a greater degree of flexibility with regard to handling the surface situation. The following must be highly flexible:

1. Caving method — stowing method
2. Past advance — slow advance
3. Advance mining — retreat mining
4. Mining on the strike — mining on the pitch

"The Zollverein 2/3 seam is mined by use of complete pneumatic stowing due to the average seam height of 10 feet. It is absolutely necessary to keep the subsidence underneath valuable surface property at a minimum.

Seventy-five percent of the reject is put on the surface and 25 percent is used for pneumatic stowing. The reject is transported through blind shafts and belt conveyors to the section where it is pneumatically stowed with a 70 psi pressure below the gob line of the roof supports.

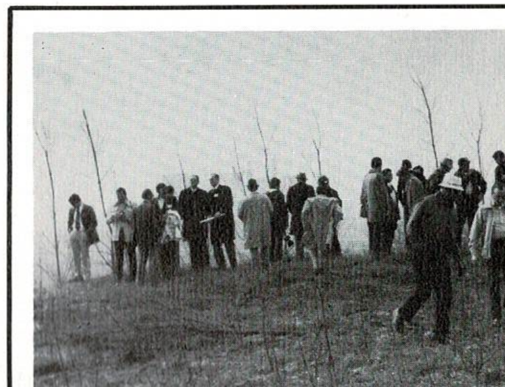
"A new method of stowing had to be developed since using the conventional stowing method would take too much time to advance the longwall face. Reasons for the delay were:

1. The single hydraulic props had to be moved.
2. The stowing area had to be protected by means of cribbing.
3. The pipeline for stowing had to be moved."

A stowing pipeline which could be moved as one piece, had to be invented in order to allow pneumatic stowing in connection with powered roof supports. The powered roof support had to be equipped with a long roof beam cantilever, extending toward the gob. In addition, a special guide unit for handling the stowing pipeline during the pushover has to be designed. An ideal support for this application would be a Hemscheidt double frame support.

When the complete unit was brought underground and tested, the mining process did not create any problems, however the stowing process needed the following improvements:

"1. Additional roof support in the stowing area behind the supports by means of wooden headers being bolted to the roof.
2. Increase of specific roof support resistance by shortening the gob side cantilever of the roof beam.
3. Use of rigid roof beam without articulation between the front and rear legs.
4. In order to take advantage of the shield support principle for stowing operations, the prototype of a chock type support will be installed at Nordstern mine. In contrary to frame type supports, a much greater area of the roof will be supported. The chock also provides better support stabilization."



Top: While the tour guides explained how the massive gob pile had been constructed and reclaimed, conference delegates took the opportunity to view the surrounding area. In the distance, the highrise of smoke stacks and coaling towers reveals another of the numerous power generating facilities in the area.

Above: Stretching for a final look before calling it a day, members peered over the edge of the huge coal mine.





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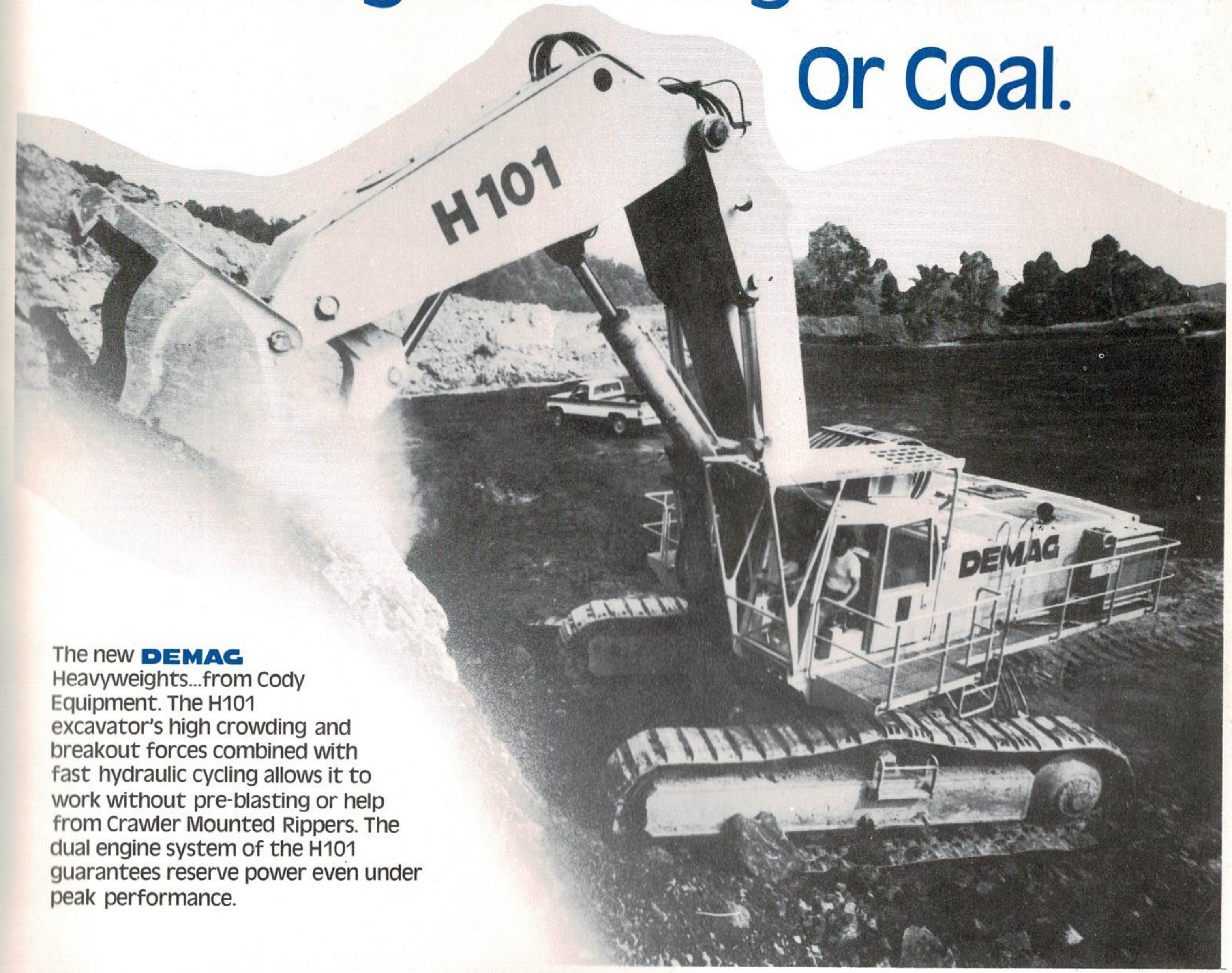

The new **DEMAG** Heavyweights...from Cody Equipment. The H101 excavator's high crowding and breakout forces combined with fast hydraulic cycling allows it to work without pre-blasting or help from Crawler Mounted Rippers. The dual engine system of the H101 guarantees reserve power even under peak performance.

Here, the H101 takes a 15 ton bite.

High static weight coupled with massive wide undercarriages gives the **DEMAG** Excavators excellent working stability.


H51-55 Ton Operating Weight


H71-77 Ton Operating Weight


H101-110 Ton Operating Weight

We'll fly you there!

Cody will fly you to the nearest job site to prove the availability and application of these excellent machines.

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