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CONTRACT S0241051

CONCEPTUAL DESIGN OF AN AUTOMATED LONGWALL MINING SYSTEM

PHASE I-SURVEY OF OPERATING LONGWALLS

SUBMITTED TO

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
DENVER, COLORADO

BY
COMINEC
A JOINT VENTURE
FENIX & SCISSON, INC. - THYSSEN SCHACHTBAU GMBH
TULSA

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Presented at the oral review at the Denver Mining Research Center
October 11, 1974.

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1. INTRODUCTION

1.1 AUTHORIZATION FOR THIS WORK AND ITS PURPOSE

This report is in partial fulfillment of Contract S0241051 awarded to COMINEC on June 27, 1974. The purpose of the work under this contract is to develop a conceptual design for an automated longwall mining system. The conceptual design will serve as the basis for future design and development of an automated longwall mining system capable of sustained production in excess of 2,500 tons per shift with reduced manpower which will ultimately be demonstrated in an area where conventional longwall mining has been successful.

1.2 DEFINITION OF THE PROBLEM

1.2.1 Why An Automated System

The most obvious benefit of automation and remote control in a longwall mining system is the reduction of accidents consequent upon a reduced working force in the hazardous face areas. However, another important aspect of the problem is the skilled labor shortage which is being compounded by the need for vastly increased coal production. The United States coal mining industry had a working force of almost 600,000 miners in 1928 but was able to muster only 145,000 miners in 1970. The miners required to staff the additional working sections and the new mines necessary to meet our energy needs are simply not available. Only automation and remote control will permit a reduced work force with increased production by keeping the face equipment operating continuously.

1.2.2 The Conceptual Design

The requirements for the conceptual design can be summarized as follows:

> Develop a conceptual design for an automated longwall mining system capable of operation in relatively flat-lying coal seams of 48 to 60 inches in thickness, with an overburden of 400 to 1,500 feet thick which contains no exceptionally strong members capable of retarding caving, or overloading the supports. The conceptual design must provide for a sustained production in excess of 2,500 tons per shift with reduced manpower.

1.2.3 Improvements To The Present Longwall Equipment

The scope of the contract work is not limited to applying automation and remote control to presently configured longwall equipment. Recognizing that an analysis of the in-mine survey data may reveal possibilities for increased production through equipment modifications, the Bureau of Mines included a requirement that longwall system's deficiencies which can be corrected by equipment modifications are to be identified. However, this requirement is limited to minor equipment modifications only.

1.3 SCOPE OF THE EFFORT

The work is divided into 3 work Phases:

Phase I - Survey of Operating Mines

Phase II - Automation and Remote Control

Phase III - Conceptual Design

Most of the 3-month Phase I work was carried out by a team of mining engineers thoroughly experienced in longwall mining. The results of the Phase I work are reported in this volume.

Phase II work carried carried out concurrently with Phase I by a team from T A B Engineers, Inc. a firm specializing in automation. Phase II results are reported in a separate volume.

This Phase I report contains recommendations for the conduct of Phase III work. Our original plan for Phase III work was to bring the members of teams I and II together for the conceptual design work. We have modified our plan by adding to the Phase III team, engineering design specialists experienced in longwall automation and remote control.

1.3.1 Phase I

Phase I was to accomplish the following:

1. Observe existing longwall mining equipment in operating mines to identify items of existing equipment most suitable for use in the automated longwall because of:
   a. Increased production capabilities
   b. Inherent safety characteristics
   c. Suitability for automation and remote control.
2. Conduct time and motion studies of men and equipment to identify those functions which;
   a. Can be performed by automation and remote control, and
   b. Which will have the greatest effect on productivity.
3. Document slow-down or stoppages.
4. Identify which of the system's deficiencies can be corrected by minor equipment modifications or by installation of automation and remote control.

5. Identify, in particular, those functions the efficiency of which is limited by the operator's capabilities.
6. Present an oral briefing at the Denver Mining Research Center and prepare a special report on the Phase I effort. This present volume is the required Phase I special report.

1.3.2 Phase II

The scope of work in Phase II is defined in the contract to consist of the following:

1. Survey the state of the art of automation and remote control, particularly as applied to mining or other heavy equipment operations.
2. Evaluate possible control, feedback, and sensor mechanisms for the reliability under mine environmental conditions and for usefulness in implementing automation or remote control of the various functions of the longwall face equipment.
3. Present an oral briefing at the Denver Mining Research Center and prepare a special report on the Phase II effort. The special Phase II report is presented in a separate volume.

1.3.3 Phase III

The scope of work in Phase III is defined in the contract to consist of the following:

1. Develop a conceptual design for an automated longwall mining system that:
   a. Is based on the use of existing equipment to the maximum

extent possible within the constraints of the project objectives.

b. Includes all equipment and functions located at the face and in the head and tail entries during panel extraction.

c. Is permissible or intrinsically safe under Coal Mine Health and Safety Standards and Regulations.

2. Include in the conceptual design:

   a. Type, number, and sensitivity of sensors, feedback mechanisms, control systems and displays.

   b. Discussion of the rationale used in selection of the recommended system and of the recommended control system logic.

   c. A discussion of productivity increases expected because of proposed modifications and supported by the data collected in the in-mine study phase.

   d. Identification of anticipated manpower and cost/ton savings accruing to each automated or remotely-controlled function of the mining system.

   e. Identification of the location and functions of all men to be employed at the face or in the head and tail entries.

   f. Identification of any items of equipment or technologies which are required to fulfill the project objectives but which do not conform to present or proposed health and safety standards or regulations with an estimate of the probability of modifying these items to conform.

3. Present the conceptual design at an oral program review held at Denver Mining Research Center.

4. Prepare a final report which is to include the conceptual design and revisions occasioned by the program review. The final report shall also include all items necessary to fully depict the proposed longwall mining system such as:
   a. Data obtained from equipment manufacturers and in-mine operators.
   b. Rationale used in the conceptual design.
   c. Design criteria.
   d. Drawings and charts.
   e. Proposed equipment modifications supported by drawings.

In addition to the work required in Phases I, II, and III, the contract requires that we:

1. Survey recent and ongoing Bureau of Mines research and development efforts to insure that technologies capable of increasing longwall productivity and safety are included in the conceptual design.
2. Thoroughly familiarize project personnel with applicable Coal Mine Health and Safety standards and regulations to insure that the proposed automated longwall system is as safe and healthful as present technology permits.
3. Maintain close coordination with appropriate representatives of the Mining Enforcement and Safety Administration to insure that the conceptual design is in conformance with existing or proposed standards and regulations.

1.4 THIS REPORT

This Phase I report was prepared to satisfy contract requirements. In addition, it will be used as a work document in Phase III - Conceptual Design.

Section 2 of this report is a discussion of the longwall system, its equipment, operations and problems. It includes a discussion of the factors to consider in deciding between the plow and the shearer as a winning machine.

Section 3 contains the results of a survey of operating longwall faces in the United States. A list of all operating longwalls and longwalls on order is included.

Section 4 is a summary of the mine visitations carried out in Phase I. We visited ten shearer faces and three plow faces at eleven different mines owned by nine different mining companies.

Section 5 contains the results of our Time and Motion Study conducted at a shearer face in the Sunnyside Mine in Utah.

Section 6 is a summary of applicable research being carried out by Bureau of Mines contractors.

Section 7 is a preliminary discussion of the Coal Mine Health and Safety Standards and Regulations that must be considered in the conceptual design.

Section 8 is comprised of our recommendations for the hardware for an automated longwall.

Section 9 contains our proposed plans for Phase III - Conceptual Design.

2. THE LONGWALL SYSTEM - EQUIPMENT, OPERATIONS, AND PROBLEMS

2.1 LAYOUT OF A LONGWALL PANEL

The longwall panels in the United States are developed by driving two sets of entries (usually 3 or 4 on 30 to 100-foot centers), perpendicular to the mainline gate on about 600-foot centers and connecting them across the end of the panel to establish a bleeder network, Figure 2.1. The 12 to 24-foot wide entries are usually supported with steel straps, roof bolts, and often with anchored beams. If adverse geological conditions exist, wooden props or wooden cribs are also used. In recent years various center distances between entries have been tried in an attempt to reduce the problems caused by the dynamic roof pressure.

From the Phase I survey of longwall faces in the United States, it was determined that longwall faces have a length up to 670 feet. The average was approximately 450 feet. This is compared to the longwall faces in Europe, which reach a length of 900 feet or more. United States operators cite the limitations of the face conveyor chain in use as one reason for the shorter faces.

A typical ventilation network for a longwall panel is shown in Figure 2.1. Fresh air travels through the headgate system and splits up at the face. One part travels through the gob to the bleeder entries for the purpose of rinsing methane out of the gob. Haulage, transport, man trip, and electric cables are in the fresh-air side in the main gate system. The stage loader and the belt conveyors are installed in the headgate of the face. The rail tracks, the man trip equipment, and the transport equipment are installed in the second gate. Cars and machines

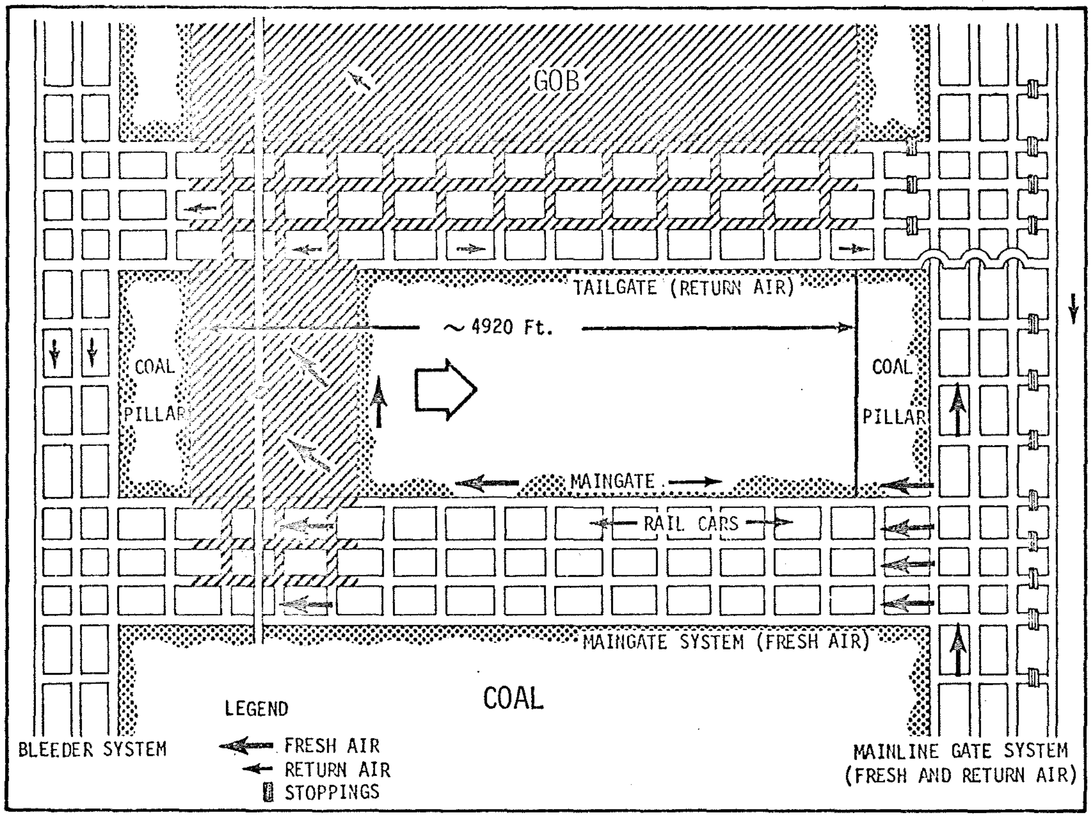


Figure 2.1 System of a Retreating Longwall Face in the United States.

without rails are able to drive in the third or fourth gate.

The gates are allowed to cave behind the face with the exception of the gate next to the neighboring unmined panel. This gate must be kept open because it serves as the tailgate for the next face.

The following paragraphs discuss the three major components of the operating longwall system.

1. Winning
2. Roof Supports
3. Haulage

Also, minor components of the system and some of the more outstanding problems of the system which must be considered in the conceptual design are discussed.

2.2 WINNING MACHINES

2.2.1 Shearer

There are three shearer manufacturers in the American market; Anderson Mavor, Eickhoff, and Sagem. Each of the manufacturers offer different types of shearers according to the different conditions found in the mines. Radio control of all machine functions is available with each shearer. Each manufacturer also offers an automatic speed control which adjusts the rate of machine travel according to the hardness of the coal.

Electric drives are available up to 600 kw and with speeds up to 44 ft/min. The motors are water-cooled and different systems are available to use the cooling water for dust suppression, Figure 2.2.

A pressure control switch is offered with each machine which prevents the shearer from being turned on until the cooling water is circulating through the machine. Water sprays can be attached to the machine body,

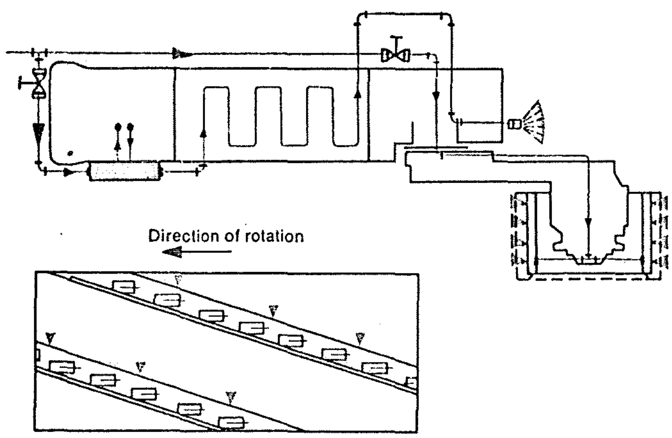


Figure 2.2 Cooling System and Position of the Spray Jets on the Drum of a Shearer.

the cowls, and in the cutting drums.

Hydraulically operated rotary deflectors (cowls) are standard for effective loading. Static ramp-plates or shuttle plows complete the clean up during conveyor advancement. When a cowl cannot be used in low seams, the shearer is equipped with two jack-operated loading doors. During the pass from tail to head, the tail door is in position and the head door is flush against the pan line. During the pass to the tailgate the door position is reversed.

2.2.1.1 Single Drum Shearer

The single drum shearer, in its different modifications, is able to cut seams from 42 to 120 inches thick. One manufacturer offers an extremely low built shearer which will work in seams 24 inches thick. If the seam thickness does not exceed 81 inches, the complete section can be cut with one traverse of the machine. Therefore, an almost equal section can be cut, resulting in an uncomplicated system which is very suitable. In this case the drum diameter is chosen according to seam thickness. In British mines this full-cut system is very common because the seams are often thicker and the roof is maintained by leaving top coal.

In the full-cut system the drum does not have to be adjustable. Turnaround is accomplished by: (1) driving the drum out of the face before advancing the face-conveyor-drive, (2) making a loop at each end of the face, or (3) the half-face system. The easiest method for an automated longwall would be the first one but there must be enough room in the tailgate for the entire machine to leave the face. "Making a loop" means that after the shearer has reached the gate, the shearer is reversed and the conveyor pushed forward until a drum-width cut is made into the face. The shearer is then returned, cutting to the gate, to start a new full cut. In the half-face system, half of each traverse is for cutting and the other half for cleaning.

If a seam changes in thickness and dip, it would be more practicle to reduce the diameter of the drum and make two cuts for every advance of the conveyor and supports. In this case the drum must have the ability to be raised and lowered to make a roof cut and floor cut. It is then possible to follow the roof and cut all the coal out although the roof or the floor is uneven. The roof cut should always be made first in order to advance the support shortly behind the shearer and to have the cleaning effect of the floor cut before advancing the conveyor.

There are different systems available on the international market for raising and lowering the drum. Most of them use ranging arms of different designs. Some are designed to carry not only the drum but also the hydraulic pump and the auxiliary pump feeding the various hydraulic jacks which have to lift or lower the ranging arms. It is also possible to cut below the level of the panline.

In some cases hydraulic jacks are installed to lift the entire machine with the fixed drum. This "pitch-type steering" has a ram and shoe support bracket which straddles the conveyor and is held by guides on front of the gearhead. The ram lifts and lowers the gearhead end of the machine that carries the cutting drum. A limited vertical movement of 8-1/2 inches is provided by this system. A special design is available by installing two tilting jacks on the gob side of the shearer which allows raising or lowering of the drum by tilting the machine along its longitudinal axis.

2.2.1.2 Double Drum Shearer

The double drum shearers available on the international market are all equipped with two ranging arms of different design. In some designs all the motors, pumps, and gear boxes are mounted on a large underframe and only the drums are raised by the ranging arms (Eickhoff, Anderson Mavor). Another design has a smaller underframe with motors and hydraulic pump and the system feeding the various hydraulic devices is located in the ranging arms (Sagem).

Different kinds of motor arrangements are in use, either singly or in pairs, in horsepower ranging from 230 to 804. In arrangements using two motors, one motor drives a drum, the other drives a drum and the driving winch. As a result, for every seam with its special conditions, a suitable motor is available in an appropriate machine design from each manufacturer.

The major advantages of a double ended shearer are:

1. The machine can free-cut both panel corners without leaving the face as is necessary with the single ended shearer. In an advancing face, the tail gate can be cut if the type of face conveyor drive is suitable.
2. The full-cut system can be used when the height and the cutting horizon is variable during the pass.
3. The full-cut system can be used up to a seam height of 120 inches. (One special design can cut a seam height of 137 inches).

2.2.1.3 Limits and Problems

The single drum shearer can leave the face end and start a new cut with little or no waiting for an advance of the face drive when two cuts are made for every advance. With the full-cut system the shearer goes into the gate each time it reaches the face end and the drive must be advanced once before the shearer can start a new cut. The double-drum shearer either has to make a loop each time at the face end and the conveyor advanced twice before the shearer can leave to start a new cut or the half-face system has to be carried out. The several factors to consider in deciding between these two systems are the length of the face, the caving behavior of the coal at the face, the roof conditions and organization at the face ends, and the support design.

In some shearer designs the major units are identical for the different versions of single and double-drum machines. So a single ended shearer can be built by taking off one gearhead, ranging arm, and drum from a double-drum shearer and mounting the rest on a suitable underframe. So for different conditions it is possible to change the system of organization and the type of the winning machine without buying new equipment.

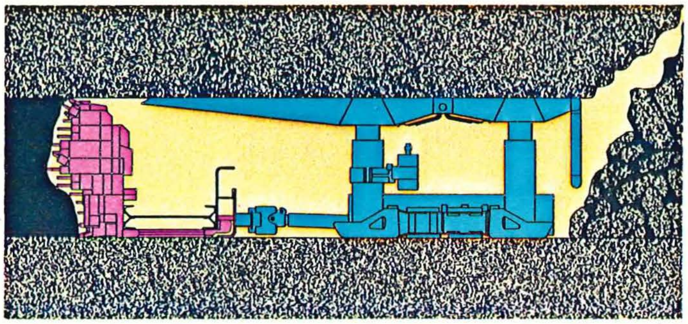
2.2.2 The Plow

The reasons for selecting a plow as a winning machine are presented in section 2.2.3. Different designs are suitable for different conditions. The two most important differences between the plow systems which are available on the market are:

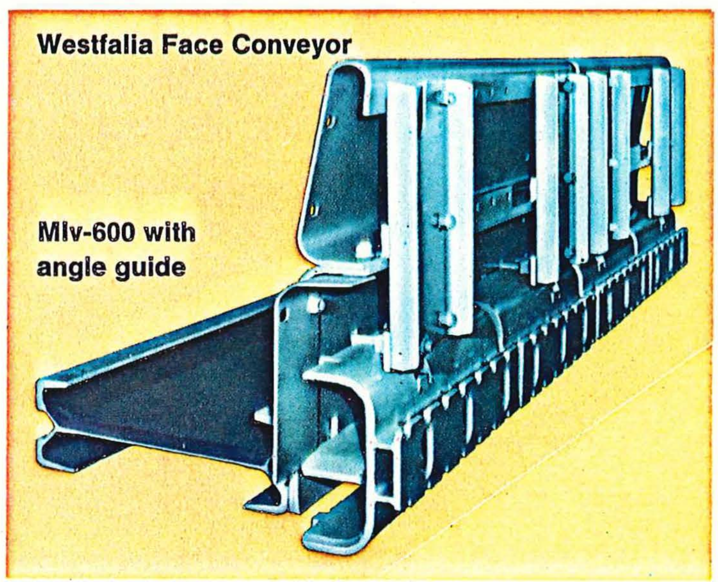
1. The method of stabilizing the guidance and the steering of the plow.
2. The location of the haulage chain.

2.2.2.1 The Hook Plow

The cutting and loading components of the hook plow are arranged on an articulated base which slides under the conveyor, Figure 2.3. The haulage chain runs in covered guides on the base of the gob side of the



HOOK PLOW



GUIDE FOR HOOK PLOW

Figure 2.3 Hook Plow

conveyor. This plow combination breaks the coal from the face instead of cutting it. Steering the plow is accomplished by changing or adjusting the bottom bits of the plow and partially by the rams moving the conveyor.

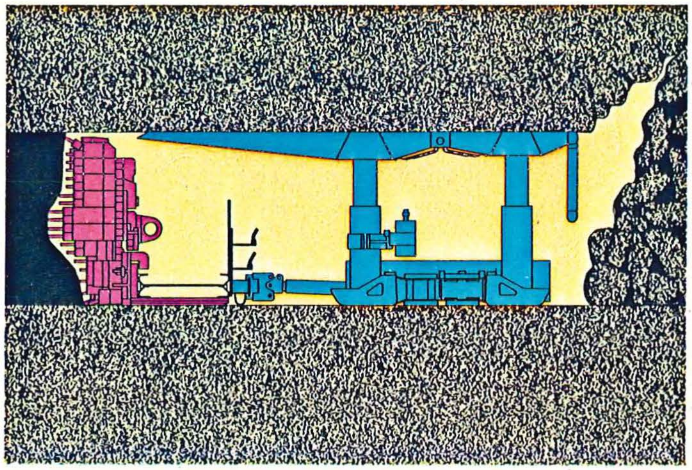
The extended plow base running under the conveyor lifts it and at the same time the cut coal is lying in front of the conveyor to be loaded. This causes fine coal to go under the conveyor where it presents problems. In addition, energy is lost by the high frictional resistance of the sword running under the conveyor.

2.2.2.2 The Guide-Plank Plow

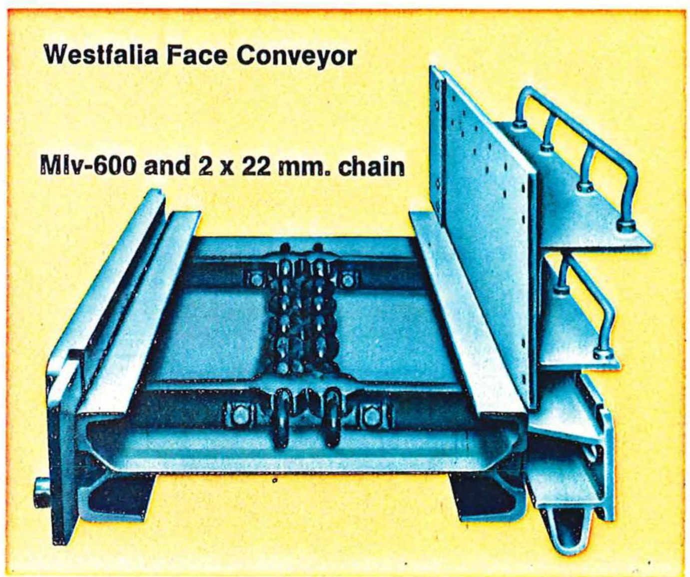
This plow is guided by the guide-plank which is located at the face side of the conveyor, Figure 2.4. The chain runs on the face side of the conveyor and pulls the plow body directly and not with a drawbar. In this way more energy is available at the plow bits. The plow is stabilized by a three part base plate running under the conveyor which presents the problems of fine coal as described above. The steering of this plow is the same as with the hook-plow.

2.2.2.3 The Gleithobel

The Gleithobel (guideplow) is guided onto a ramp-like guidance attached to the face side of the conveyor, Figure 2.5. No base plate under the conveyor is used. The plow body is stabilized by its own weight and a stabilizer arm reaches across the conveyor to a gob-side located tube-guide. This plow does not run on the floor but on the guiding ramps and therefore the frictional resistance is very low. The chain runs at the face side of the conveyor and pulls the plow body directly. The design of the Gleithobel gives a higher percentage of

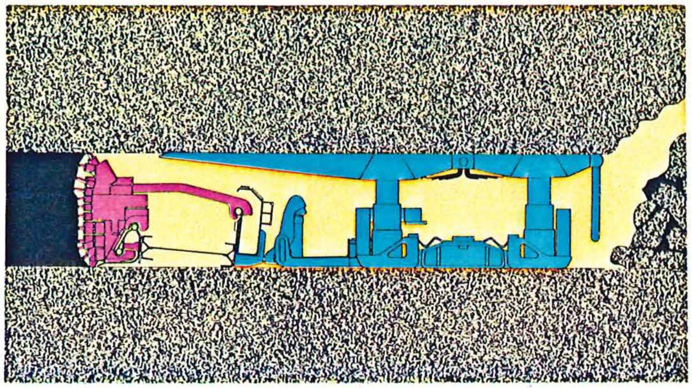


GUIDE PLANK PLOW

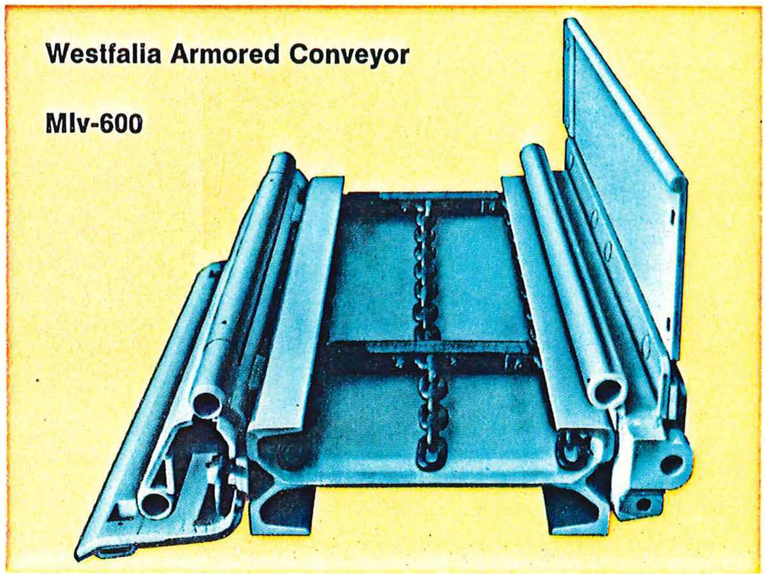


WESTFALIA FACE CONVEYOR
WITH GUIDE PLANK

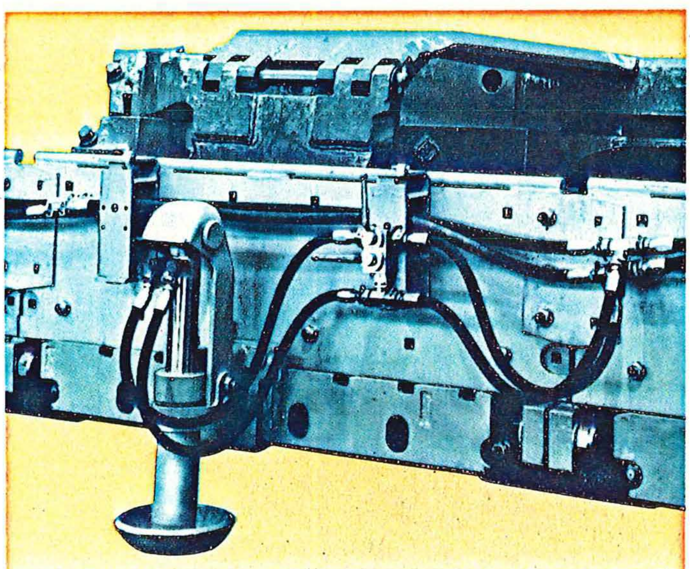
Figure 2.4 Guide-Plank Plow



GLEITHOBEL



GUIDE RAMP FOR GLEITHOBEL



STEERING JACK FOR GLEITHOBEL

Figure 2.5 Gleithobel

the chain energy to the plow bits which enables it to make a deeper cut or to cut harder coal than the hook or guideplank plows.

A new system was created to steer the Gleithobel. In addition to the ability to adjust the plow bits to give a steering effect along the total face length, for the first time a steering system is available for the plow which helps to overcome the problem of differing floor conditions along the longwall face.

Hydraulic jacks are installed to lift and lower the gob-side of the conveyor and to tilt the conveyor face along its longitudinal axis. The guide ramp in front of the conveyor is the fixed point in this system, Figure 2.5. Thus a different steering direction in different areas of the face is possible because a hydraulic jack is attached to the conveyor every 15 feet or less.

Another important difference between the Gleithobel and other plows is that it is able to take a predetermined cut from the coal face. After each cut the guide ramp is pushed against the coal face and the plow always cuts the desired thickness once adjusted by the plow bits. It is also easier to keep the conveyor face straight with this system than with the other plow equipment.

2.2.2.4 Limits and Problems

The advantage of the plow is its ability to work in extremely small seams.

Formerly the problems of the plow were:

1. Steering difficult if the conditions in the face were not consistent.
2. Steering difficult if there was a soft floor.

3. Difficulty in cutting hard coal.

4. Difficulties in keeping the face straight because of the different thickness of the slices.

With the design of the Gleithobel these difficulties may be diminished. Experience with this new system in the last few years gives hope of overcoming these problems.

The first Gleithobel was recently installed in the United States. Great Britain and Germany have had several years of experience with the Gleithobel.

2.2.3 Shearer or Plow

The answer to the question of whether to apply the cutting or planing method depends on many factors. A few years ago the "resistance of the coal against loosening" was one of the most important factors considered for this basic decision. But improvements to the plow have made this factor only one of many to consider. Additional factors are:

1. Variations in the seam and conditions of roof and floor.
2. Fault type and frequency.
3. Operating characteristics of the equipment.
4. Dust suppression.
5. Costs of the winning machine.
6. Installation, repair and maintenance.
7. Methane liberation.
8. Winning rates (cu ft/min).

2.2.3.1 Variations In The Seam And Conditions Of Roof And Floor

Cutting is better than planing if:

1. The floor resistance varies.
2. The floor is soft.
3. The "resistance against loosening" of the lower part of the seams is great.
4. There is a hard streak in the coal.
5. The floor undulates.
6. There are hard inclusions and rock bands in the seam.

When floor resistance varies the plow is difficult to control. On soft floors the plow planes into the floor. If the resistance against loosening is greater in the lower part of the seam the plow tends to climb. These difficulties were observed in the Phase I mine visitations.

Hard or sticking coal at the roof or a hard streak in the coal above the planing zone can cause over-hanging coal with its attendant problems. An undulating floor also makes control of the plow difficult.

All of these geological conditions sometimes makes it necessary to blast and/or shovel when using a plow. That requires time and lowers the utilization factor. Except in extreme conditions, these geological factors do not influence cutting with a shearer. However, recent experience with the Gleithobel indicates use of this type plow may be a partial solution to these geological problems.

2.2.3.2 Working Through Faults

Areas of faulting which can be cut or planed are easier to cut than plane. The shearer can cut the floor or roof equally well, in such a zone, but the plow is very difficult to control under such conditions and cannot plane the roof and floor equally. If the plow does not plane the full height of the face it can cause an overhang of coal which sometimes has to be blasted.

2.2.3.3 Characteristics Of The Equipment

Coal flushings by cutting are not as large and required as often as with planing. If there are planes of weakness in a seam which is not mined in a full cut, overhanging coal can be a serious problem. The consequences are big chunks and perhaps cavings. These chunks must be crushed, which can create a substantial problem at the middle of the face and also at the face end. The problem of big chunks is usually compounded when the seam thickness increases.

Roof control is generally much better with a cutting system (especially with a double-drum shearer) than with a planing system. The support can advance directly behind a shearer whereas it cannot advance directly behind a plow.

A few years ago many men were needed in a longwall face where single hydrualic props were used as roof supports. These men were able to crush the big chunks, to observe the planing, and to control the plow by the rams. Today in a longwall face with frames or chocks and a high speed plow, a man is not always present or able to observe and control these operations.

Other characteristics of the equipment to consider are:

1. Certain types of plows plane fine coal under the conveyor because of the plow base plate.
2. Coarse coal is produced better by plow.
3. If the tailgate must be heavily timbered and roof conditions

do not permit the development of a stable hole, a shearer may have to be selected.

2.3.3.4 Dust Suppression

For comparison of the two winning systems, as far as dust is concerned, dust samplings on tyndallometric and gravimetric basis done in Europe give decisive advantage to the shearer. It must be noted that these samples are single and comparable measurements and not yet generally proven. With a shearer, a machine mounted dust control system can suppress the dust at its point of origin. Better results are achieved this way than with water sprays mounted on the conveyor as is now used with the plow. Further investigations to improve the trailing water hose design on the Gleithobel should be carried out.

2.3.3.5 Work Organization And Manpower Requirements

Good organization of shearer faces is more important and more difficult than in plow faces. The amount of shearer turn-around-time at the tailgate and main gate is relatively high, especially with the full-face system. In the full-face system, the drive has to be advanced two times before the shearer can leave the face end. Most of the labor force at the shearer face is concentrated on these activities. If a half-face system is used, the concentration is not quite as intensive because cutting and advancing of the face-conveyor drives are separated.

2.3.3.6 Costs Of Winning Machine

The prices for plow equipment and the daily machine costs of a plow face are lower than that of a shearer face. When it is possible to get nearly the same production with a plow as with a shearer, this factor is very important.

2.3.3.7 Installation, Repair, And Maintenance

Labor required for installation, repair, and maintenance is greater in a shearer face than in a plow face. The plow is a less complicated piece of equipment than the shearer.

2.3.3.8 Methane Liberation

Coal is crushed more with a shearer than with a plow. Since methane liberation can depend upon the percentage of fine coal in the raw coal, the methane liberation is greater in a shearer face.

2.3.3.9 Winning Rate (sq ft/min)

In the coal mining industry of England and West Germany, with the exception of some borderline cases, shearers are preferred to plows in seams thicker than 60 inches. The plane is the dominant winning machine for seams less than 48 inches thick. For seam thicknesses in between, the range for which the conceptual designs has to be developed, plowing as well as shearing have equal chances. Under good geological conditions winning rates of 36 sq ft/min can be reached.

2.3.3.10 List Of Criteria To Consider

The above mentioned factors were considered for seams ranging in thickness from 48 to 60 inches; the thickness range designated by the Bureau of Mines for the conceptual design of an automated longwall system. In Table 2.1 we present a tentative evaluation of the factors discussed here as they relate to the decision of selecting the plow or shearer. We have not at this stage of our work weighed the factors. However, indications are that either a shearer or a plow may be applicable.

Table 2.1
Cut or Plane-Evaluation Factors in a Seam Thickness of 48 to 60 inches

Factors to Consider	Better Plane	Better Cut	Plane or Cut	Remarks
1. Floor - Soft		X		Plane into the floor
- Hard			X*	Gleithobel can be an advantage here
- Resistance varies		X		
- Undulating		X		
Roof - Apt to cave		X		Big chunks
- No problem			X*	
Seam - Apt to flush		X		Big chunks
- Various seam thicknesses		X*		
- Hard streaks		X		Overhanging coal
Resistance against loosening - High		X		Of lower part of seams
- No problem or indifferent			X*	
2. Working through faults		X		Shearer cuts floor and roof equal
3. Characteristics of the equipment - Overhanging coal		X*		If plow doesn't reach the roof
- Chocks and frames		X*		Roof control
- Control the operation		X		Man walks with shearer
- Haulage problem due to fine coal		X		Under the conveyor with certain types of plows
- Winning machine cannot drive into the tailgate		X		Tailgate is heavily timbered
Coal Size - Coarse coal necessary	X			For sale
- No problem			X*	
4. Dust suppression		X		
5. Work organization	X			Especially at the face-conveyor drives
6. Costs of winning machines	X*			
7. Installation, repair, & maintenance	X*			
8. Methane liberation	X*			
9. Winning rate (sq ft/min)			X*	

*Factors which now seem to have the most impact upon the planned conceptual design.

The factors to consider cannot be added up until new installations are planned. Each seam requires careful consideration; conditions in each area and each panel have to be ascertained to come to the final conclusions whether to use a plow or a shearer.

2.3 ROOF SUPPORT

The rock mechanic problems change when changing from the room-and-pillar system to the longwall system. The dynamic forces and pressures became more important with the longwall system.

The overburden of the mined seams is very different in the United States when compared to those in Europe. Although United States seams are not at depths that gives the high static pressures like those abroad, the overburden is sometimes not thick and strong enough to build a closed rock body able to carry itself over a certain distance. This results in the roof caving up to the surface. When this happens the pressure on the roof support in a longwall face is at least as high as it would be in a greater depth where the main roof is able to carry itself for a certain distance. In selecting a roof support system, careful consideration is given to this problem.

There are 3 basic types of roof support available on the market; the chock, the frame, and the shield.

2.3.1 The Chock

The most common support in this country is the chock. The typical characteristic of the chock is that it is one unit with a certain number of legs (2 to 6) and one or two canopies and is connected to the face conveyor by a double-acting hydraulic ram. When the chock is pressurized this ram is able to advance the conveyor. When the chock is lowered the conveyor gives the counter power for pulling the chock. In this way the chock and the face conveyor are an integrated system. The advantage of the chock is the fact that it is always advancing in the right direction because of its connection to the conveyor. The disadvantage is the large unsupported roof area when the chock is lowered.

2.3.2 The Frame

The frame consists of two or three separate units with 2 legs per unit. When one part of the frame is pressurized the other parts are moved by one or two rams located between them. Then the first part is set and the second or third part is pulled by taking the counterpower from the first one. The problem presented by the frame is that it is able to move in the wrong direction. Each time the frame is operated it must be inspected and controlled to make sure it moves in the right direction. The use of the frame is an advantage when used with a fragile roof because only a small roof area is unsupported in advancing.

Both the chock and the frame are available with different designs; particularly different in strength. Yielding loads are offered from 30 tons up to 200 tons per leg so the proper yielding load for a particular roof support requirement is available. The manufacturers make entirely different recommendations for the setting load of both chocks and frames. Some manufacturers recommend a low setting load of about 30 percent of the yielding load to avoid crushing of a soft roof. Other manufacturers recommend a high setting load of 70 and 80 percent of the yielding load.

In Germany, the best experiences have been with a high setting load when roof conditions became bad. The roof should not be allowed the remotest chance to move before the full yielding load is in action. Thus, the rock has the chance to carry itself as far as possible. When the rock moves only a small distance it loses contact, and is no longer able to carry itself, therefore, it becomes weaker. As a result a higher pressure is on the support because the rock does not carry itself and the resistance of the rock against the high yielding load of the support is less than it was.

2.3.3 The Shield

The shield has basically changed the system of keeping the face area open. The chock and the frame with their long canopies support a large area of the roof and the pressure of the roof increasing from the face to the end of the canopy is taken up more or less by the strong legs. The shield only supports a very short area of the roof and keeps the face area open by holding the gob back which is gliding down on the gob shield when the shield is advancing. Therefore the roof is able to cave shortly after mining of the seam. The supported area is where the roof pressure is not as high as at the end of a long canopy. The individual differences between the systems of shield support are given by W. Kohlgrueber in his report* at the American Mining Congress Coal Convention in Pittsburgh this year.

* The Application of Shield Support in Longwalls of West German Coal Mines

2.3.4 Anchorage Of The Drives

The anchorage of the drives is more important in a plow face than in a shearer face because of the greater pulling power of the plow chain. All the power for the winning machine is transmitted by the chain in a plow face. The energy of the shearer is provided by a separate cable and only the pulling power has to be counterpowered by the drives at the face ends.

When anchorage is necessary, the drives of the face conveyor and the winning machine are firmly anchored between roof and floor. Different designs are possible for this. Two anchor chocks can fulfill this function at each end of the face. They are equipped with rams capable of moving the entire pan-line in either direction along the face. They are mounted in a rugged cradle to protect them against the effect of lateral power and movement. In addition to these anchor chocks, available in different designs, are a powered roof support at the critical face end areas, Figure 2.6.

Another method used to stabilize the drive units of the face is the "beam type anchorage" Figure 2.6. Two beams, a short and a long, with 2 single props each, prevent jackknifing and buckling of the pan-line. In moving the drive, the props of the short beam are lowered and moved forward, taking counterpower from the long beam. After pressurizing the props the long beam is advanced by taking counterpower from the short beam.

2.3.5 Rock Pressure

Rock pressure at a longwall face particularly effects the entries at a distance of about 100 feet ahead of the face. The roof and floor may

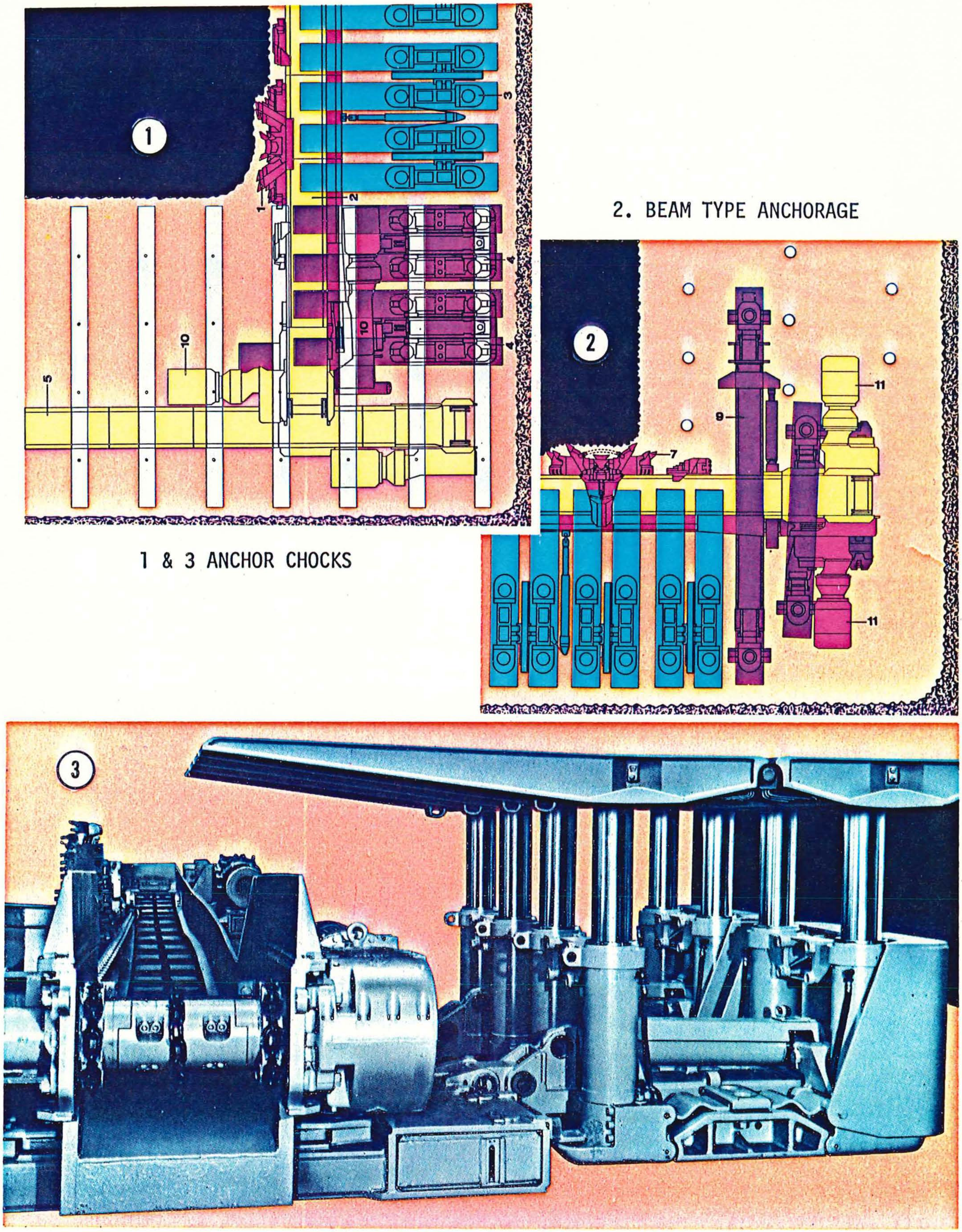


Figure 2.6 Anchorage of the Drives

squeeze into the gate 50 to 100 feet ahead of the face. The roof at the intersection of entries and crosscuts is especially stressed by the dynamic rock pressure. Rock falls from between the straps and roof bolts. The usual roof bolting used in the gates is unable to prevent the roof faulting.

A research program of the Steinkohlenberg-bauverein in Germany resulted in the knowledge that this faulting can be avoided only by roof bolts with a length of half the width of the opening. Shorter roof bolts serve only as lagging.

In the mines visited in Phase I, two or three rows of wooden cribs in the tailgates and main gates were used. Sometimes wooden props were used instead of cribs. This system of gate support may prevent large roof falls, but has disadvantages. For example, because soft wood is used in the cribs, too much movement of the roof takes place before the cribs are able to carry the pressure. The load is carried too late. The wooden legs carry earlier but strata pressure causes them to break with only a small convergence.

In some mines observed, one or more rows of hydraulic props were under the wooden beams in this critical portion of the gates. In these gates there were no roof or floor faults. When using hydraulic props, the support resistance is immediately present due to the high setting pressures. Faults in the roof or floor are easier avoided when using hydraulic props instead of wooden cribs. Even when strata movement cannot be avoided totally, the high setting load stops the movement better than the wooden cribs or wooden props. This problem has been discussed in detail in the report of Dr. Geotze of Steinkohlenbergbauverein and Mr. E.A. Curth of United States Bureau of Mines dated October 21, 1971, Essen.

2.4 THE CONVEYORS

2.4.1 Conveyor Configurations

Conveyors with an endless chain are standard today in all longwalls and in the face area of the headgate. Different manufacturers are offering different conveyor configurations for individual mines. Many of the conveyors, although of different design, are equal in operating capability. In the last few years, chain selection has been the subject of many discussions. There are four kinds of chain designs available:

1. Three strand chain
2. Double strand chain
3. Double middle chain
4. Middle chain

2.4.1.1 Three And Double Strand Chain

The double and triple chain for many years were standard equipment in all longwalls. If it is not difficult to keep the face straight, the double chain and triple chain present no problems when their strength is suitable for the individual conditions. If one chain breaks the other one can be used to pull the broken part into an area where it can be easily worked on thereby decreasing the repair time.

2.4.1.2 The Double Middle And The Middle Chain

When keeping the face straight becomes a problem, the pull on one chain becomes greater than on the other one. As a result, one chain must take most of the energy provided to the conveyor and becomes overloaded. Often in a shearer face the conveyor is advanced shortly behind the shearer in order to move the chocks and keep delay of the roof support to a minimum. This can cause the conveyor to be in a curve. Then the middle or the double middle chains have the advantage because they always receive the same power. Also, the connections between links can be stronger for the middle chain than with an outside chain. Experience with a strong middle chain has been very good in the United States and abroad.

An advantage of the double middle chain is that the diameter of the sprocket can be smaller due to the smaller diameter of the two chains. This is important because it enables the manufacturers to design a smaller drive frame. A smaller frame is necessary for the shearer to leave the face before advancing the drive and starting a new cut without making a loop. Also a small drive frame is an advantage for the chain.

2.4.2 The Stage Conveyor

For the stage loader the same system as in the face should be used to have interchangeable spare parts. The stage loader is sometimes run at a higher speed than that of the face conveyor to prevent pile up of coal at the delivery point of the face conveyor.

2.4.3 The Panel Conveyor

As a panel conveyor, the conveyor belt is standard in all longwalls. The position of the stage loader and conveyor belt is moved, usually in the maintenance shift, when the face has advanced 15 to 30 ft. Up to this time the stage loader is pulled over the conveyor belt when the headgate drive of the face is advanced.

The panel entries in this country do not usually have problems with roof and floor control before the dynamic pressure of the face effects them. Therefore, it is possible to obtain a very accurate alignment of the conveyor belts. Usually the belt is hung from the roof. The experience with conveyor belts in the mines in this country is extensive and there are no problems with this part of the longwall equipment.

2.4.4 The Discharging Point Of The Face Conveyor

The height of the gates at a longwall panel are developed in the United States only to the height of the seam. For this reason the height at the discharging point of the face conveyor onto the stage loader is usually very limited. The equipment at this point has to be compact because:

1. Plow or shearer should be able to plane or to cut the ends of the face without a stable.
2. The discharging point has to be designed for an uninterrupted operation.

In the Phase I work, it was sometimes observed that fine coal was pulled into the bottom trough of the face conveyor. Accumulated, this fine coal can and does cause stoppages of the face conveyor.

There are several ways to prevent accumulations of fine coal in the bottom trough of the face conveyor. For example, if the floor of the face and the gate are on the same level, a short single-chain conveyor can be used underneath the drive of the face conveyor. The fine coal of the bottom trough falls into the short conveyor and is transported to the stage loader. The coal pushed out of the face by the plow or the shearer can also be transported onto the stage loader by this short conveyor. A wide-mouth mobile feeder-breaker of the type used at the belt terminals for dumping by shuttlecars will also prevent recirculation of slack coal by the bottom chain and is preferable to an additional conveyor at face ends where space is available. This or similar devices should be used at the maingate drive to guarantee uninterrupted haulage.

3. REVIEW OF OPERATING LONGWALLS IN THE UNITED STATES

Currently (December, 1974) in the United States there are 62 mining operations using longwall equipment and 16 additional locations where equipment has been ordered or installation is already in progress. The total annual production from those companies reporting, ranges from 280 to 1,800 tons per shift from faces 40 to 96 inches high and 225 to 672 feet long.

Table 3.1 Longwall Mining Operations - 1974 shows mine locations, production figures, seam thickness, and equipment used in United States longwall mining operations. The table was compiled during September and revised in December 1974 from information obtained from various sources including:

1. Mine operators during Phase I mine surveys.
2. Longwall equipment manufacturers.
3. Bureau of Mines personnel and contractors.

Of the 62 operating faces 40 use shearers and 22 use plows. Orders for new equipment include 10 shearers and 6 plows which indicates a continuing interest in longwall equipment. As can be seen from the above figures shearers account for 64.5 percent of the winning machines in operation while plows make up the remaining 35.5 percent. The dominance of shearers in use will be increased when the ordered equipment is installed. Shearer usage will increase to 69 percent and plows will comprise 31 percent of the total.

Included in new equipment orders are shield support systems for two longwall faces. These shield support systems have not been used in domestic coal mining and should provide interesting performance information to the coal mining community.

Sunnyside Sunnyside, Utah	1	72-78	550		2 Shearers-AM;SRA E;EDW 170L	E;EKF3	Chocks-Dowty	450/4	February 1975
York Canyon Raton, New Mex.	1	72-77	672	280	Shearer-AM;DDRA	Meco	Chocks-Dowty		Operating
York Canyon Raton, New Mex.	1	72-84	672		Shearer-AM;DDRA	E;EKF3	Shields-Hemsheidt		January 1975
MID-CONTINENT COAL & COKE CO.									
Dutch Creek Carbondale, Colo.	1	84	516		Shearer-AM;DDRA	Meco	Chocks-Dowty		June 1975
NORTH AMERICAN COAL CORP.									
Black Lick Seward, Pa.	1	72	450	750	Shearer-AM;Bi-Di	W;MIV-600	Chocks-Westfalia	460/4 B2.1	Operating
ROCHESTER & PITTSBURGH COAL CO.									
Emilie Schelocta, Pa.	1	42-60	450	650	Shearer-E;EW 150L	E;EKF3	Chocks-Klöckner	400/4	Operating
Helvetia Indiana, Pa.	1	56	350	600	Plow-Anbauhobel	W;MIV-600	Frames-Westfalia	700/4 Kl.3A	Operating
Jane Schelocta, Pa.	1	56	450	600	Shearer-E;EW 150L	E;EKF3	Chocks-Klöckner	440/4	Operating
UNITED STATES STEEL CORP.									
Gary #9 Filbert, W. Va.	1	44	342	600	Plow-Hook	W;MIV-600	Frames-Westfalia	560/4 Kl.3A	Operating
Gary #9 Filbert, W. Va.	1	55	500		Plow-Hook	W;MIV-600	Frames-Westfalia	600/4 Kl.3A	Ordered
YOUNGSTOWN SHEET & TUBE CO.									
Olga Coalwood, W. Va.	1	50	350	650	Plow-Hook	W;MIV-600	Frames-Westfalia	560/4 Kl.3A	Operating
VIRGINIA ELECTRIC POWER									
Laurel Run Mount Storm, W. Va.	1	84	500	650	Shearer-S;DTS 300	W;MIV-600	Chocks-Westfalia	460/4	Operating

LEGEND

[1] AM - Anderson Mavor; BJD - British Jeffrey Diamond; E - Eickhoff; S - Sagem; W - Westfalia; Bi-Di - Bi-Directional; DC - Dual Center; DD - Double Drum; DDRA - Double Drum Ranging Arm; SD - Single Drum; SDRA - Single Drum Ranging Arm. [2]All plows are Westfalia.

Percentage distributions of equipment provided by the various manufacturers in presented in Table 3.2. This table does not reflect equipment superiority but only equipment in use or on order.

The length and distribution of United States longwall faces are shown in Figure 3.1. The average length of United States longwall faces is 460 feet which is short compared to European faces which usually range from 650 to 820 feet.

As shown in Figure 3.2, 21 seams being mined are in the thickness range being considered for the conceptual design of an automated longwall.

PERCENTAGE DISTRIBUTION OF LONGWALL EQUIPMENT
AMONG THE MANUFACTURERS IN THE U.S., 1974

(This list is not intended to indicate equipment superiority, only equipment in use.)

NAME OF MANUFACTURERS	WINNING MACHINES NUMBER OF FACES SHEARER	PLOW	PERCENT OF TOTAL	FACE CONVEYOR NUMBER OF FACES	PERCENT OF TOTAL	ROOF SUPPORT NUMBER OF FACES	PERCENT OF TOTAL
Anderson Mavor[1]	16		20.3	2	2.6		
British Jeffrey Diamond	1		1.3				
Dowty						12 1/2	16.0
Eickhoff	22		27.8	16	20.5		
Gullick						11	14.1
Hemsheidt						2 1/2	3.2
Huwood				6	7.7	4	5.1
Klockner Ferromatik[2]						4	5.1
Meco[3]				10	12.8		
Sagem[4]	12		15.2				
Westfalia[5]		28	35.4	43	55.1	42	53.9
Long-Airdox				1	1.3		
Dobson						2	2.6
Total	51[6]	28	100.0	78	100.0	78	100.0

[1] Represented by Dowty
[2] Represented by National Mine Service
[3] Branch of Dowty
[4] Represented by Mining Progress, Inc.
[5] Parent Company of Mining Progress, Inc.
[6] Includes 2 shearers on 1 face.

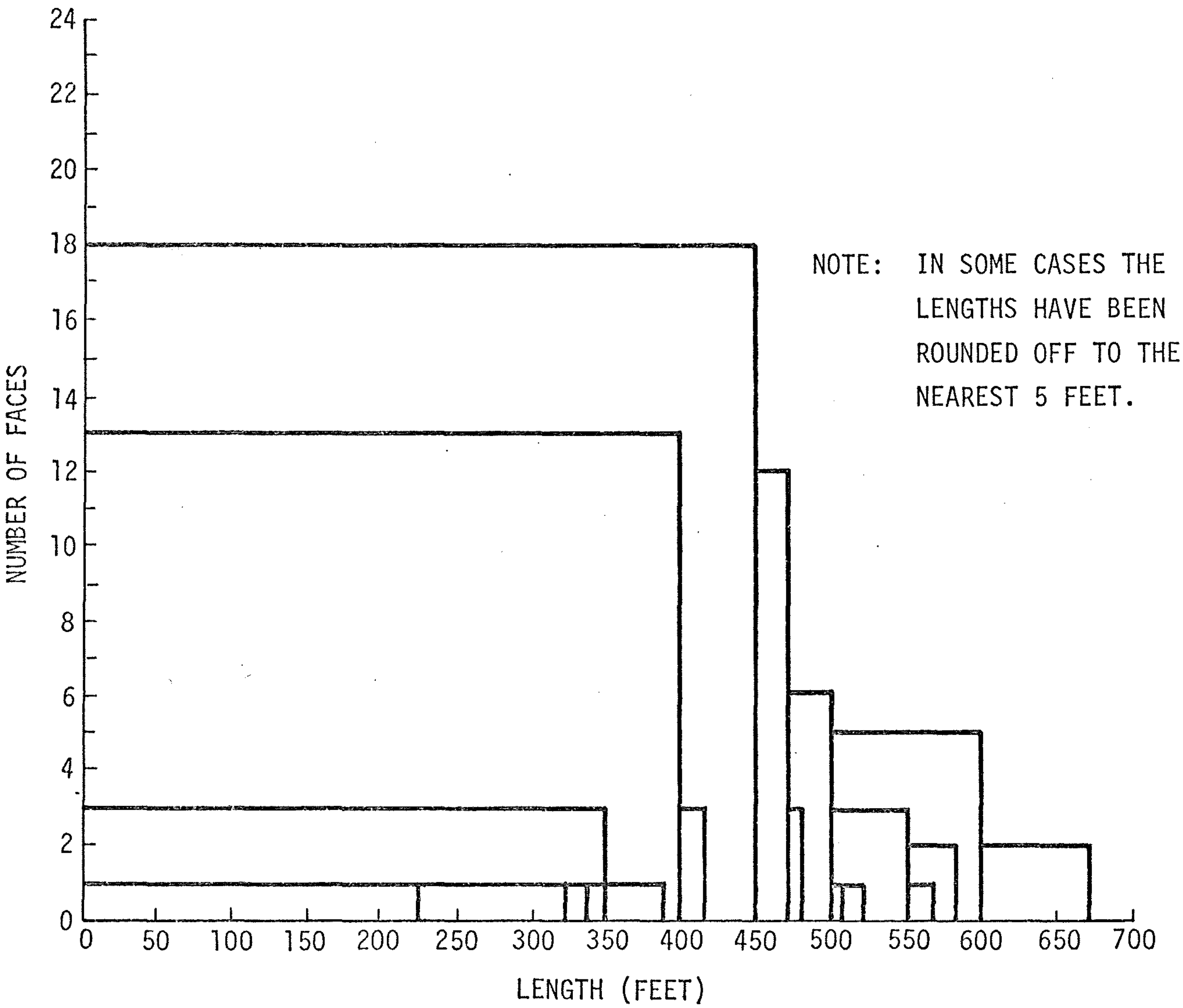


Figure 3.1 Length of Longwall Faces in the United States.

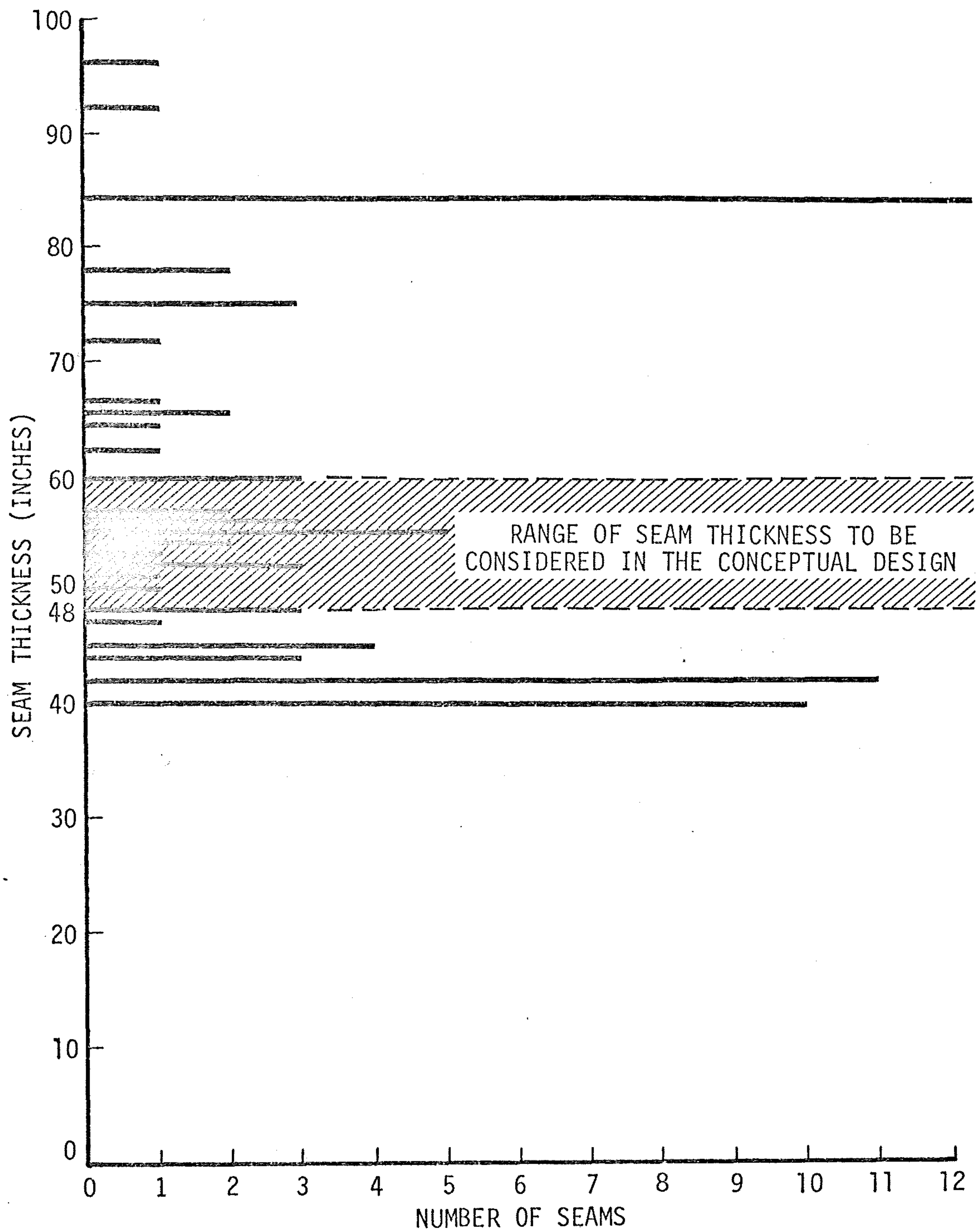


Figure 3.2 Thickness of Seams Now Mined by Longwall System in the United States.

4. VISITS TO OPERATING LONGWALL FACES

In Phase I a survey team of longwall experts visited the following longwall faces:

SHEARER FACES	MINE OWNER
S-1 YORK CANYON, 7th Panel, 8th Right	Kaiser Steel Corp.
S-2 ALLEN MINE, 9th Panel, 4th South	C F & I Steel Corp.
S-3 ALLEN MINE, 10th Panel, 4th South	C F & I Steel Corp.
S-4 SUNNYSIDE MINE, 3rd Panel	Kaiser Steel Corp.
S-5 SUNNYSIDE MINE, 15th Right, Panel C	Kaiser Steel Corp.
S-6 FEDERAL NO. 2, 7th Right	Eastern Associated Coal Co.
S-7 DELMONT MINE, 5th Right	Eastern Associated Coal Co.
S-8 LANCASHIRE NO. 24D, B 14	Barnes & Tucker Coal Co.
S-9 CAMBRIA SLOPE NO. 33, 4th Right	Bethlehem Mines Corp.
S-10 PIKE MINE NO. 26, between 3E & 4th Right	Bethlehem Mines Corp.

PLOW FACES	
P-1 GARY MINE NO. 9, 2nd Left	United States Steel Corp.
P-2 KOPPERSTON NO. 1, 4th Right	Eastern Associated Coal Co.
P-3 POCAHONTAS NO. 3, 2nd Panel, 5th South	Island Creek Coal Co.

4.1 WHY WE MADE THE VISITS

The purpose in visiting these 13 operating longwall faces was to collect information concerning the longwall equipment in use, its conditions of use, and its potential in an automated system.

4.2 HOW WE SELECTED THE MINES

In our proposal for this work we said that, in the mine selection process, we would consider such factors as:

1. Mining system in use,
2. Production rates,
3. Geological conditions,

4. State of development, and
5. Ease of obtaining entry.

Even though all of these factors were considered in the mine selection process, ease of obtaining entry was far and above the most important factor in mine selection.

4.3 RESULTS

Summary reports were prepared for these mine visitations and are included in Appendix A.

Table 4-1 is a listing of the various types of equipment being used in the surveyed mines. Nearly all longwall manufacturers furnishing equipment to the American market are represented in this list.

Table 4-2 is a summary of the geological conditions existing at the visited mines.

As shown in Table 4-3, average production per day ranged from 240 tons to 5,000 tons and maximum production ranged from 1,290 tons to 9,000 tons per day.

Table 4-4 presents the make-up of the longwall production crews in the visited mines. It is interesting to note that nearly 50 percent of the crew (power support operators and snakers) are involved in advancing the powered supports and the conveyor.

Listed below are some of the problems which hindered production at the various faces. These problems are not necessarily representative of the whole, they are individual observations.

PROBLEMS	CAUSES	POSSIBLE SOLUTIONS
1. Overloaded conveyor	Winning machine speed not coordinated with conveyor speed.	Select and use properly coordinated equipment.

PROBLEMS	CAUSES	POSSIBLE SOLUTIONS
2. Bad roof conditions due to insufficient setting and yielding load of roof supports.	a. Deficiencies of roof support hydraulic system, and b. Misunderstanding by management of roof support requirements.	a. Rehaul hydraulic system and instigate effective maintenance program. b. Confer with equipment manufacturers and other experts to determine proper setting.
3. Floor deterioration.	a. Excessive water from spray bars mounted on shearer, and b. Leakages from hydraulic system.	a. Water spray should be mounted in the drum and the cowl for the particular operation. b. Rehaul hydraulic system and instigate effective maintenance program.
4. Big coal chunks between chocks.	Caving from face.	Higher spillplates.
5. Conveyor walking.	Improper connection of flight chains.	Connect flight chains properly.

TABLE 4-1
LONGWALL EQUIPMENT USED IN THE SURVEYED MINES

EQUIPMENT

	MINES VISITED												
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	P-1	P-2	P-3
WINNING MACHINE													
Make	AM	E	AM	E	E	Sagem	BJD	E	AM	AM	W	W	W
Type	DD	EDW 170	SD	EW 170L	EDW170	DTS300	SD	EW 170L	SD	Bi Di	HP	GPP	P
Drum Width (in.) Plow Ht.	30	30	30	30	30	28	26	30	30	30	45	50	45
Drum Dia. (in.)	60	51	48	52	52	56	44	40	52	45			
Speed: Design	30	27	24	30	30	60			27	38	3 spd		150
(ft/min): Actual	12-15	51	13-15			20		18		15	Med. (88")	120	
Capacity (t/hr)	1390		540		1300								
Chain Dia. (mm)	22	22	18	18	22	22	7/8" rope	18		7/8" rope	26mm	26mm	22mm
CONVEYOR													
Make	Meco	EKF3	AM	EKF3	EKF3	MIV-600	Hu	Meco	Hu	Meco	MIV-600	MIV-600	W PFI
Width (in.)	30	30	30	30	30		32	30	27	30			
Chain Dia. (mm)	22	30	3 x 18	30	30	18	18	18	19	18	18	18	18
Speed (ft/min)	212	219	204	212	212	212		264	212	180	225	213	225
Capacity (t/hr)	700		600	600	600								
Flt. Spacing (ft)	3	3	1.5	3	3	3	3		1.5	2	3	3	3
Brackets (in.)	15	20	15	18	15	28	15	10	15	15		36	48
STAGE LOADER													
Make	Meco	EKF3	AM	EKF3	EKF3	MIV-600	J	Meco	Hu	Meco	W PFI	MIV-600	W PFI
Chain Dia. (mm)	18	30	3 x 18	30	30	18		18	19		18	18	18
Speed (ft/min)	212	219	204	212	212	212		302	212	212		213	250
Flt Spacing (ft)	3	3	1.5	1.5	1.5	1.5	1		1.5	2	1.5	1.5	1.5
Brackets (in.)			15	12	15	28	17	10	15				15
ROOF SUPPORTS													
Type & Make	D Ch	G Ch	H Ch	D Ch	D Ch	MP Ch	D Ch	G Ch	D Ch	Hu Ch	W Fr.	Dbl. Fr.	W Fr.
Tons	450	500	500	448	448	460		200	172	280	560	560	560
Legs	4	4	4	4	4	4	6	5	4	4	4	4	4
Wrk. Pres. (psi)	2500	2600-2800	4100-4300	1800-2250	2250	2000	1800	1500	1600	1500	2000	3000	2000
Control	Adj.	Adj.	Dir.	Adj.	Adj.	Dir.	Dir.	Adj.	Dir.	Dir.	Dir.	Dir.	Dir.
RAMS													
Type & Make		G	H	D	D	MP	D	G	D	Hu		MP	
Push (tons)	9	9.4	5.3	7.5	7.5	10		7	9				
Pull (tons)	14	12.6	15.7	12	12	14		5	14				
Spacing (ft)	4½ to 5	53"	5	4.5	5	4'11"	4	4'11"	4'11"			10	
Control	Adj.	Adj.	Dir.	Adj.	Adj.	Adj.	Dir.	Adj.	Adj.			Dir.	

AM - Anderson Mavor
BJD - British Jeffrey Diamond
D - Dowty
E - Eickhoff
G - Gullick
H - Hemsheidt
Hu - Huwood
J - Jeffrey
MP - Mining Progress
W - Westfalia (Mining Progress)
Ch - Chock
DD - Double drum ranging shearer
Fr. - Frame
GPP - Guide-plank plow
HP - Hook plow
P - Plow

Table 4-2
Geological Conditions at Visited Mines

	S-1	S-2	S-3	S-4	S-5
Seam Orientation	2°	Flat	Flat	6-8°	4°
Seam Thickness (in.)	80	92	92	64	84
Overburden (ft.)	300-650	1200	1200	1000	1500
Temperature (°F)	63°	68°	68°	62°-68°	62°
Immediate Roof Mtl.	Slate to SS	Sft Sh	Sft Sh	Sft Sh to SS	Wk Sh to SS
Immediate Floor Mtl.	Slate	Hd Sh	Hd Sh	Sh	Sh
Roof-Floor-Seam Relative Hardness	F > R > S	F > R > S	F > R > S	F > R > S	RF > S

	S-6	S-7	S-8	S-9	S-10
Seam Orientation	-	Flat	Flat	-	Flat
Seam Thickness (in.)	84	54	42	52	48
Overburden (ft.)	750 - 1150	560	350	500	1050
Temperature (°F)	65°	63°	68°	63°	68 - 70°
Immediate Roof Mtl.	Sh to SS	Sd Sh to SS	Hd Sh	Sh to SS	Sh to SS
Immediate Floor Mtl.	Lm	Lm	Hd Sh	Lm	Soft Soap S
Roof-Floor-Seam Relative Hardness	RS > F	RF > S	RF > S	RF > S	RF > S

Table 4-2 (cont'd)
Geological Conditions at Visited Mines

	P-1	P-2	P-3
Seam Orientation	6°	Flat	Flat
Seam Thickness (in.)	40	56	60
Overburden (ft.)	130 - 650	800 - 1000	1220
Temperature ($^{\circ}$F)	68°	68°	-
Immediate Roof Mtl.	Sh	Sd & Cly Sh	Sh to SS
Immediate Floor Mtl.	Sh	Lm	Sdy Sh
Roof-Floor-Seam Relative Hardness	RF > S	RF > S	RF > S

Table 4-3
Operations At Visited Mines

	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	P-1	P-2	P-3
Longwall Experience (yrs)	-	4	4	13	13	1	6	9	9	1	3	12	2
Observed Panel Started	5/74	-	5/74	12/73	3/74	11/73	4/74	5/14	3/74	3/73	1/74	1/74	5/74
Retreat(R) or Advance(A)	R	R	R	R	R	R	R	R	R	R	R	R	R
Face Width (ft)	672	450	450	450	550	450	400	450	585	550	342	600	450
Aug. Seam Thickness (in.)	80	92	92	64	84	84	54	42	52	48	40	56	60
Production: Maximum (t/day)	1,290	-	2,400	5,700	3,000	-	1,600	2,000	9,000	5,600	2,710	2,200	2,700
: Average	240-560	300	800-1,200	2,500	2,600	-	1,200	>1,000	5,000	3,000	1,600	1,800	2,200
Daily Advance (ft)	2.5	-	7.5-10	30	30	30	20	20	50	36	40	10	21
Time/Cut (min)	45	-	60	30	30	35	2	30	25	35	-	-	-
Cuts/Advance	1	-	2	2	1/2 face	1/2 face	2	2	1	1	-	-	-
Production Shifts	2	-	2	3	3	2 1/2	2	3	3	3	2	2	3
Working Time/Shift (min)	380	-	360	360	360	390	390	370	390	390	390	380	400
Maintenance Shift	Yes	-	No	No	No	1/2	Yes	No	No	No	Yes	Yes	No
Total Crew	38	-	28	27	30	35	20	30	33	30	29	31	39

Table 4-4
Make-up Of Longwall Production Crews
In Visited Mines

	S-1	S-2[a]	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	P-1	P-2	P-3
Production Shifts	2		2	3	3	2 1/2	2	3	3	3	2	2	3
Maintenance Shifts	1		0	0	0	1/2	1	0	0	0	1	1	0
Total Crew	38		28	27	30	35	20	30	33	30	29	31	39
Working Time at the Face (min)	380		360	360	360	390	390	370	390	390	390	380	400
Production Crew													
Powered Support Operators	2		3	2	2	3	2	2	3	3	6	6	6
Cornerman - Headgate	1		2	2	1	1	1	2	2	1	1	2	2
- Tailgate	1		4	1	2		1	2	1	1	2	2	2
Snaker	1			1	1		1	1	1	1			
Shearer or Plow Operator	2		1	1	2	2	1	1	1	1	1	1	1
Mechanic	1		1	1	1	1	1	1	2	2	1	1	1
Foreman	1		1	1	1	1	1	1	1	1	1	1	1
Others	5[b]					5[c]							
Totals/Shift	14		12	9	10	13	8	10	11	10	12	13	13

a) Production curtailed because of fault.
b) 3 wiremen, 2 cleanup men.
c) 3 timbermen (1st shift only), 2 road dusters.

5. TIME AND MOTION STUDY

5.1 WHY WE CONDUCTED THE TIME AND MOTION STUDY

Motion studies are used to observe and document the detailed operations and basic functions and to determine what is accomplished in the following situations.

1. Man working alone.
2. Man working with equipment.
3. Equipment working alone.

The most important question to be answered is "Why" the operation is done. For example, for our conceptual design work it is not only important that the shearer operator lifted the drum, but also why he had to lift it.

Two kinds of motion studies are possible.

1. Motion studies of the man operations.
2. Motion studies of the machine operations.

In our case both kinds were necessary to observe all detailed functions of a working longwall face. An analyses of the collected data will help us to decide:

1. Which operations can be automated.
2. Which part of the equipment has to be perfected for automation.
3. Which operations still have to be done by manpower.
4. The effect of mechanization or automation on operations and production.

5.2 MINE SELECTION

The original plan was to make motion studies at a plow and a shearer face. In spite of a great deal of effort it was not possible to obtain approval from any mine owner to make motion studies in a plow face. Different reasons were given: geological difficulties, bad advance of the plow face, labor unrest, etc.

For the shearer motion studies we wanted a double drum shearer face because the operations include the operations of a single drum shearer but not the other way around. The Sunnyside Mine of the Kaiser Steel Corporation is a well operating face with a double drum shearer. This mine was chosen for the motion studies.

5.3 OPERATIONS IN THE SELECTED MINE

The shearer face at the Sunnyside Mine is operating with the full cut method in combination with the half face system, Figure 5.1. The shearer cuts from the middle of the face to the tailgate and returns cleaning to the starting point. This operation is repeated to the main gate. The chocks always are advanced directly behind the cutting machine running to the face end. At the face ends, the chocks are advanced after the shearer has started its return to the middle of the face.

The face conveyor was pushed directly behind the cleaning shearer. Only the tailgate drive could not be pushed before the shearer had left the face end. Unlike the main gate drive, the tailgate drive was not installed into the gate, but at the end of the face. For this reason the face side of the tailgate end had to be cleaned before it was possible to push the tailgate drive.

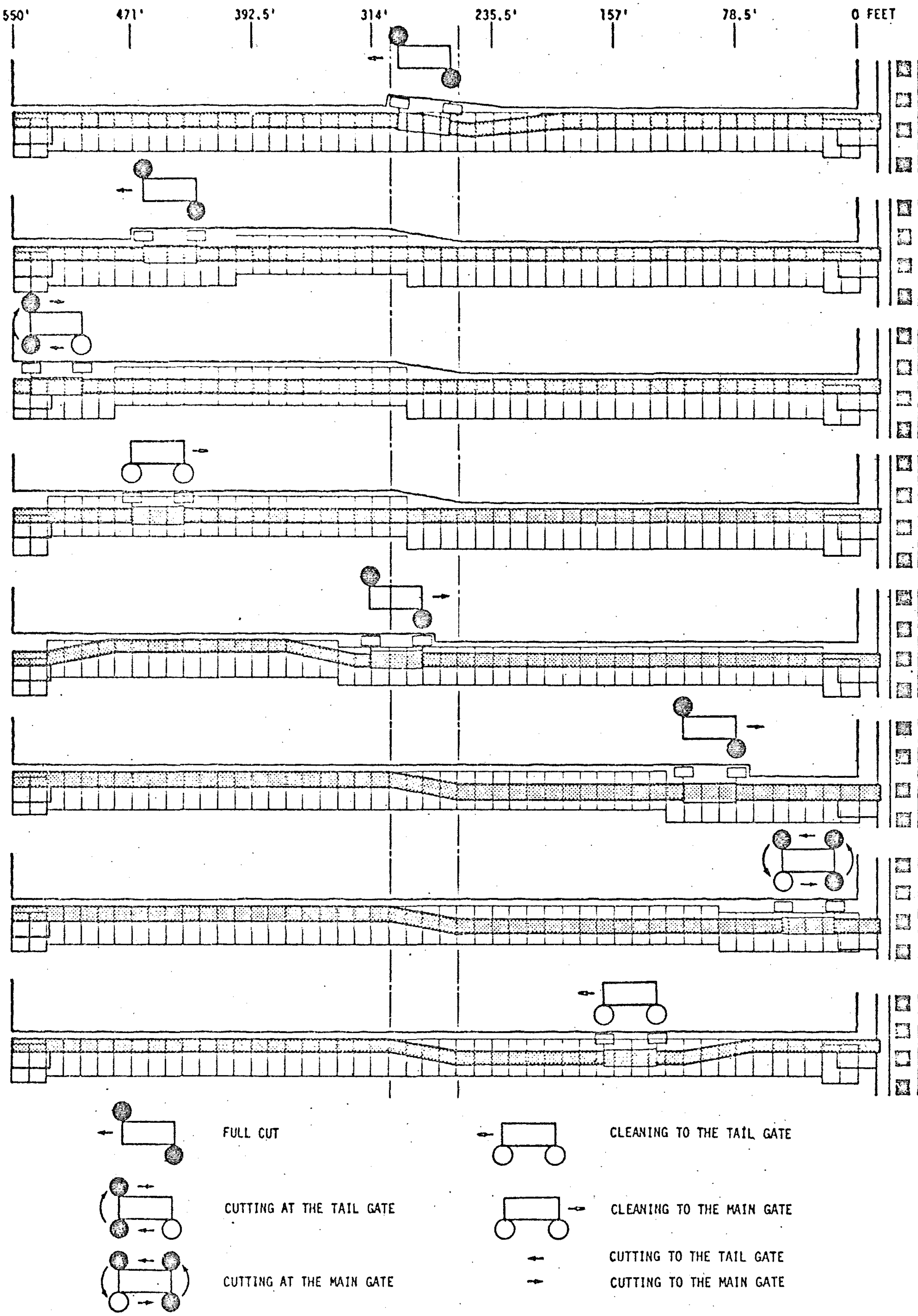


Figure 5.1 Cutting Cycle - Motion Study Mine

5.4 THE PROCEDURE WE USED

During the motion studies, coal production was in two shifts. We observed the total time of the first shift. In this way we could observe and document the following:

1. All activities, working and pausing times of the observed men.
2. All activities, waiting times and stoppages of the machines and other equipment.

All activities longer than 0.2 minutes were documented. The times, according to the running time and to the individual activity, were entered on forms. These forms were designed for each observer and the conditions, equipment, and activities he had to look for. (See Appendix B)

As far as possible not only the time and kind of activity was observed and entered but also why these particular activities were carried out or why stoppages and waiting times happened. The reasons were determined by personal observations or by asking the operators and entered in the column "Remarks". Events of less than 0.2 minutes were not listed over the entire shift but only for a short time when it was important to give some idea of the exact system of an important activity. Very short events of less than a few seconds, for example the powering of the shearer, were marked only by an X in the appropriate column.

Five working areas were observed with these motion studies:

1. Shearer	- tailgate drum	Study No. 1A(a)
	- tailgate drum operator	Study No. 1A(b)
2. Shearer	- headgate drum	Study No. 1B(a)
	- headgate drum operator	Study No. 1B(b)

3. Advancing the supports and the conveyor — Studies No. 2 and No. 3

4. Activities of the tailgate cornermen — Study No. 4

5. Activities of the headgate cornerman — Study No. 5

The equipment and organization of the observed 15th right panel is described in the report of the visit at Sunnyside Mine on August 1, 1974 which is in the Appendix.

5.5 RESULTS

5.5.1 Shearer - Tailgate Drum Operations; Motion Study No. 1A

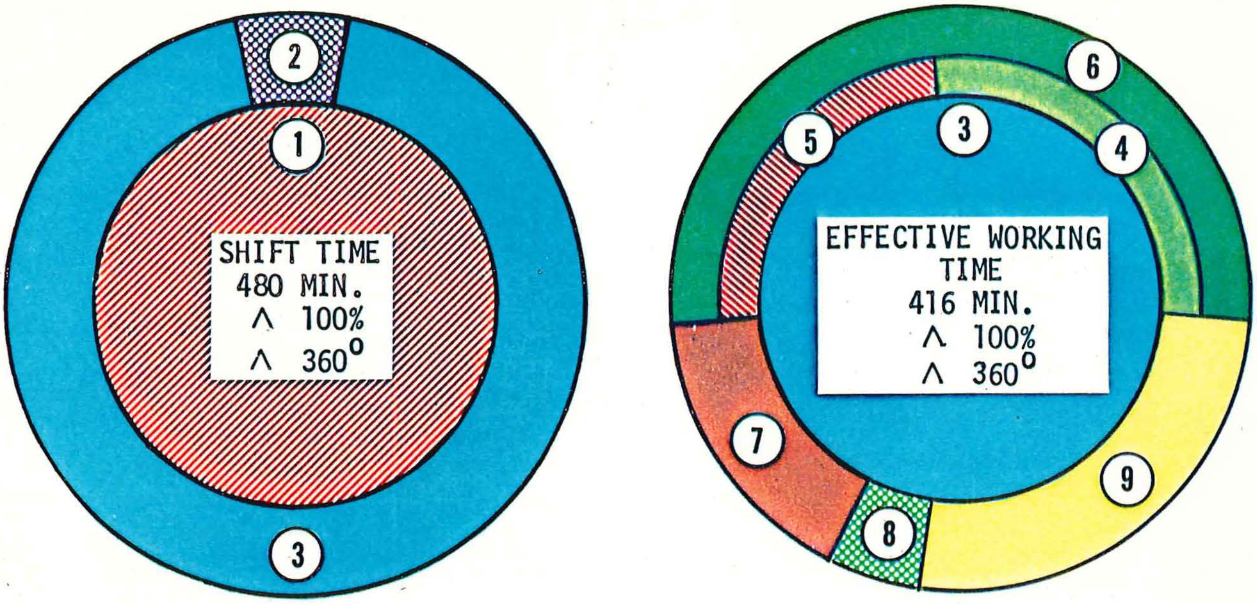
Two men were engaged in activities at the shearer, one at the tailgate drum and one at the maingate drum. In Motion Study No. 1A we observed the operations of the tailgate drum and its operator.

5.5.1.1 The Shearer - Tailgate Drum, Table 5.1 and Figure 5.2

The effective working time of the shearer was 6 hours and 56 minutes. At lunchtime the mechanic was the substitute for the operator so no time was lost for lunch. The full cut method in combination with the half-face system was in use. The shortest time required for one cut was about one hour without stoppages from elsewhere. In the observed shift the shearer reached a utilization factor of 52.14 percent including all stoppages of less than 0.15 minutes. It was not practical to write down the stoppages of less than 0.15 minutes. They usually occurred because of big chunks of coal or rock behind the shearer. The shearer had to be

Table 5-1.
Motion Study No. 1A(a): Time Distribution for Shearer; Tailgate Drum.

No.	Time Phases	Minutes	Percent	Remarks
1	Shift time including man trip	480	100	
2	Man trip	64	13.33	
3	Effective working time of the shearer	416	100	
4	Cutting time including short stoppages of less than 9 seconds (= 0.15 min)	113.55	27.30	
5	Moving time of the shearer without cutting (cleaning and other)	103.35	24.84	
6	Working time of the shearer (utilization factor)-including short stoppages of less than 0.15 min.	216.90	52.14	Total of Nos. 4 and 5
7	Stoppages of the shearer greater than 0.15 min.	70.10	16.85	
8	Checking of the shearer	20.00	4.80	
9	Stoppages from elsewhere	109.00	26.21	
	Totals	416.00	100.00	Total of Nos. 6,7,8 and 9



1. Shift time
2. Man trip
3. Effective working time including short stoppages of less than 0.15 min.
4. Cutting time of the shearer including short stoppages of less than 0.15 min.
5. Moving time of the shearer without cutting (cleaning and others)
6. Utilization factor of the shearer
7. Stoppages of the shearer greater than 0.15 min.
8. Checking of the shearer
9. Stoppages from elsewhere

Figure 5.2 Motion Study No. 1A(a) Shifts Time Distribution Diagram of the Shearer - Tailgate Drum. (See Table 5-1) frequently stopped and sometimes even removed because of large coal chunks, especially in the cut towards the maingate.

The shearer was not working with the Eicomatik. The winch ran slowly when the shearer cut in the direction of the maingate and at the face ends. The operator had to frequently stop cutting toward the maingate because the conveyor was overloaded. When cleaning and cutting in the direction of the tailgate, the shearer ran with "fast" speed. The tailgate drum was lifted during cutting operations and lowered during cleaning operations. The roof was not level so it was impossible to cut coal without movements of the drum. About every 5 seconds the drum had to be lifted or lowered because of the undulations of the seam roof. At the face ends the shearer was moved backward and forward, sometimes cutting and sometimes cleaning. In the last few feet at the tailgate, the tailgate drum was lowered, cutting in the direction of the tailgate and was lifted cutting toward the maingate. This last activity took place because the maingate drum could not reach the corner of the face.

At the beginning of the winning shift, maintenance of the shearer takes 20 minutes or 4.80 percent of the effective working time. Picks were changed and oil checked.

Each time the shearer reached the maingate, the oil level was checked and oil added due to a defective gasket in the gearbox of the shearer. This oil checking, the crushing of big coal chunks by hand, and one repair of a broken water pipe caused stoppages of the shearer. Together they totaled 1 hour and 10 minutes or 16.85 percent of the effective working time of the shearer.

Stoppages from elsewhere (outside the face) totaled 109 minutes or 26.21 percent of the effective working time.

5.5.1.2 The Shearer Operator Tailgate Drum, Table 5.2 and Figure 5.3

Many motions of the shearer operator took place in less than nine seconds. These motions were usually:

1. Lift or lower the tailgate drum during cutting operations approximately every 5-10 minutes.
2. Look for big chunks and stop the shearer when they appeared.
3. Crush the big chunks by hand.
4. Measure the cut height by hand (about every 3 minutes).
5. Watch and correct the location of the cable belt.
6. Clean cable belt of coal parts.
7. Pick big chunks out of the chocks and place on the conveyor.
8. Watch the cantilevers of the chocks and lift them or lower the shearer drum if it appears the cantilever and drum will come in contact.
9. Control the adjustable water nozzle and correct it by hand according to the movements of the drum.
10. Control the shearer (power the shearer, lift the drum, lower the drum, winch faster, winch slower, stop the shearer, cowl turnover).
11. Walking with the shearer.

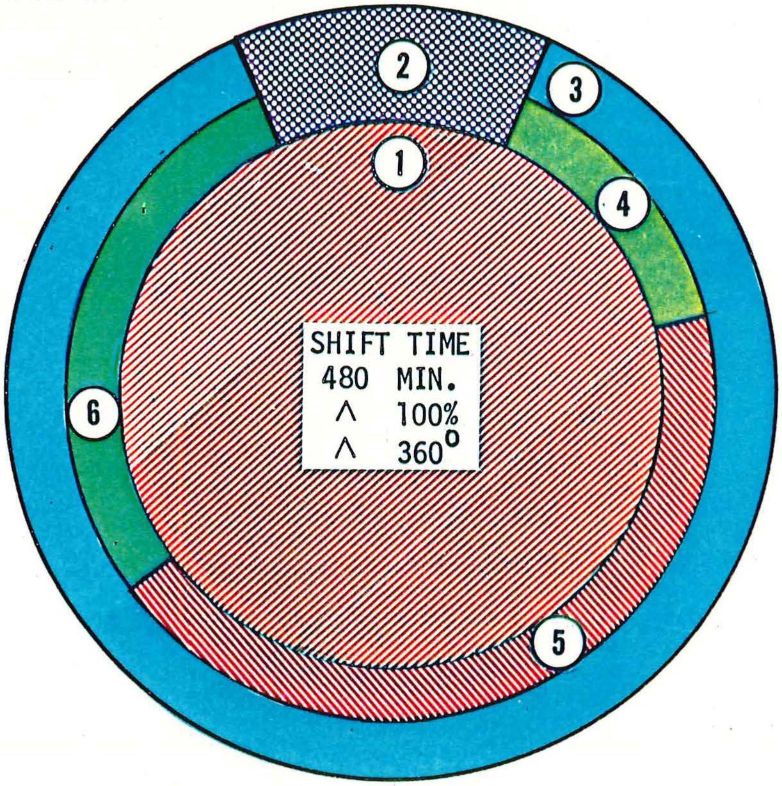
Item 5 in Table 5.2 includes these operations, activities and observations.

5.5.2 <u>Shearer - Maingate Drum - Motion Study No. 1B</u>

On the same day of Motion Study No. 1A, another observer was stationed at the shearer headgate drum and made observations for Motion Study 1B.

Table 5-2.
Motion Study No. 1A(b) Time Distribution for Shearer Operator - Tailgate Drum.

No.	Activities	Minutes	Percent	Remarks
1	Shift time	480.0	100.00	
2	Man trip	64.0	13.33	
	(Lunch time)			Mechanic is the substitute at lunch time
3	Available working time	416.0	86.67	
4	Working at the shearer	70.1	14.61	
5	Watch operations and control of the shearer, walk-other activities related to the motions of the shearer	215.9	44.98	
6	Waiting time	130.0	27.08	
	Totals	480.0	100.00	



1. Shift time
2. Man trip
3. Available working time
4. Working at the shearer
5. Watch and control operations of the shearer, walking with the shearer, other activities related to motions of the shearer.
6. Waiting time

Figure 5.3 Motion Study No. 1A(b) Shifts Time Distribution Diagram for the Shearer Operator - Tailgate Drum. (See Table 5-2)

The shearer working time and the utilization factor for control should be the same for 1A and 1B. The difference between them ranges from 0.35 minutes to 0.95 minutes and is caused by the accuracy of measurement. The effective working of the headgate drum is one minute less because the operator arrived later at the shearer than the tailgate operator.

5.5.2.1 The Shearer - Maingate Drum, Table 5.3 and Figure 5.4

The headgate drum was working in the lowered position most of the time. When the shearer was cutting, production of large coal chunks was reduced. The big chunks coming out of the face remained in front of the conveyor and were crushed and loaded by the shearer when it was cleaning up the floor in front of the conveyor before it was advanced. The headgate drum was lifted only at the headgate end to cut the upper level of the coal in that area which the tailgate drum couldn't reach. The shearer went to the headgate with the drum lowered and returned after the drum was lifted to the roof. In all other cases where lowering or lifting of the drum is noted it was for correcting by a few inches to get the suitable height of the face when the conveyor climbed on fine coal or was too low.

5.5.2.2 The Shearer Operator - Headgate Drum, Table 5.4 and Figure 5.5

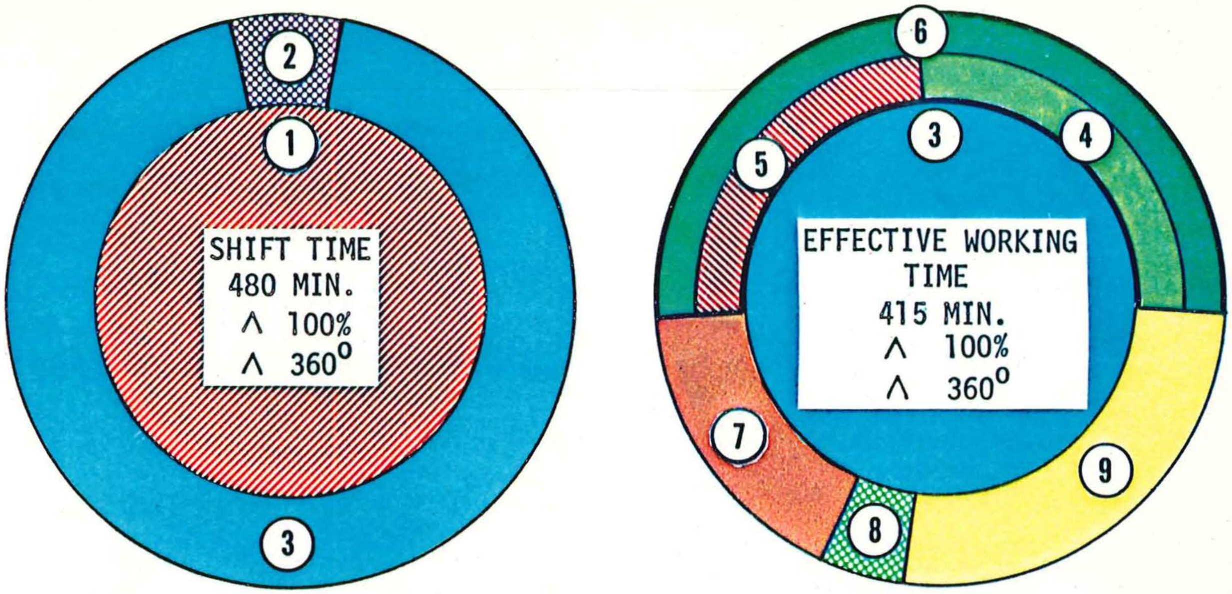
Most of the activities of the headgate drum operator took less than 6 seconds. They are similar to the operation of the shearer operator at the tailgate drums.

5.5.3 Support And Conveyor, Motion Studies Nos. 2 & 3

During the motion studies there were 4 chockmen in action and some-

Table 5-3.
Motion Study No. 1B(a) Time Distribution for
Shearer - Headgate Drum.

No.	Time Phases	Minutes	Percent	Remarks
1	Shift time including man trip	480	100	
2	Man trip	64	13.33	
3	Effective working time of the shearer	415	100	
4	Cutting time including short stoppages of less than 9 seconds (= 0.15 min)	113.90	27.44	
5	Moving time of the shearer without cutting (cleaning and other)	102.40	24.68	
6	Working time of the shearer (utilization factor) - including short stoppages of less than 0.15 min.	216.30	52.12	Total of Nos. 4 and 5
7	Stoppages of the shearer greater than 0.15 min.	68.70	16.55	
8	Checking of the shearer	21.00	5.06	
9	Stoppages from elsewhere	109.00	26.27	
	Totals	415.00	100.00	Total of Nos. 6,7,8 and 9



1. Shift time

2. Man trip

3. Effective working time including short stoppages of less than 0.15 min.

4. Cutting time of the shearer including short stoppages of less than 0.15 min.

5. Moving time of the shearer without cutting (cleaning and others)

6. Utilization factor of the shearer

7. Stoppages of the shearer greater than 0.15 min.

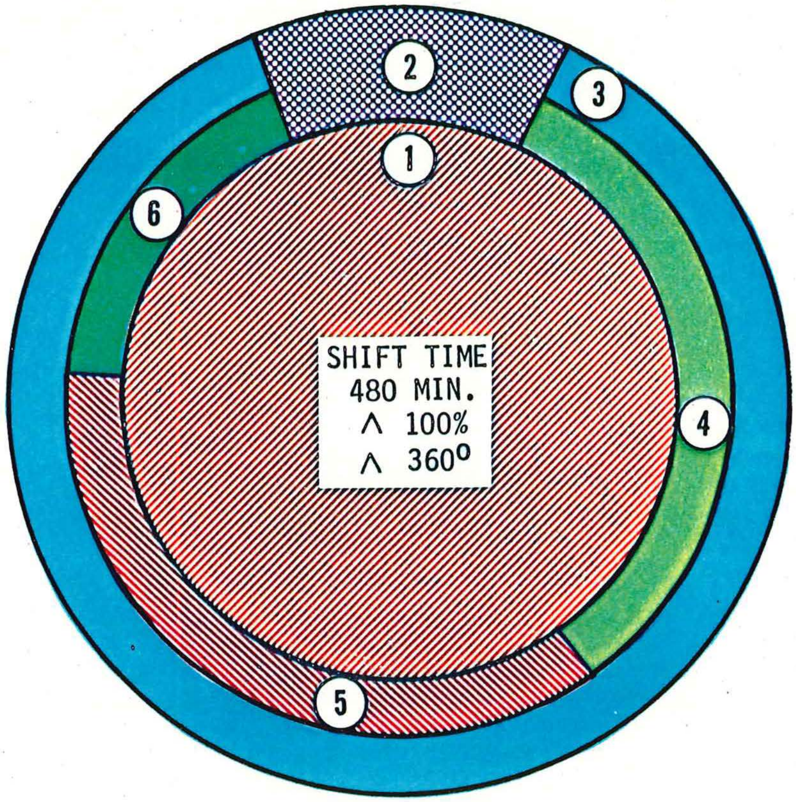
8. Checking the shearer

9. Stoppages from elsewhere

Figure 5.4 Motion Study 1B(a) - Operations Shifts Time Distribution Diagram of the Shearer - Headgate Drum. (See Table 5-3)

Table 5-4.
Motion Study No. 1B Time Distribution for Shearer Operator - Headgate Drum.

No.	Activities	Minutes	Percent	Remarks
1	Shift time	480.0	100.00	
2	Man trip	65.0	13.54	
	(Lunch time)			Mechanic is the substitute at lunch time
3	Available working time	415.0	86.46	
4	Working at the shearer	157.5	32.81	
5	Watch operations and control of the shearer, walking with the shearer, other activities related to the motions of the shearer	174.1	36.27	
6	Waiting time	83.4	17.38	
	Totals	480.0	100.00	



1. Shift time
2. Man trip
3. Available working time
4. Actual working time at the shearer
5. Watch and control operations of the shearer, walking with the shearer, other activities related to the motions of the shearer.
6. Waiting time

Figure 5.5 Motion Study No. 1B (b) - Shift Time Distribution Diagram for the Shearer Operator - Headgate Drum. (See Table 5-4) times a fifth man was added to help. These chockmen also advanced the conveyor. A separate snaker was not in the crew. Two men were always in charge of half the face, to advance the chocks and the conveyor and to clean the floor between and in front of the chocks. Sometimes they advanced the drives of the face conveyor. Every chockman had a lunchtime of 30 minutes but each of them was relieved by the mechanic or by the fifth man, so no time was lost at lunch. The crew in charge of the head-gate part of the face was observed in the Motion Study No. 3 (September 10, 1974) and the crew in charge of the tailgate part was observed in the Study No. 2 (September 6, 1974).

Motion Study No. 2 was concerned with the activities of the 2 chock-men in the tailgate. Their chock advancing activities are described in the Motion Study No. 3 as System B. Their only additional task was putting the timber on the canopy, with the help of tailgate crew, to prevent slushing in the face end at the tailgate area. They snaked the conveyor after advancing the chocks, starting from the tailgate and working towards the main gate. One man started pressurizing all rams and a second man straightened the conveyor visually following the first man. They spent most of their spare time on cleaning the space between chocks, and between chocks and conveyor. The top of the canopies were clean so they did not need to work that area. (Table 5.5 and Figure 5.6)

The working schedule of the chockmen was according to the "half-face cutting system" of the shearer. In Motion Study No. 3 (Table 5.6 and Figure 5.7), the shearer started in the middle of the face, cutting to the tailgate. The observer team was waiting for the shearer. When the shearer returned from the tailgate to the middle of the face it was clean-

Table 5-5.
Motion Study No. 2; Time Distribution for the Chockman (Tailgate end).

No.	Activities	Minutes	Man min	Percent	Diagram Color (See Fig. 5.6)
1	Shift time	480	960	100.00	
2	Man trip	75	150	15.62	
3	(Lunch time)	33	66	6.88	
4	Advancing Chocks		67.0	6.98	
	4.1 Lowering and advancing		(26.6)	(2.77)	
	4.2 Pressurizing		(40.4)	(4.21)	
5	Walk to the next chock		29.3	3.05	
6	Clean between the chocks		146.6	15.27	
7	Put timber on canopy		11.1	1.16	
8	Walk to the next ram		35.7	3.72	
9	Operate conveyor ram		25	2.6	
10	Move tailgate drive		19.1	1.99	
11	Wait		363.5	37.86	
12	Align pan line		26.5	2.76	
13	Raise cantilever while preventing pressure to the legs		20.2	2.11	
14	Available Working Time 4-13		774.0	77.5	

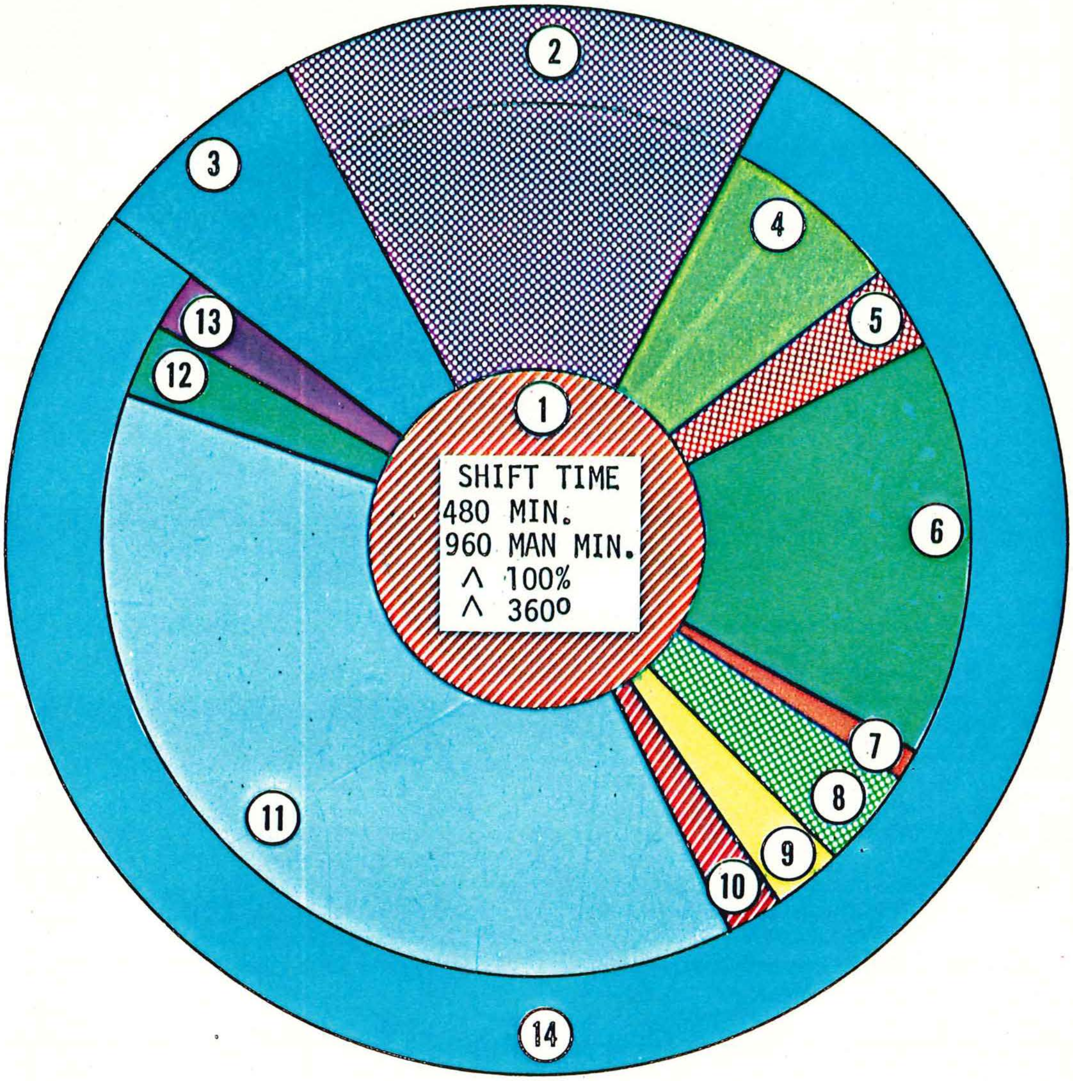


Figure 5.6 Motion Study No. 2 Shift Time Distribution for Chockman (Tailgate End). (See Table 5-5)

Table 5-6.
Motion Study No. 3: Time Distribution for the Chockman (Headgate end).

No.	Activities	Minutes	Man min	Percent	Diagram Color (See Fig. 5.7)
1	Shift time	480	960.00	100.00	
2	Man trip	70	140.00	14.58	
3	(Lunch time)	(30)	(60.00)	(6.25)	
4	Advancing chocks		81.3	8.47	
	1. Lowering and advancing		(32.8)		
	2. Pressurizing		(48.5)		
5	Walking to the next chocks		48.2	5.02	
6	Cleaning between support		201.0	20.94	
7	Crushing big chunks		25.0	2.60	
8	Walking to the next ram		39.1	4.07	
9	Operating conveyor ram		39.2	4.08	
10	Moving Maingate drive		1.2	0.13	
11	Waiting time		274.2	28.57	
12	Raising cantilevers		37.7	3.93	
13	Others (without lunch)		73.1	7.61	
14	Available working time 4-13		820.0	85.42	

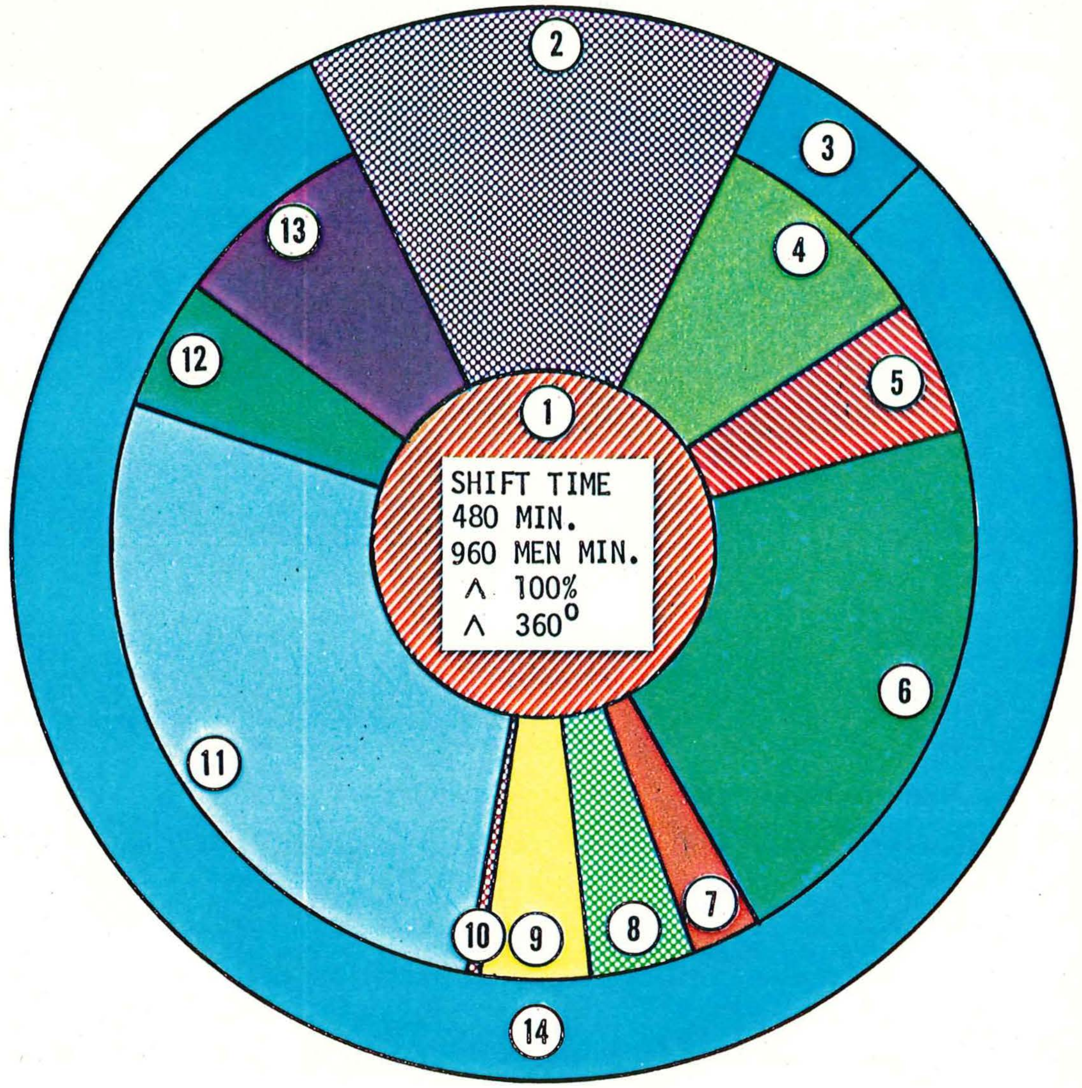


Figure 5.7 Motion Study No. 3 Shift Time Distribution Diagram for the Cornermen (3) at the Tailgate. (See Table 5-6)

ing the upper part of the face. In the middle of the face, the shearer started to cut the lower part of the face to the maingate. The chocks were advanced behind the shearer at a distance of 6 to 9 feet.

Each time the shearer arrived at the headgate, time was required for maintenance because of a leakage in the gearbox of the shearer. Oil was added and bits were changed at this time by the mechanic, the foreman, and sometimes by the chock operators.

The shearer left the headgate cleaning up the floor. The conveyor was advanced shortly behind the shearer by the chock operators. Coal was caving from the face and quick advance of the conveyor was necessary to allow the caving coal to fall in the conveyor rather than in front of it.

Each time the shearer moved away from the headgate the last two chocks in the face and the headgate chocks were advanced. These chocks had been kept to make room for maintenance work at the shearer.

When the conveyor was advanced and the shearer was cutting the upper part of the face (to the tailgate) the crew had to clean up between and in front of the chocks. The chockman then waited until the shearer came back from the tailgate and started to cut the lower part of the face to the headgate.

Advancement of the chocks was accomplished by two chock operators, usually working together. Two chock operating systems were in use. The chocks had an adjustable cantilever. Normally this cantilever was lifted at the same time as the legs by pressuring the legs and cantilever with the same valve (System A). It was sometimes necessary to line up the centilevers. In this case as one man pressurized the legs and centilever the second man operated a special valve to stop the pressure to the legs so only the cantilever was lifted. The second man had to calculate the best moment to release his valve so legs and cantilever were both pressurized (System B).

With System A the two chock operators worked the following schedule:

FIRST MAN	SECOND MAN
1. Walk to the valve in chock No. 4	Walk to chock No. 2
2. Pressurize ram No. 3 to fix the conveyor, (not to advance it) so that it will not be moved by pulling chock No. 2.	Wait in chock No. 2
3. Walk to chock No. 3	Wait in chock No. 2.
4. Pressurize ram No. 2 and lower chock No. 2 at the same time.	Wait in the advancing chock No. 2 and look for the pipes and telephone cable.
5. Pressurize legs and cantilever	Take pressure off ram No. 1 and wait.

Working with System B the first 4 activities were the same as above. The action was continued as follows:

6. Pressurize legs and cantilever.	Operate special valve for stopping pressure in the legs (cantilever is lifted).
7. Pressurize legs and cantilever.	Take pressure off ram No. 1 and wait.

This schedule shows that the second man was mostly waiting. Actually when the crew was advancing the support (9.81 percent of the effective working time) the second man was a reserve for any mishap because it was very important that the roof be supported shortly behind the shearer. In System B, the second man's only job was to operate the special valve for lifting the cantilever and to take pressure off of the ram.

Other jobs usually carried out by a chockman such as cleaning the face or building wooden cribs, could have been done by only one man. But because these jobs were done quickly and thoroughly by the two men, conditions were good and the machines were operating smoothly. Also in case of a mishap there was always a man available to help and to make the whole system work. So the relative high percentage of "waiting time" for the second man (33.45 percent working time) was insurance.

5.5.4 Cornermen At The Tailgate

In Motion Study No. 4 the three men engaged in activities at the tailgate face end were observed. For man trip and lunch they lost 1 hour and 45 minutes or 315 man-minutes. The effective working time was 6 hours and 15 minutes or 1,125 man-minutes, Table 5.7 and Figure 5.8.

Because the tailgate drive was not in the tailgate except at the face end, the shearer was not able to clean the face end completely. A lot of coal at the face side and behind the conveyor had to be shoveled. In addition, the shearer did not always cut the whole stable. It was then necessary to drill and blast the stable coal. Of the total working time, 22.71 percent was spent in cleaning the face side of the conveyor,

Table 5-7.
Motion Study No. 4; Time Distribution for Cornermen (3) at the Tailgate.

No.	Activities	Minutes	Man min	Percent	Diagram Color (See Fig. 5.8)
1	Shift time	480	1440.00	100.00	
2	Man-trip	69	207.00	14.37	
3	(Lunch time)	36	108.00	7.50	
4	Clean the face end 4.1 face side 4.2 gob side 4.3 behind the drive		447.00 (327.00) (105.00) (15.00)	31.04 (22.71) (7.29) (1.04)	
5	Advance the conveyor at the tailgate		20.60	1.43	
6	Advance the chocks		42.40	2.95	
7	Keep ready or pick up timber		32.00	2.22	
8	Measure methane		106.00	7.36	
9	Hang up curtain		52.00	3.61	
10	Cover the floor of the gate with rock dust		32.00	2.22	
11	Wait		310.00	21.53	
12	Others (without lunch)		83.00	5.77	
13	Available Working Time		1125.00	78.13	

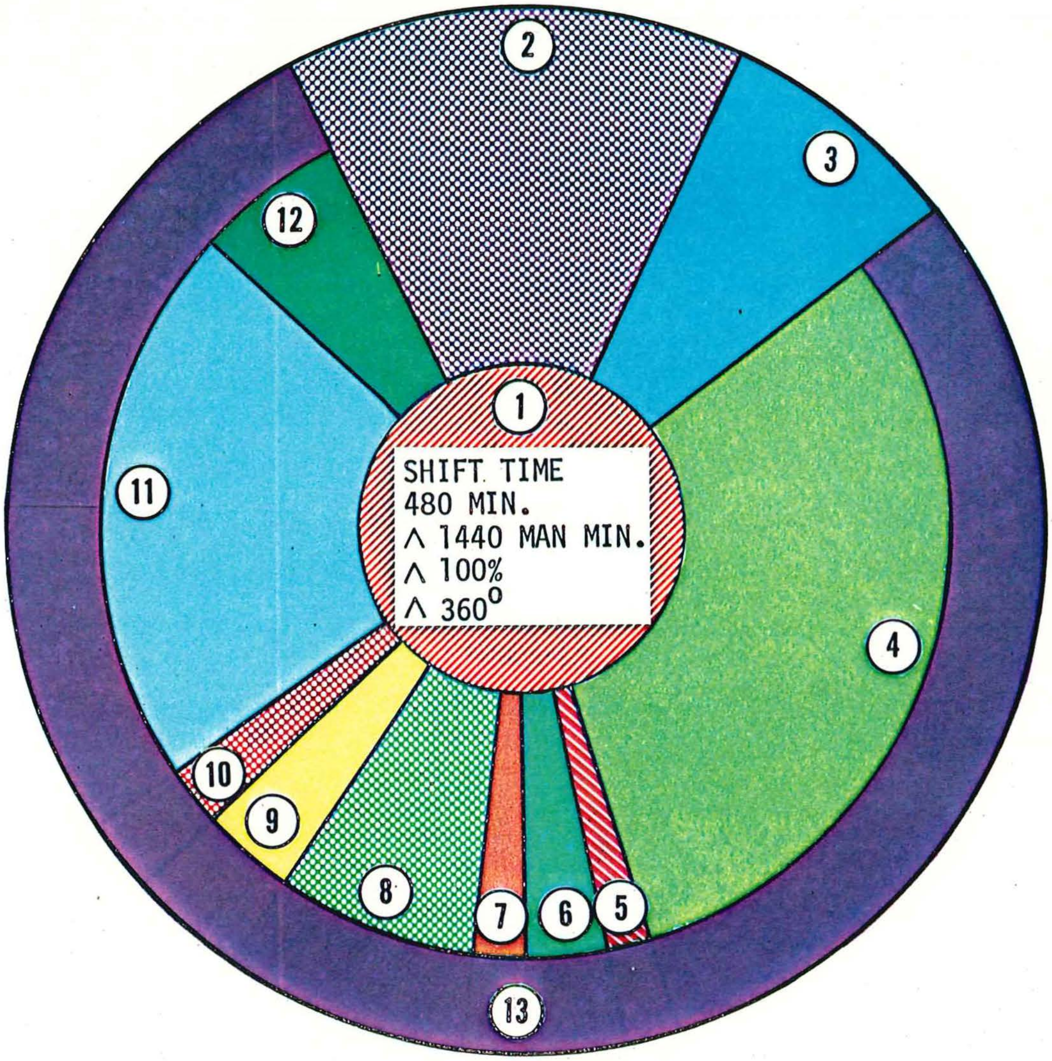


Figure 5.8 Motion Study No. 4 Shifts Time Distribution Diagram for Cornermen (3) at the Tailgate. (See Table 5-7)

7.29 percent at the gob side and 1.04 percent in front of the tailgate drive.

If the corner of the face had to be blasted it had to be done quickly to hold delay to a minimum. The shearer would have to wait if only two men are at the tailgate drive to clean the face. Additionally, the seam was very gassey and it was necessary to measure methane frequently and to hang up curtains. The amount of time required for cleaning the face end, for safety, and for adjusting the ventilation was difficult to calculate by the management. These facts seem to be the reasons for having three men working at the tailgate face end and for the long waiting time shown in the motion study.

When the shearer cut and cleaned the tailgate face end as much as possible and returned toward the maingate, the chock No. 2 was advanced. Two men placed two timbers on the cantilevers, then the third man pressurized the chock legs. Sometimes this operation had to be repeated if timbers were not well placed on the cantilevers. After this operation was completed, the next three chocks advanced in the sequence 1, 3, 4. When the face side and the front of the tail end drive was cleaned, and the single anchor leg at the face side recovered, the tailgate drive was advanced about 20 to 22 inches, pushed by four rams. Then the last four chocks were advanced in the sequence 4, 3, 2, and 1. Finally the conveyor was pushed against the face. Each time this described operation was carried out the tailgate drive was advanced 27 inches.

It was sometimes necessary to correct the position of the conveyor in the direction of the maingate by pushing or pulling the conveyor with the chock rams at the lower end of the fourth chock. After the conveyor end advanced completely the single anchor leg was set by two men.

5.5.5 Cornerman At The Maingate

In Motion Study No. 5 the activities of the man on the headgate corner were observed. Since the possibility of replacing the man by other sensor devices is being considered, as many actions as possible were recorded. However, some actions that took place in a very short time, such as 5 seconds or less, could not be recorded, Table 5.8 and Figure 5.9.

The cornerman was observing operations at his work station about 46 percent of the shift time, but at the same time he did some unrecorded tasks helpful to the operation. These tasks were recorded when they took longer than 5 seconds. Thus all his actions are recorded at least once.

He spent 15 percent of the shift time on both observing the entire operations, and doing other things, such as: crushing large chunks, cleaning up around the conveyors, operating the water supply valve, advancing the lines and other less time consuming but essential tasks.

This study did not include maintenance carried out at the beginning of the shift. This maintenance was carried on the previous day when the face was not operating. However, maintenance during the shift was recorded and took 5.2 percent of the shift time.

The cornerman was released for lunch by the mechanic so lunch did not affect the operation.

Table 5-8.
Motion Study No. 5 Time Distribution
for Cornerman at the Headgate.

No.	Activities	Man Min	Percent	Diagram Color (See Fig. 5.9)
1	Shift time	480.0	100.00	
2	Man-trip	61.0	12.70	
3	(Lunch time)	24.0	5.00	
4	Observe the operation (O.O.) stay in place	222.7	46.4	
5	0.0 & crush large chunks	13.7	2.86	
6	0.0 & clean up tail site of stage loader	23.9	4.98	
7	0.0 & clean up head site of face conveyor	17.8	3.70	
8	0.0 & operate water supply valve	1.8	0.38	
9	0.0 & advance lines	9.0	1.88	
10	0.0 & others	5.0	1.04	
11	Stop face conveyor, crush large chunks	4.2	0.88	
12	Stop face conveyor and stage loader, crush large chunks	1.4	0.29	
13	Inform the face crew, & start the conveyors	1.0	0.21	

Table 5-8 (Cont)

No.	Activities	Man min	Percent	Diagram Color (see Fig. 5.9)
14	Others	41.1	8.56	
15	Walk to the next job	4.0	0.83	
16	Wait	49.40	10.29	
17	Available working time	395.00	82.29	

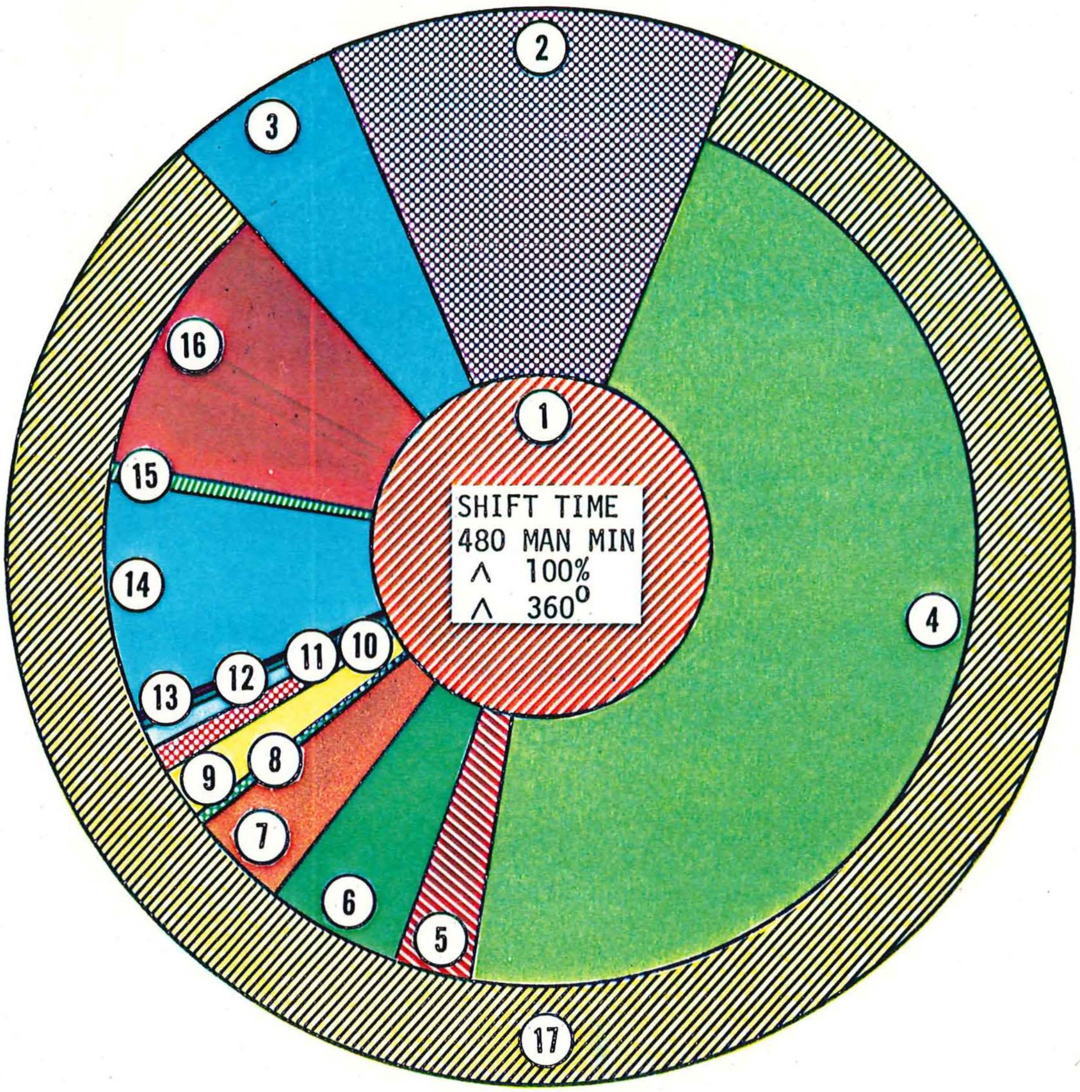


Figure 5.9 Motion Study No. 5 Time Distribution for Cornerman at the Headgate. (See Table 5-8)

6. RELATED BUREAU OF MINES RESEARCH

In Phase I we began a survey of recent and ongoing Bureau of Mines research and development efforts to insure that technologies capable of increasing longwall productivity and safety are included in the conceptual design. A partial listing of Bureau contract research reviewed is presented in Table 6-1. Abstracts of the work are included in Appendix C.

We have divided the research work into 7 categories

Mining Systems

Mining System Components

Ground Control

Dust Control

Communication and Monitoring

Illumination

Health and Safety

In Phase III we will continue our survey of pertinent Bureau of Mines research.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts

A. MINING SYSTEMS

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Master Environmental Control & Mine System Design Simulator for Underground Coal Mines"	G. Schottler DMRC	G0111808 Penn State University $434,729	6/1/71 39 mo 9/1/74	Current contract.
2.	"Systems Analysis of an Inherently Explosion-Proof Coal Mining Operation"	T. Johnson MSED PB211980	H0110079 Westinghouse Electric Corp. $109,642	7/24/70 14 mo 9/24/71	COMINEC library.
3.	"Inherently Safe Mining Systems"	D. Rogisch WO	H0111670 FMC Corp. $9,217,392	6/18/71 42 mo 12/18/75	Current contract.
4.	"Develop an Underground Coal Mine Systems Model"	F. Ball MSED	H0122005 Computer Science Corp. $303,348	8/16/71 20 mo 4/16/73	Final report not submitted. Contractor out of money.

B. MINING SYSTEM COMPONENTS

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Evaluation of Mine Electrical Systems"	G. Conray PMSRC PB225475/1AS	G0101729 Penn State University $306,972	6/19/70 38 mo 8/19/74	Work continued under grant G0133077 for $79,048.
2.	"Feasibility of Remote Control & Development of Remote Control Devices & Sensors"	M. Bowser PMSRC PB224257 thru 263	H0111194 Bendix Research Lab. $1,180,491	6/10/71 33 mo 3/10/74	COMINEC library.
3.	"Design and Construction of Continuous Mining Machine"	R. Schmidt TCMRC	H0122039 Ingersoll-Rand Research $778,495	1/1/72 34 mo 1/1/74 Extended 8/75	Current Contract.
4.	"Circuit Breaker Development & Application"	E. Litchfield PMSRC	H0122058 Westinghouse Electric Corp. $259,822	6/30/72 23 mo 5/30/74 8/75	Phase I 10/73, Phase II 6/74. Final report delayed by patent dispute.
5.	"Research in Advanced Power Systems for Mining"	C. Mason PMSRC PB214277	H0220004 Aerojet Liquid Rocket Co. $106,980	8/25/71 9 mo 5/25/71	COMINEC library.
6.	"Study on Continuous Mining Machine Bit Technology"	K. Strebig TCMRC PB225-633	H0220061 Bituminous Coal Research $58,145	6/22/72 9 mo 5/22/73	COMINEC library.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts (continued)

C. GROUND CONTROL

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Development & Design of a Mine Roof Simulator"	L. Wade PMSRC	H0122067 Wyle Laboratories $312,770	6/28/72 21 mo 3/28/74 8/74	Final report in process 8/74
2.	"Feasibility Study of Pnuematic Stowing for Ground Control in Coal Mines"	Soderberg SPO Open file only	H0210057 ITT Research Institute $68,649	6/18/71 9 mo 3/18/72	COMINEC library.
3.	"Development of a Permissible-Type Remote Reading Automatic Data Acquisition System for Absolute Ground Pressure Measuring Devices"	W. Tesch DMRC	H0220002 Bendix Corp. $104,982	8/17/71 12 mo 8/17/72	Final report abstracted 5/73 MRCR.
4.	"Comprehensive Ground Control Study of a Mechanized Longwall Operation"	P. Lu DMRC	H0230012 Harza Engineering Co. $686,390	5/24/73 34 mo 3/24/76	Current contract.

D. DUST CONTROL

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Experience Survey of Engineering Methods Used to Control Respirable Dust in Underground Coal Mines"	W. Courtney PMSRC PB219615	H0111464 Apt, Bramer, Conrad, & Assoc. $50,212	6/22/71 8 mo 2/22/72	COMINEC library.
2.	"Coal Mine Vacuum Sweeper"	E. Divers PMSRC	H0122057 Envirotech Corp. $483,811	4/21/72 24 mo 4/21/74 12/74	Phase I Final report (10/73) not available.
3.	"Survey of Dust Control Research"	K. Strebig TCMRC PB222-831	H0230015 Bituminous Coal Research $21,696	11/15/72 3 mo 2/15/73	COMINEC library.
4.	"A Mine Dust Control Program"	PB197739 (AP/71)	S0100231 Garrett Research & Development Corp.		
5.	"Dust Control on Longwall Shearers Using Water Through the Shearer Drum"	K. Strebig TCMRC	H0230031 Bituminous Coal Research $224,713	5/23/73 24 mo 5/23/75	Current contract.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts (continued)

E. COMMUNICATION & MONITORING

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Mine Communications & Monitoring"	M. Bowser PMSRC PB225862/AS	G0101702 West Virginia University $623,584	6/5/70 50 mo 8/5/74	COMINEC library.
2.	"Mine Surveillance & Communication System"	J. Murphy PMSRC	H0110845 Mine Safety Appliances $758,414	6/15/71 24 mo 6/15/73	Final report in process. 8/74
3.	"System Study of Coal Mine Communications"	H. Parkinson PMSRC	S0122076 Collins Radio Co. $98,333	6/13/72 12 mo 6/13/73	Final report in review by BuMines. 8/74

F. ILLUMINATION

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Exploration of Illumination Concepts for Underground Coal Mines"	J. Murphy PMSRC PB212070	H0111403 (H0220065) Crouse-Hinds Co. $577,375	6/20/72 23 mo 5/20/74	COMINEC library.
2.	"Development of Minimum Luminance in Underground Coal Mining Tasks"	J. Murphy PMSRC PB230447/AS	H0111069 U. S. Dept. of Navy $199,000	5/25/71 18 mo 11/25/72	COMINEC library.
3.	"Portable Task Luminaire System"	F. Scott PMSRC	H0220055 Ocean Energy Inc. $171,329	6/20/72 17 mo 11/20/73	Draft final report submitted 4/74. Final report approximately 8/74. In review by BuMines.
4.	"Development of Illumination System for Longwall Coal Mines"	F. Scott PMSRC	H0230020 Ocean Energy, Inc. $167,591	5/10/73 14 mo 7/10/74	Phase I extended. Current contract.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts (continued)

G. HEALTH & SAFETY

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Aspects of Noise Generation & Hearing Protection in Underground Coal Mines"	J. Murphy PMSRC PB219087	G0122004 Penn State University $61,416	9/20/71 13 mo 10/20/72	Final Report abstract 4/73 MRCR.
2.	"A Comprehensive Study of Intrinsic Safety Criteria"	E. Litchfield PMSRC PB219799	H0111585 University of Denver $240,758	4/27/71 40 mo 8/27/74	Interim report 3/72.
3.	"The Miner, His Job, and His Environment"	J. Church TCMRC PB211732	H0122019 National Bureau of Standards $75,000	9/15/71 10 mo 7/15/72	COMINEC library.
4.	"The Development of Health and Safety Indices for the Evaluation of Underground Coal Mining Systems"	M. Sikich TCMRC Open file only	H0122028 University of Minnesota $86,990	10/1/71 25 mo 11/1/73	COMINEC library.
5.	"Suppression of Fire on Underground Coal Mine Conveyor Belts"	Don Mitchell PMSRC	H0122086 Walter Kidde & Co., Inc. $258,346	6/26/72 20 mo 2/26/74	Final draft report being reviewed by BuMines.

7. APPLICABLE COAL MINE HEALTH AND SAFETY STANDARDS AND REGULATIONS

Regulations and standards have not been established specifically for longwall mining operations; however, the mandatory regulations established for underground coal mining include longwall operations. The most important standards which affect the conceptual design for an automated longwall operation are briefly outlined in this section.

7.1 VENTILATION

Approved ventilation equipment shall be installed, operated and maintained (daily examination) to include fireproof surface installations and subsurface ducting, with alarms to indicate system failure. Special fireproofing and explosion protection shall be required, and routine maintenance inspection and records maintained.

Air quality shall be as follows:

1. Not less than 19.5 volume per centum of oxygen
2. Not more than 0.5 volume per centum of carbon dioxide
3. No noxious or poisonous gases in excess of established Threshold Limit Values (TLV's) as specified by the American Conference of Governmental Hygienists. (Detectors for analysis of mine air shall be employed.)
4. Minimum air quantities will be 9,000 cubic feet per minute of air at crosscuts in room air, and 9,000 ft^3/minute at intake end.
5. A minimum of 3,000 ft^3/minute at all working faces is required.
6. The air shall have perceptible movement everywhere in the mine

openings, and be sufficient to dilute or remove all harmful elements as prescribed.

7. Explosive gases shall not exceed prescribed limits.

8. Each mechanized mining section shall be ventilated individually. Longwall mining sections may be ventilated by a single split of air if approved by the Coal Mine Safety District Manager.

For longwall operations the mean entry air velocity at the face will be determined by dividing the total quantity of air delivered, by the cross sectional area of the longwall place at the entrance to the face. This determination can precede equipment emplacement, or be performed during its presence using an approved anemometer or similar device. A continuous automated methane analyzer and alarm will be installed nearest the face on longwall equipment. Examination and monitoring of the mine air shall be performed at regular intervals (each shift, weekly, etc.) as prescribed in <u>Mandatory Health and Safety Standards - Underground Coal Mines</u> Subpart D - Ventilation, pp. 349 to 366.

7.2 DUST

Each operator shall maintain a respirable dust concentration of less than 1.0 milligram/M^3 of air in the intake air courses, and less than 2.0 mg/M^3 in the active mine workings. If quartz is present, the lower concentration of either 2 mg/M^3, or the % quartz divided into 10 will prevail. Sampling methods, procedures, and schedules are detailed in Mandatory Health and Safety Standards Subpart B, pp 317-325.

Working sections in which longwall mining machines are used shall be sampled nearest the return air side of the longwall face (portable samples), or within 48 inches from the corner on the return air side of the longwall face (stationary sampler).

7.3 NOISE

Permissible noise standards have been established using a time/decibel exposure rating. For one eight hour shift the maximum limits are as follows:

8 hrs - 90 decibels	1.0 hrs - 105 decibels
6 hrs - 92 decibels	0.75 hrs - 107 decibels
4 hrs - 95 decibels	0.50 hrs - 110 decibels
2 hrs - 100 decibels	0.25 hrs - 115 decibels
1.5 hrs - 102 decibels	

The total noise exposure may include single or multiple levels during one shift, and is determined using a formula presented in Subpart F - Mandatory Health and Safety Standards, pp 325-328.

7.4 ILLUMINATION

A proposed illumination standard for coal mines was announced in the Federal Register, Vol. 36, No. 207, Oct. 27, 1971 which requires the surface brightness in the normal working places of underground coal mines to be not less than 0.06 foot lamberts.

7.5 ELECTRICAL EQUIPMENT

Permissible electrical equipment, including cables, junction boxes, face equipment, lighting, blasting, communication, etc. must be adequately maintained, and updated maps showing location and ratings shall be available to mine personnel and safety inspectors. Electrical face equipment inventories shall be maintained and filed with appropriate regulatory agencies.

Overload and short circuit protection must be provided with automatic deenergizing capability for motors, adequate insulation of lines, adequate conductor sizes, suitable connectors, insulators, etc. (Subpart F - Electrical Equipment - General pp 367-376.)

Trailing cables shall be flame resistent (Ref. Bureau of Mines Schedule 2G). Short circuit protection with automatic circuit breakers, or acceptable fuses (duel element, unless specifically approved otherwise). No more than one temporary splice (less than 24 hrs), 25 feet or more from the machine. Permanent splices essentially equal to original electrical, mechanical, and flame resistant qualities are permissible.

Adequate grounding of all sheaths, conduits, and/or armors which shall be continuously enclosing electric power conductors, will be made. All conductive frames, casings, or other enclosures of electrical equipment shall be grounded by approved methods. Approved methods include a solid connection to low resistence borehole casings, metal water lines, surface ground conductor, or other approved methods that assure equal potential between the equipment and the earth.

High voltage circuits shall be protected against under-voltage, grounded phase, short circuit and over-current by adequate circuit breakers, resistors, grounding, installation, connectors, etc.

Low and medium voltage (alternating current) serving three-phase equipment will be similarly protected.

Limits and specifications are detailed in: Mandatory Health and Safety Standards - Subchapter 0 - Coal Mine Health and Safety - Subparts H, I, J, and K, pp 377-387.

7.6 CONVEYORS

Belt conveyors shall have positive acting stop controls readily accessible, and well maintained. If used for man trips conveyors must: (1) be stopped while loading or unloading, (2) have 18 inch vertical clearance and 36 inch side clearance at loading stations, (3) be run at less than 300 feet/min if the overhead is less than 24 inches, or 350 feet/min if the overhead is greater than 24 inches, (4) have a clear travelway of 24 inches on each side. They shall be adequately illuminated and communication shall be provided at all loading stations.

If not used to transport men, stop and start controls should be installed at less than 1,000 foot intervals, and be readily accessible. Persons should not cross moving conveyors, unless suitable crossing facilities are provided.

Detailed and expanded transport and haulage regulations are provided in Coal Mine Health and Safety - Subpart 0, pp 403-407.

7.7 ROOF SUPPORT

All active mine areas shall be adequately supported to protect workers from rock falls from roof or ribs. Ongoing programs to improve support controls will be implemented, and control plans filed with designated agencies for approval. Support systems for longwall mining, as a modified open-end method of pillar extraction, shall be approved on an individual basis. Detailed regulations are presented in Subpart C - Mandatory Health and Safety Standards, pp 342-349.

7.8 COMBUSTIBLE MATERIALS AND ROCK DUSTING

No combustible materials, including coal dust, float coal dust, or loose coal shall be allowed to accumulate on electrical equipment or in active workings. Cleanup and abatement measures shall be implemented to provide adequate control. All areas within 40 feet of the working faces shall be rock-dusted, unless no hazards exists to the miners, the area is inaccessible, or is unsafe to enter. Additional provisions and controls are presented in Subpart E, Mandatory Health and Safety Standards, pp 366-367.

7.9 COMMUNICATION

Communications shall be provided (telephones or equivalent approved systems) to the surface at all landings, working sections more than 100 feet from the portal, and as otherwise prescribed.

7.10 ESCAPEWAYS

At least two separate escapeways, individually ventilated, shall be available as provided by Coal Mine Health and Safety - Subpart P - paragraphs 75.1704 and 1704-1, p 409.

8. EQUIPMENT RECOMMENDATIONS FOR AN AUTOMATED LONGWALL

To find the equipment most suitable for an automated longwall we have reviewed the conceptual design criteria and the data from Phase I and reached the following conclusion and recommendations.

8.1 WINNING MACHINE

Both the shearer and plow are suitable in a seam with good roof and floor conditions where the coal is not too hard and the seam is flat and without undulations. The discussion in Section 2.2.3 shows an advantage of the shearer in the thicker seams. We believe that for automation the shearer has the advantage under the criteria established for this work.

8.2 ROOF SUPPORT

Of the three types of roof support - chock, frame, and shield - the chock more readily fits the design conditions established for this work. The chock, under normal conditions in this country, is an adequate roof support. The control system is simple and adaptable to automation.

The frame should be dropped from further consideration because of two problems:

1. It is difficult to keep a frame moving in the right direction.
2. The control system of the frame is the most difficult of the three kinds of support used.

The use of the shield in the last few years has helped to overcome difficulties of roof control in longwalls. The control system of the shield support is the simplest of the three kinds of support. However, in seam thicknesses of 48 to 60 inches, established for this conceptual design, the shield can only be used with a plow. There would not be enough free space for a shearer to move in this seam thickness with a shield support.

8.3 THE FACE CONVEYOR

The face conveyor subsystem will not present problems for automation of a longwall system. Conveyors with a single chain or with a double middle chain hold some advantage according to the latest experience in this country and abroad.

8.4 THE STAGE LOADER

The stage loader should be of the same design as the face conveyor.

8.5 OTHER EQUIPMENT

No specific conclusions have been reached on other longwall equipment for the automated system. However, selection of the additionally required equipment appears, at this time, to present no problems for the conceptual design process.

9. WHAT WE SHOULD NOW DO IN PHASE III

9.1 RECOMMENDATIONS FOR PHASE III

The criteria established by the Bureau of Mines for the conceptual design is that it be for a longwall system usable in seams from 48 to 60 inches thick. Our conclusions are that this requirement precludes the use of shields as roof support in the conceptual design. Shields do not allow enough headroom for a shearer and a shearer, as a winning machine, is necessary in the conceptual design to meet the various roof and floor conditions found in U.S. coal seams. This is unfortunate in that the shield and the plow are probably the easiest and least costly to automate. Therefore, we propose that in Phase III we include <u>two</u> conceptual designs, one for shearer and chocks and another for plow and shields.

To provide for this effort we have revised the schedule for Phase III and have included it as Figure 9.1.

9.2 PLAN OF EXECUTION

We have revised the Phase III Program Plan. The outline of this plan is as follows:

PHASE III

Conduct Plow Face Time & Motion Study

TASK A CRITERIA

1. Prepare Mine Specifications
2. Gather Detailed Equipment Data
3. Make Hardware Selection
4. Develop Standard Mine Layout
   a. Plan & Elevation
   b. Size & Dimension
   c. Speed & Capacity

TASK A (cont'd)

d. Time & Motion Data

e. Manpower Data

f. Mechanization Profile

5. Determine Automation Specifications

TASK B DESIGN

6. Prepare First Overall Concept

7. Develop Automated Mine Layout

a. Plan & Elevation

b. Size & Dimension

c. Speed & Capacity

d. Time & Motion Data

e. Manpower Data

f. Mechanization Profile

8. Cost Justification

9. Project Performance

10. Discuss Rationale

TASK C REPORT

11. Prepare Phase III Report & Make Oral Presentation

12. Prepare Final Draft Report & Final

PHASE III SCHEDULE

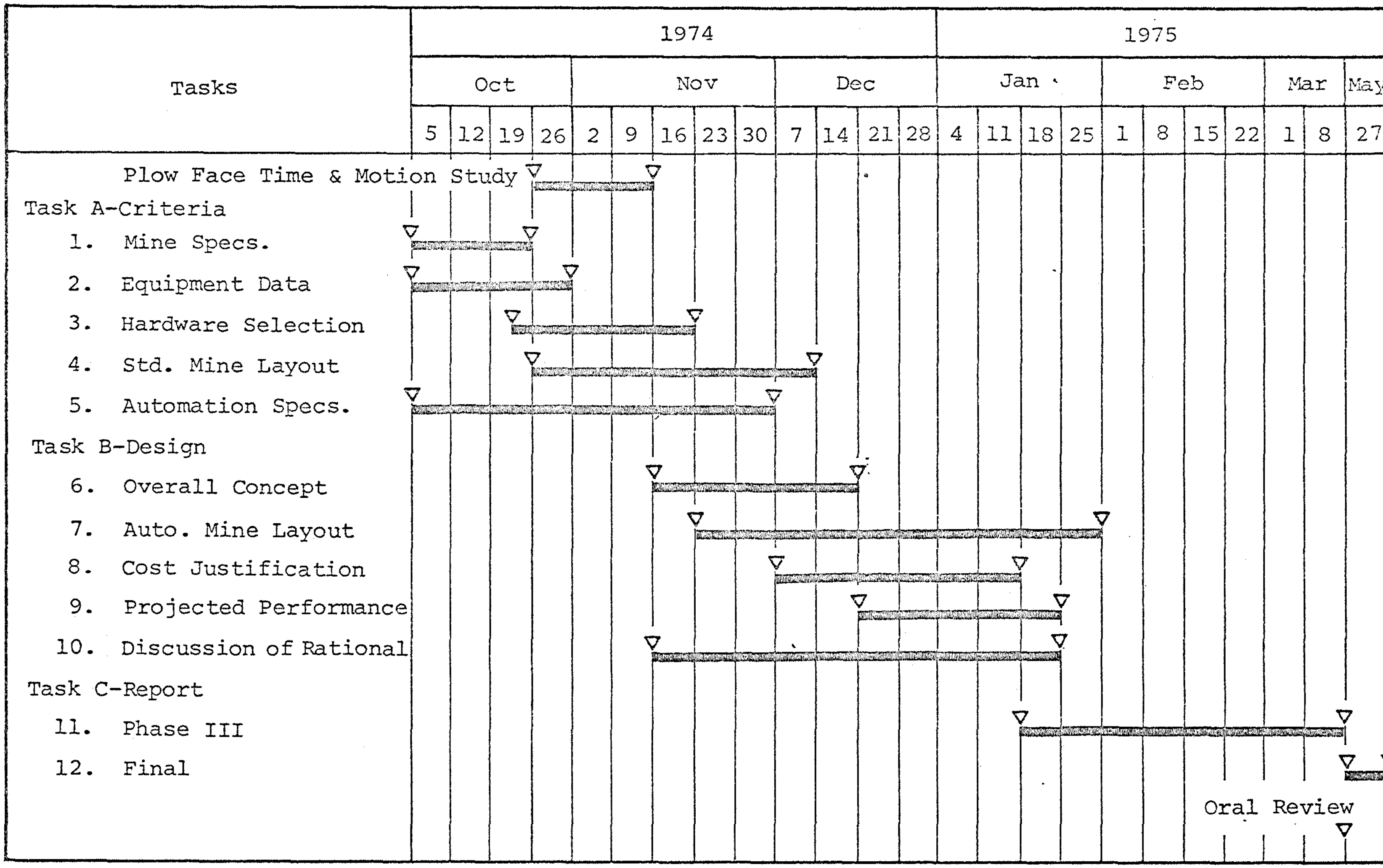


Figure 9.1
Proposed Schedule for Phase III

APPENDIX A

Mine Visitation Reports

APPENDIX A

MINE VISITATIONS REPORTS

York Canyon Mine, 7th Panel 8th Right
Kaiser Steel Corporation
Raton, New Mexico

Survey Report No. S-1
Survey Date: July 26, 1974

The York Canyon Mine had used longwall mining techniques on 3 previous panels with a total length of 2850 ft. The panel observed was started in May, 1974.

I. GEOLOGICAL CONDITIONS

The main seam of the York Mine varies in thickness between 48 and 156 inches. It is flat and outcrops in the canyon. The greatest part of the seam has a thickness ranging from 72 to 84 inches. The face surveyed has a height of 80 inches. No definite bedding plane between roof and seam could be observed. Cleats strike at 40^{o} to the face in the seam and roof as well, the dip is 80^{o}. The average distance of the cleats is 1/2 inch and more. A fault of 1 1/2 ft offset crosses the face at 45^{o}.

Roof consists of slate and sandy slate which changes into striped sandstone at some places. Rock breaks into fine sizes immediately behind the support.

The floor consists of slate and is relatively hard but also very sensitive to water. Overburden varies between 300 and 650 ft.

II. OPERATIONS

The retreating face is 672 ft long. Production reached last month was 358 t/day, last week 240 t/day, the day previous to our visit 560 t/day. Maximum production of 1290 t/day was gained one day in May. Daily advance is about 2 1/2 ft.

ig.
-1

The low production is the result of the bad condition of the roof support which causes insufficient support resistance and allows the roof to cave between the face and front edge of the cantilever and between the canopies.

III. LONGWALL EQUIPMENT

A. Winning Machine

The face is equipped with an Anderson Mavor, double drum shearer with ranging arms. A 300 hp, water-cooled, electric motor powers the machine. The drums are 60 inches in diameter and 30 inches wide and rotate at 42 rpm. The ranging arms are hydraulically adjustable. Cowls are turned mechanically by means of chains or wood put between cowl and drum. The designed maximum speed is 30 feet/minute, that means a theoretical capacity of 23 t/min at the seam height of 80 inches. Speed of the machine during actual operation was 12 to 15 ft/min. The full-cut method was applied. Dust suppression is achieved by spray blocks and spray bars mounted on machine and ranging arms.

ig. -9

B. Roof Support

Roof is supported by Dowty chocks with 4 double telescoping legs. The designed setting load is 46 tons in the lower stage and 31 tons in the top stage at a working pressure of 2000 psi. The yielding load is 125 tons. This type of support is designed for a height of from 42 to 132 inches. Canopies are of single unit design with adjustable cantilevers. Thirty-four chocks on the face are of slightly different shape and have two single-unit beam canopies. Total length of the canopies and cantilevers is 175 3/4 inches, forebearing part 82 3/4 inches. Hydraulic pressure of 2500 psi as observed, is provided by two Worthington triple piston pumps with a capacity of 22 gal/min. The rams for pulling the chocks and pushing the conveyor are operated by the same hydraulic pressure, thus reaching a strength of 9 tons pulling and a differential push of 7 tons. Chocks are adjacently controlled while the conveyor is pushed with only every third ram. This is done directly.

C. Conveyors

The face conveyor was a double-chain conveyor, Dowty-Meco made, with a width of 30 inches and spillplates 15 inches high. Two 150 hp motors power the conveyor. Motors, gearboxes and fluid couplings are arranged on the gobside parallel to the panline at each end. Diameter of the chains is 22mm, flights are spaced at 3 ft centers. Running with a speed of 212 ft/min, the conveyor has a capacity of 12 t/min. Ramp plates on the face side do the last clean-up when advancing the conveyor.

ig. -15

The stage loader is also of Dowty-Meco design. The 18mm double chain is powered by one 75 hp motor. Speed is also 212 ft/min, distance of the flights is 3 ft.

IV. CREW

Total crew consists of 38 men working on two production shifts and one repair shift. Average working time is 380 minutes/shift. The 2 production crews are each made up of:

1 face boss
2 shearer operators
2 chockmen
1 headgate operator
1 snaker
1 mechanic
3 wiremen
1 tailgate man
2 utility men

The maintenance shift has:

1 foreman
5 mechanics
4 asst. mechanics

ig. -3

Note: Gates are supported by wooden cribs, single props, and roof bolts.

Allen Mine, 9th Panel, 4th South
Colorado Fuel & Iron
Trinidad, Colorado

Survey Report No. S-2
Survey Date: July 29, 1974

The Allen Mine has had experience with longwall since 1970. Since then 3 panels have been worked. Two more are now in operation.

I. GEOLOGICAL CONDITIONS

The COMINEC team studied the geological conditions of the Allen seam along the main slope, the gates of 9th and 10th and the 9th panel. The seam has an average thickness of 92 inches. In this area it shows a flat arrangement with few undulations in the roof. It is split by two dirt bands; a coaly slate, 11 inches thick and a sandy slate, 1 inch thick. Cleats strike at an angle of 45° to the face and dip at 45°; distance is 2 inches or more. An irregularity crosses the face at an angle of 80° in the headgate area where the height of the seam goes down to 3 feet for about 10 feet along the face and has to be mined by shotfiring. During this operation the roof frequently caves ahead of the support 10 to 15 ft high and is very difficult to control.

The immediate roof is a thin coaly shale layer, 3 inches thick. Above this is 11 inches of black shale covered by gray broken shale and sandy slate. As these layers tend to cave, 1 foot of topcoal is left.

The floor is different layers of shale and is very hard. Overburden is 1200 ft thick.

II. OPERATIONS

Operations have been hindered by the above mentioned geological irregularity for nearly two months. Production is down for the same time to about 300 t/day. No systematic operation is possible for presumably another 3 weeks. The length of the face is 450 ft.

III. LONGWALL EQUIPMENT

A. Winning Machine

ig. The face is equipped with an Eickhoff double ended ranging arm
-6 shearer (EDW170). One 170KW machine powers the winch and drums as well. The 30-inch wide by 42-inch diameter drums run with 51 rpm. They and the cowls on both drums are hydraulically adjusted. An "Eicomatic" regulator control system automatically adjusts the haulage speed in relation to the cutting. When operated with the designed maximum speed of 27 ft/min the machine can reach a production of 22 t/min in the 92-inch seam. The effect of the water spray mounted on the machine for dust suppression
ig. could not be observed. Full face cutting system was normally in use.
-5

B. Roof Support

ig. Gullick 4-leg chocks were in use, each bearing a nominal load of
-10

125 tons at 7280 psi. Setting load is 40 tons reached at a working pressure of the pumps of 2600 to 2800 psi. Chocks are designed for a seam height ranging from 55 to 88 inches. Total length of the single unit canopies with adjustable cantilevers is 140 inches. The forward bar is 81 inches long. Differential raise is possible between rear and front legs and also of the capsule loaded forward bar. A single lever "dead man's handle" type control valve gives standard functions to adjust the chocks. Chocks are installed at 3 ft 11 inch center.

Rams operated by the same hydraulic pressure as the chocks reach a pushing force of 18 ton and pulling force of 12.2 ton.

C. Conveyors

Both the face conveyor and stage loader were Eickhoff single-chain conveyors with 30mm chains. The face conveyor is run by one 125 hp motor, with Eickhoff gearbox and Voith fluid couplings arranged parallel to the panline on the gobside at each end of the conveyor. Running with a speed of 219 ft/min the capacity reaches 14 t/min. Spillplates along the pans are 20 inches high. Final cleaning of the cut coal is achieved by ramp plates at the conveyor. The stage loader is of the same design, also powered by a 125 hp motor.

IV. CREW

No normal operation.

Allen Mine, 10th Panel, 4th South
Colorado Fuel & Iron
Trinidad, Colorado

Survey Report No. S-3
Survey Date: July 29, 1974

The Allen Mine has had experience with longwall since 1970. Since then 3 panels have been worked. Two more are now in operation. The observed panel was started in May, 1974.

I. GEOLOGICAL CONDITIONS

The COMINEC team was able to study the geological conditions of the Allen seam at Allen Mine along the main slope, the gates of the 9th and 10th panel and the 10th panel itself. The seam has an average thickness of 92 inches. In this area it shows a flat arrangement with few undulations in the roof. It is split by two dirt bands; a coaly shale 11 inches thick and a sandy shale 7 inches thick. Cleats strike at a right angle to the face dipping at 80°, spacing is 1/4 inch and more. A fault of 3 1/2 ft offset crosses the face in the middle at an angle of 40°. Both the roof and floor are harder than the seam.

The immediate roof is a small coaly shale layer 3 inches thick. Above that is 11 inches of black shale covered by gray broken shale and sandy shale.

The floor consists of different types of shale. Overburden is 1200 feet thick.

II. OPERATIONS

Length of the retreating face is 450 feet. Production reached last month was 800 t/day, last week it was 1000 t/day, the day previous to
Fig. A-2 the survey, 1200 tons. Maximum ever reached was 2400 t/day. Daily advance of the face is 90 to 120 inches.

Production is influenced by breakdowns of the conveyor chains and by bad roof conditions in the tailgate area due to high pressure.

III. LONGWALL EQUIPMENT

A. Winning Machine

The face is equipped with an Anderson Mavor single ranging-arm drum shearer. One 300 hp water-cooled electric motor powers the machine. The drum has a diameter of 48 inches and is 30 inches wide. Running with its maximum speed of 24 ft/min it cuts about 540 t/hour, the average speed is 13 to 15 ft/min. As it applies only one drum the shearer has to run two ways for one cut. The drum is arranged on the headgate side of the machine. Because of the bad roof conditions at the tailgate, an 18 ft long machine stable has to be mined out by man. Water sprays were mounted on the machine and ranging arm.

B. Roof Support

Hemsheidt 4-leg chocks were in use. Yielding load is 125 tons and setting load 104 tons on each leg, reached by a working pressure of 4100 to 4300 psi. Chocks are designed for a seam height ranging from 48 to 89 inches. The single unit canopies (167 inches total length) have a forebearing cantilever of 83 inches, adjustable by a hydraulic jack. The chocks are installed at 5 ft centers. Chocks are operated by direct control. Two Uraca pumps, one standing by, provide the pressure of 4100 to 4300 psi at a capacity of 22 gal/min. Support is in good condition but due to the low advance of the face the fine grained caving roof flushed through the canopies into the chocks thus hindering the walking along the face.

C. Conveyors

The face conveyor is an Anderson Mavor triple-chain conveyor with 18mm chains, 30 inches wide with spillplates 15 inches high. Pans are 1.5m long. Spacing of the flights is 18 inches. Running with a speed of 204 ft/min it has a capacity of 10 t/min. It is driven by one 120 hp motor on each end arranged parallel to the panline on the gobside. Ramp plates on the face side do the final clean-up when the conveyor is advanced.

The stage loader is of the same design as the face conveyor.

IV. CREW

There were two production shifts with 13 men each. There is no maintenance shift. One shift consists of:

2 headgate men
1 shearer operator
3 chock operators
4 tailgate men
1 mechanic
1 supply man
1 man at the slope (loads)

They have an actual working time of 360 min/shift.

ig. -4

Note: Gates are supported by steel beams, wooden cribs, single props, and roof bolts.

Sunnyside Mine, 3rd Panel
Kaiser Steel Corporation
Sunnyside, Utah

Survey Report No. S-4
Survey Date: Aug 1, 1974

A total of 75,000 feet of panel has been mined with the longwall system. The panel surveyed has been in operation since December, 1973. Sunnyside Mine has had experience with longwall mining since 1961.

I GEOLOGICAL CONDITIONS

In the Sunnyside Mine there are two mineable seams: the Upper Sunnyside and Lower Sunnyside. They outcrop along the Bookcliff Range and pitch an average of 6 to 8° into the inner part of the mine. The thickness of the Upper Sunnyside seam varies from 36 to 72 inches, while the Lower Sunnyside seam ranges in thickness between 60 and 168 inches. The rock separation between the two seams varies in thickness from a few inches to about 50 feet. In the areas where the separation is only a few inches, the rock is mostly bone or weak shale. As the thickness increases the separation changes to laminated sandstone.

The longwall face at the 3rd Panel South in the Lower Sunnyside was surveyed by the COMINEC team. The thickness of the seam was 64 inches at that location. Significant bedding planes or natural cleats were not observed. The floor is harder than the roof and the roof is harder than the seam. Overburden is approximately 1000 ft thick. Temperature in the mine varies between 62 and 68°F.

II. OPERATIONS

Length of the retreating face from gate to gate is 450 ft. The maximum production reached was 5700 t/day. Average production is 2500 t/day. Advance of the face is about 30 ft/day.

III. LONGWALL EQUIPMENT

A. Winning Machine

Fig. A-7 Winning operation was by an Eickhoff single drum shearer (EW170L). The shearer is equipped with a drum which can be hydraulically moved up and down by the ranging arm and a hydraulically operating Eicomatic haulage box. The haulage speed of the machine is automatically controlled by this Eicomatic device in accordance with the load on the drum due to the hardness of the coal to be cut. The shearer pulls itself along an 18 x 64mm chain that is anchored to the head and tail of the conveyor. This pulling action is accomplished in the haulage box with a sprocket wheel which engages the links in the haulage chain. An electric motor having a rating of 170 hp powers the drum and Eicomatic haulage box. The machine rides on the face conveyor through four articulated shoes and is trap guided by a tubular guide on the gobside of the conveyor.

The diameter of the drum was 52 inches with a cutting depth of 30 inches. The shearer was taking two cuts to excavate the whole seam section. The machine was making the roof cut with the drum raised from one gate to the other, and taking the bottom coal on a second cut with the drum lowered and traveling in the opposite direction. The bulk part of the extracted coal was transported onto conveyor through the spiral webs of the drum. The final clean up of the floor was achieved by means of static ramps attached to the face side of the conveyor during snaking the conveyor to the face. Machine mounted water spray jets were used for dust suppression.

B. Roof Support

The roof is supported by 4-leg, two single unit canopy Dowty chocks. These chocks are able to collapse to 52 inches and extend to 75 inches. These supports are operated with a setting load of 35 t/leg and yielding load of 112 t/leg. They are spaced 4.5 ft center to center and have adjacent control systems. The working pressure of the chocks is 2250 psi which is provided by Jeffrey pumps with a flow rate of 20 gpm using 5 percent of oil in the emulsion.

The rams pushing the conveyor and pulling the chocks toward the face are Dowty made and operated at a pressure of 2250 psi with a pushing power of 7.5 tons and pulling power of 12 tons. The rams are spaced with a distance of 4.5 feet and are operated by an adjacent control system.

The head and tail gates are mainly supported by roof bolts with steel straps. In addition to this there are single hydraulic props used toward the face and one row of wood cribs used behind the tail of the stage loader in the headgate. In the tailgate, however, two rows of wooden cribs are used at the opposite side of the face.

C. Conveyors

The Eickhoff, EKF3, face conveyor is in use at the face for face conveying and has a 30mm single chain with a strength of 64 tons. The flights on the string are spaced a distance of 1 meter. The conveyor is powered by three electrical motors with a rating of 125 hp each. Two of them were in use at the head and one at the tailgate. Protection of the motors is provided by "Voith" fluid couplings. The speed of the chain is 212 ft/min which provides a carrying capacity of 10 t/min. The alignment of the conveyor at the face is achieved visually.

Every 90 feet along the conveyor a phone is provided for communication. There is a wire line along the face conveyor attached to the conveyor switch. The face conveyor can be shut off by pulling the wire at any point. The stopped conveyor can be started only from the headgate with the starter switch.

There is a stage loader between the face conveyor and belt conveyor at the headgate. This conveyor is identical to the face conveyor and is powered by an electric motor with a rating of 125 hp. The only differences are the heights of the spillplates which are 12 inches at both sides of the conveyor and the distance between the flights which is 1 1/2 ft.

IV. CREW

There are three production shifts per day with a working time of 6 hours per shift at the face. Maintenance has been accomplished between the shifts and on weekends. The crew consists of 9 men per shift as follows:

1 foreman
1 mechanic
1 shearer operator
2 chock setters
1 snaker
2 headgate men
1 tailgate man (gas watcher)

Sunnyside Mine, 15th Right, Panel C
Kaiser Steel Corporation
Sunnyside, Utah

Survey Report No. S-5
Survey Date: Aug. 1, 1974

Longwall mining has been in use at the Sunnyside Mine since 1961. Since then a total of 75,000 feet of panels has been mined. The panel surveyed started in March, 1974.

I. GEOLOGICAL CONDITIONS

In the Sunnyside Mine there are two mineable seams: the Upper Sunnyside and Lower Sunnyside. They outcrop along the Bookcliff Range and pitch an average of 6 to 8° into the inner part of the mine. The thickness of the Upper Sunnyside seam varies from 36 to 72 inches, while the Lower Sunnyside seam ranges in thickness between 60 and 168 inches. The rock separation between the two seams varies in thickness from a few inches to about 50 feet. In the areas where the separation is only a few inches, the rock is mostly bone or weak shale. As the thickness increases the separation changes to laminated sandstone.

The COMINEC team surveyed the longwall in the Lower Sunnyside seam, 15th right, Panel C. Geological conditions were in general as described above. The thickness of the seam was 84 inches, the face moved upward at 2° against the dip. Cleats at angles of 45° and 135° to the face were observed in the seam and roof. Inclination of the cleats was 80° up to vertical, the distance of 1/2 inch and more. Both floor and roof are harder than the seam.

Roof and floor were clearly separated, bedding planes in the seam, unconformities in the roof and floor or other inclusions were not seen. Behind the chocks the roof collapsed in relatively small pieces and is unlikely to produce difficulties in other panels in this area.

The floor is of sufficient strength but is sensitive to water. Overburden is approximately 1500 ft thick.

II. OPERATIONS

Length of the face from gate to gate is 550 ft. Production has been 2600 t/day from the beginning, with a maximum of 3000 tons on several days. The average daily advance of the face is 30 ft.

III. LONGWALL EQUIPMENT

A. Winning Machine

The face is equipped with an Eickhoff double drum shearer (EDW-170). The range of application of this machine is in seam heights between 55 and 120 inches. One 170 KW water-cooled electric motor powers the machine. The hydraulic winch and the motor occupy the central position in the assembly. The diameter of the drums is 52 inches, the width 30 inches. Transmission to the drums is through gearboxes at each end. A hydraulically regulated "Eickomatic" control system automatically adjusts the haulage speed in relation to cutting. The ranging arms are hydraulically adjusted, the cowls can be turned by the same device. Dust suppression is achieved by water sprays mounted on the machine. Drums rotate at 50 rpm. Applying the full-cut method in combination with the half-face system the time required for 1 cut is 30 min. The other time is needed for advancing the drives in the gates. The designed speed of the EDW170 is 30 ft/min, that means it theoretically can cut 1300 t/day at a seam height of 84 inches. A 22mm chain is in use for shearer haulage.

B. Roof Support

Dowty chocks with 4 double telescopic legs were in use. This type of roof support is designed for a working height ranging from 42 to 87 inches. When operating the chocks with a pressure of 2500 psi they reach a setting load of 58 tons in the lower stage and 39 tons in the top stage of each leg. The designed yielding load is 112 tons for each leg. Canopies are of single unit design with adjustable cantilevers. Total length of the canopies and cantilevers is 175 3/4 inches. Two Dowty pumps working at a pressure of 2250 psi and a capacity of 20 gal/min provide the hydraulic circuit of the chocks.

Cracks of 2 inches in the roof along the whole face were observed due to high pressure from the roof. These cracks were insignificant to the winning procedure.

The rams for moving the conveyor are Dowty made. They are operated with a pressure of 2250 psi, thus providing a pushing strength of 7.5 ton and a pulling strength of 12 ton. The stroke is 32 inches which is 2 inches more than the width of the drum. Spaced at 5-foot centers, they are interconnected in groups of three. When pushing, groups of 3 are always operated.

In the headgate the roof is supported by roof bolts with steel mats at 5-foot centers and a few additional single hydraulic props ahead of the face. Behind the tail of the stage loader one row of cribs is installed at 9-foot centers. The tailgate is supported by two rows of cribs on each side of the gate.

C. Conveyors

The face conveyor was a single-chain conveyor (EKF3) of Eickhoff with a width of 30 inches and spillplates 15 inches high. It is powered by one 125 hp motor each at the head and tailgate arranged parallel to the panline on the gobside. The electric motors are protected by Voith fluid couplings. The chain diameter is 30mm, flights are spaced at 3-foot centers. Running with a speed of 212 ft/min the conveyor has a capacity of 10 t/min. Alignment of the face is done visually.

Phones are installed every 90 ft along the face. Conveyor can be stopped from any place by means of a wire spanned parallel to the conveyor which switches off the motor. Switching on is only possible at the headgate.

The stage loader is also of the EKF3 design. It is powered by a 125 hp motor. The only difference is the distance between the flights which are mounted on 1 1/2-foot centers.

IV. CREW

Production is gained in three shifts without a repair shift. Repair work and maintenance is done during or between shifts or on weekends. Total crew consists of 30 men. That means 10 men per shift with:

1 foreman
1 mechanic
2 shearer operators
2 chockers
1 snaker
1 headgate man
2 tailgate men

Actual working time is 360 min/shift, that means 1080 min/day.

Federal No. 2, 7th Right
Eastern Associated Coal Corporation
Grant Town, West Virginia

Survey Report No. S-6
Survey Date: Aug 6, 1974

The Federal No. 2 Mine has had experience in longwall mining since November, 1973. The visited longwall is the first panel. There was a labor strike at the time of the visit so the face was not in operation.

I. GEOLOGICAL CONDITIONS

Detailed information could not be obtained from the mine management. Excellent geological conditions with good caving behavior of the roof were observed. The roof caved in small pieces immediately behind the chocks. Roof and floor were harder than coal. The Pittsburgh seam was being mined. This seam usually has a thickness of 84 inches in this area. Overburden was between 750 and 1150 feet thick.

II. OPERATIONS

Information about productivity of the face could not be obtained from the mine manager. The half-face technique is in use. Face width is reportedly 450 ft. One cut takes 35 minutes.

III. LONGWALL EQUIPMENT

A. Winning Machine

The face is equipped with a Sagem DTS-300 double drum ranging shearer designed to operate in seams 55 to 118 inches thick. The Sagem DTS-300 is different from other shearers. The hydraulic winch forms the central part of the machine. At each end of the winch a 230 hp electro-mechanical assembly provides power to the drums. Each assembly is linked to the winch by a central control unit. The haulage speed is infinitely variable between 0 and 60 ft/min, but a selector system also provides intermediate regulation in three speed ranges. Headgate drum rotates at 67 rpm, tailgate drum at 55 rpm. The drums are 56 inches in diameter by 28 inches wide.

B. Roof Support

'ig. -11 Westfalia (Mining Progress) heavy duty 4-leg chocks, type B2-1 were in use. These chocks are designed for a seam height ranging from 56 1/2 inches to an extended height of 88 inches. Operating the pumps with a setting pressure of 3000 psi, a setting load of 52 t/leg is reached. Yielding load is 115 t/leg at a pressure of 7250 psi. A solid rear canopy and two articulated front headers insure good roof contact. Chocks are adjacently controlled. Lowering of the chocks is achieved by a second low-pressure hydraulic circuit of 800 psi working permanently against the yielding pressure. Rams for pulling the chocks and pushing the conveyor are operated by the same pressure of 3000 psi like the chocks. When pushing only every 3rd ram is operated manually at a force of 10 tons. When pulling they reach a force of 14 tons. Two 3-plunger Woma high pressure pumps of 30 gal/min provide the hydraulic circuit. The low pressure pump, also a 3-plunger pump, is driven by the high pressure pump over a reduction gear.

C. Conveyors

The face conveyor was an 18mm triple-chain conveyor (MIV-600) of Mining Progress with a width of 23 3/4 inches and spillplates 28 inches high. One 125 hp motor is arranged parallel to the panline on the gobside at the headgate and one 75 hp motor arranged in the same way on the tailgate end power the conveyor. Running with a speed of 212 ft/min the conveyor has a capacity of 19 t/min. A shuttle plow does the last clean up when advancing the conveyor.

The stage loader is also a MIV-600 of Mining Progress, but has 18mm double chains. It is powered by a 125 hp motor. Flights are arranged at 1 1/2-foot centers.

IV. CREW

Normally, production is on 2 1/2 shifts, night shift is partly used for production and maintenance work as well. The total crew consists of 35 men. No. 1 production shift consists of:

1 foreman
2 shearer operators
3 chockers
1 headgate man
3 timbermen
2 roaddusters
1 mechanic

No. 2 production shift works with the same team except the 3 timbermen. No. 3 shift consists of:

1 foreman
1 mechanic
1 greaser
2 shearer operators
3 chockers
1 headgate - cornerman

Delmont Mine, 5th Right Panel
Eastern Associated Coal Corporation
Hunkar, Pennsylvania

Survey Report No. S-7
Survey Date: Aug. 9, 1974

The Delmont Mine has had experience with the longwall system since 1969. The 5th right panel was observed. Longwall mining of this panel was started in April, 1974.

I. GEOLOGICAL CONDITIONS

The Freeport seam has an average thickness of 64 inches and is lying nearly flat. The roof was not uniform and flat, therefore, the thickness of the seam ranged from 50 to 70 inches. To get a uniform roof, up to 25 inches of top coal were left. When the thickness of the seam decreased below 50 inches, the roof was cut with the shearer to allow an equal amount of open space for the chocks. The seam itself was very clean. Bedding planes were seen. The orientation of the cleats was nearly parallel to the face. Their inclination was about 90°. The seam was softer than the roof and the floor.

The roof was very different along the face. Sandy shale was found and very hard sandstone as well. In the area of the sandy shale there was a covering of the same hard sandstone. Due to this the caving of the roof was very different. Sometimes the roof caved immediately behind the chocks and sometimes only the first 4 or 5 feet of the immediate roof caved, whereas the main roof hung over up to 50 feet before caving. The main roof always caved in very big pieces so pressure on the chocks varied considerably. Bedding planes and cleats could not be observed in the roof.

The floor was limestone. The overburden was 560 ft thick. Temperature in the mine was 63°F.

II. OPERATIONS

The retreating face had a length of about 400 feet and had an average production of 1200 t/day. The maximum ever reached in this face was about 1600 t/day. The average advance per day was 20 feet. For every advance of the equipment two cuts were made with the single drum shearer.

III. LONGWALL EQUIPMENT

A. Winning Machine

A single drum shearer made by British Jeffrey Diamond with a drive unit of 170 hp was in use. The drum diameter was 44 inches, width was 26 inches. A cowl was in use. Water sprays were located alongside the machine. There was no ranging arm. For adjusting the drum the machine was lifted by hydraulic lifting jacks (up to 9 inches). The shearer was out of date but it was working without difficulties because of an intensive maintenance program.

B. Roof Support

Dowty 6-leg chocks were in use, with a yielding load of 60 t/leg. The working height of the chocks was between 37 and 52 inches. This was another reason for leaving top coal in the face when the thickness was greater than 50 inches.

The supports had been in use for many years but were in very good condition because of an intensive maintenance program. The roof with its bad caving behavior was sufficiently supported and no difficulties were observed in the operation of this equipment. The emulsion pumps were working with a pressure of about 1800 psi. The good conditions in the longwall were the consequence of the good conditions of the powered roof support and the fact that the top coal was hard enough to be a good roof and did not cave between the supports. No bedding planes were observed between coal and roof.

C. Conveyors

The shearer was running on a triple chain conveyor constructed by Huwood Irwin. The conveyor width was 32 inches and it had brackets 15 inches high. Two 60 hp motors at the main gate and one 60 hp motor at the tailgate were in use. They were all equipped with a fluid coupling.

IV. CREW

There were two winning shifts per day and one for maintenance and repairing. The winning shifts had 8 men:

1 foreman
1 mechanic
1 shearer operator
2 chockmen
1 pusher for the conveyor
1 cornerman at tailgate
1 cornerman at headgate.

On the maintenance shift there were:

1 foreman
2 or 3 mechanics

The working time at the face was 390 min/day.

Lancashire No. 24D
Barnes & Tucker Corporation
Keantown, Pennsylvania

Survey Report No. S-8
Survey Date: Aug.13, 1974

The Lancashire 24D Mine has been working with the longwall system for 9 years. The mine now has two longwall faces in the same seam with the same type equipment.

I. GEOLOGICAL CONDITIONS

The seam is 42 inches thick and is flat lying. A bedding plane was observed 7 inches below the roof. There was no bedding plane between seam and roof. The cleats had an inclination of 90° and orientation about 45° to the face running to the maingate. The roof and the floor were harder than the seam.

The roof was a uniform hard shale. Bedding planes in the roof were observed up to a height of 1 ft. Thereover a thin seam of about 1 1/2 ft thick was located. The roof did not cave before or between the chocks. The roof caved 3 to 9 feet behind the chocks. Water was coming from the roof. The floor was a hard shale and there were no difficulties with it, as with the roof. The overburden was about 350 ft thick. Mine temperature was 68°F.

II. OPERATIONS

The length of the retreating face was 450 ft. Two cuts per advance were made. The average advance per day had been about 20 ft. Time required for one cut was about 30 minutes. The average production was less than 1000 t/day. Maximum production reached was 2000 t/day for one day.

III. LONGWALL EQUIPMENT

A. Winning Machine

The winning machine was an Eickhoff Shearer (EW 130L) with a single drum. The diameter of the drum was 40 inches, width 30 inches, rpm was 60, and the drive unit had 180 hp. The diameter of the haulage chain was 18mm. For dust suppression water nozzles were located on the machine. The shearer was working bi-directional with removable cleaning shields at each side of the drum. The drum could be lifted by a hydraulic ranging arm. The maximum speed of the machine was 18 ft/min. The automatic speed control had been removed because the management saw no chance to train the mechanics so they could understand the system.

B. Roof Support

ig. -12 Gullick 5-leg chocks were in use. The setting pressure of the legs was about 1500 psi and the yielding pressure was 6000 psi. The setting load was 10 t/leg. The yielding load was 40 t/leg. The chocks had one double unit canopy. Four legs were supporting the rear and one the front part of the roof support. Both parts were connected by a link for getting better contact to the roof. The legs of the chocks were double acting and a "one hand" operated control valve was in use.

Due to many leakages in the hydraulic system and the water out of the roof, the face was very wet.

The rams for moving the conveyor were built by Gullick. They were working with the same pressure as the chocks. Their power was 5 ton pulling and 7 ton pushing.

C. Conveyors

The conveyors in the face and in the maingate were constructed by Meco. They had a width of 30 inches and the brackets were 10 inches high. The face conveyor had two 125 hp motors at the maingate end. It was equipped with a static ramp. The stage conveyor had a 50 hp motor. The face conveyor had two 18mm chains. The stage conveyor had three chains of the same strength.

IV. CREW

The working time at the face was nearly 370 minutes. The 3 shifts were all winning shifts (7:00 am, 15 pm, 23 pm). Repairs and maintenance were made between and during the winning shifts. Greater repairs were made on Sundays. Usually the longwall was operated 6 days a week. There was a total crew of 30. Each crew consisted of:

1 foreman
1 mechanic
1 shearer operator
2 chockmen
1 snaker
2 headgate men
2 tailgate men

Cambria Slope No. 33
Bethlehem Steel Corporation
Ebensburg, Pennsylvania

Survey Report No. S-9
Survey Date: Aug. 15, 1974

The Cambria Slope No. 33 was founded in 1962. The longwall mining system has been in action for 9 years. The observed longwall was started in March, 1974.

I. GEOLOGICAL CONDITIONS

The "B" seam was about 52 inches thick. The seam varied in thickness because the roof was not equal and flat. Top coal was left when the thickness was higher than 52 inches. The cleats had an inclination of about 70° to the face and their orientation was 30 to 35° to the face running to the tailgate. The spacing of the cleats was less than one inch. The seam was softer than roof and floor.

The roof changed from shale in the maingate area to a sandy shale and finally to a hard sandstone in the tailgate area. Therefore, the caving behavior of the roof was different but never caved in a bad way hanging over more than 15 ft. Caving in front of the chocks or between the canopies was not observed. Very typical bedding planes were seen in the roof but not between roof and coal. The floor consisted of an equal and flat-lying limestone. The overburden was about 500 ft thick. Mine temperature was 63°F.

II. OPERATIONS

The average production of the 585-ft long retreating longwall face in recent months was more than 5000 t/day; on good running days 6000 to 7000 t/day and one time 9000 t/day was reached. The advance per day was an average of 50 ft.

The shearer was cutting full cuts. The time required for one cut was about 25 minutes. At the tailgate end of the face the new cut was started without a loop. The drum of the shearer left the face before starting the new cut. At the main gate only a very short loop of 3 or 4 feet was made with the shearer.

III. LONGWALL EQUIPMENT

A. Winning Machine

An Anderson Mavor single drum shearer was used as a winning machine. The haulage rope had a diameter of 7/8 inch and the motor had 270 hp. The shearer had no ranging arm. Drum adjustment was by hydraulic jacks. Diameter of the drum was 52 inches, the width 30 inches, and rpm was 60. A cowl was in use and the conveyor was equipped with a static ramp. Spray bars were mounted on the machine for dust suppression. Machine maximum speed was 27 ft/min.

B. Roof Support

Dowty 4-leg chocks were in use with single unit canopies. The legs had a yielding load of 43 tons and a setting load of 15 tons. Working pressure was 1600 psi. The chocks were operated "one web back" of the conveyor. In one area where the roof was not reliable the chocks were drawn close to the conveyor. The hydraulic pumps were Dowty made as well. The capacity at a pressure of 1600 to 2000 psi was 20 gal/min. The relatively low yielding load of the support was sufficient because the roof was in a very good condition and caved very good behind the support.

The rams for pushing the conveyor and pulling the chocks were Dowty made.

C. Conveyors

A Huwood triple-chain conveyor was in use with an 18mm chain. The conveyor pans were 4 ft 11 inches long and 27 inches wide. The spacing of the flights was 1 1/2 ft. At each end of the face, 150 hp motors were installed. The speed of the conveyor was 212 ft/min.

VI. CREW

The working time at the face was 390 min. There were three winning shifts per day but no special maintenance shift was in operation. Repairing and maintenance was done during the winning shifts and on the weekends. The preventive maintenance on the shearer was done on the morning shift when the face conveyor was aligned by the snaker.

The three shifts had:

2 men at the headgate
1 man at the tailgate
3 chockmen
1 snaker
1 shearer operator
2 mechanics and 1 foreman

Pike Mine No. 26
Beth-Elkhorn Corp.
Jenkins, Kentucky

Survey Report No. S-10
Survey Date: August 26, 1974

The Pike Mine No. 26 was founded in 1969 and has been working with the longwall system since 1973. The total production of the mine today is 4200 t/day. The observed longwall face started on March 28, 1974.

I. GEOLOGICAL CONDITIONS

The Elkhorn No. 2 seam was 48 inches thick but 5 inches of the top, up to a bedding plane, came down. So the height of the face was about 53 inches. It is flat-lying. The cleats had an orientation of 75° from the face running to the maingate. Their inclination was nearly 90°. The distance between the cleats was less than 1/2 inch. Bedding planes could be seen in the shale areas but not between coal and roof and not in the sandstone area. Both top and bottom were harder than the coal. The coal hardness was about 48 HGI.

The roof changes from a black shale to a sandy shale and to a hard sandstone. This hard sandstone is always found above the shale.

The floor consisted of a soft soapstone and beyond that a soft fireclay. In the area now being mined, the seam is at a depth of about 1050 feet.

II. OPERATIONS

The retreating longwall had a length of 550 feet and the production average was 3000 t/day. The maximum ever reached was 5600 t/day and 2500 t/shift. The advance of the face, on the average, was about 36 feet. (For a production of 5600 t/day an advance of 67 feet was necessary.) The machine was working with the full-cut system. The top coal and 5 inches of the black shale fell down without being cut by the shearer.

Telephones were installed every 25 feet for communication in the longwall and to the headgate and the tailgate men.

III. LONGWALL EQUIPMENT

A. Winning Machine

ig.
-8

An Anderson Boyd shearer, type AB16, was in use as a winning machine. This type machine is bi-directional with a single drum. The drum diameter was 45 inches; width 30 inches. It was adjustable by hydraulic jacks which lifted the whole machine. The shearer was equipped with a cowl. Water sprays were located in the drum and on the machine. The winch pulled the shearer with a 7/8 inch rope. The drive unit had 270 hp and it gave an average speed to the machine of about 15 ft/min. The maximum speed of the shearer was 38 ft/min.

B. Roof Support

Fig. A-13 Huwood Mastabar 4-leg chocks were in use. The yielding load of these chocks was 280 t. The setting load was about 100 t. The legs carried one single-unit canopy. The spacing between the chocks - center to center - was 49-1/2 inches. The chocks were operated by direct control and the men moving the chocks were under the wide canopy.

The caving behavior of the roof was good and it never hung over more than 6 feet. No caving in front of the support was observed. Between the chocks the roof sometimes caved up to 10 inches high.

Two Gullick pumps were installed in the maingate. They were working with a pressure of 1500 psi. They had a capacity of 12 gal/min each and they were working parallel to get a greater capacity.

Huwood-Irwin rams with a stroke of 30 inches were in use.

C. Conveyors

A Meco conveyor with a width of 30 inches was in use at the face and at the tailgate as well. The face conveyor had a drive with a 150 hp motor at each end. The stage loader had a 75 hp motor. Both conveyors were equipped with double chains with a diameter of 18 mm. The speed of the face conveyor was 180 ft/min. The speed of the stage loader was 212 ft/min. The spacing of the flights was 2 feet. Spill-plates were installed 15 inches high alongside the conveyors. The shearer haulage rope was used to align the face conveyor. The static ramps were modified by shimming them 3/8 inch to keep the conveyor from climbing on the fine coal.

VI. CREW

Working time at the longwall was 390 min/shift and 1170 min/day. Three winning shifts and no special maintenance shift were in operation. Every winning shift had:

1 foreman
1 headgate - cornerman
1 tailgate - cornerman
3 chock operators
1 shearer operator
1 snaker
2 mechanics

Gary Mine No. 9
U.S. Steel Corporation
Gary, West Virginia

Survey Report No. P-1
Survey Date: Aug. 27, 1974

The Gary Mine No. 9 started with longwall mining in September 1971. The observed longwall was started in January, 1974.

I. GEOLOGICAL CONDITIONS

The geological profile immediately above the seam was as follows:

Pocahontas No. 4 Seam (mined out with room & pillar system)
Heavy Sandstone - 20 to 30 ft
Sandy Shale - 20 ft
Clod Shale - 0 to 8 ft
Pocahontas No. 3 Seam (now being mined)

The pillars left in the Pocahontas No. 4 seam are causing difficulties in mining the No. 3 seam because high-pressure zones under the pillars change to low-pressure zones under the rooms.

The seam is 44 inches thick and dips 6°. The roof was not equal over the panel so that the thickness of the seam changed. Sometimes two or three inches of the roof were cut with the plow to get the height needed by the frames. Spacing of the cleats was less than one inch. Their orientation was about 30° to the face, running to the headgate and their inclination was 90°.

The floor was a shale not much harder than the seam. In the area being mined the overburden was about 650 ft thick. Temperature in the mine was 68°F.

II. OPERATIONS

The retreating longwall face was 342 ft long and had an average production of 1000 t/day. Maximum production was 2710 t/day. The average daily advance of the face was nearly 40 ft. The maximum advance was 67 ft/day.

The geological conditions in the tailgate made it necessary to place the tailgate drive in the face end. The plow could not cut the whole face at that end so a 3-ft stable hole was made by blasting and loading by hand. At the headgate end of the face, the plow was drawn out of the face before the drive was advanced. A stable at this end of the face was not necessary.

A telephone was installed every 40 ft in the face and at the drives of the face conveyor.

III. LONGWALL EQUIPMENT

A. Winning Machine

A Westfalia plow 45 inches high was in use as a winning machine. The plow was a modified S2 type built only for this mine. Two drives of 75 hp each gave it a speed of 88 ft/min. The diameter of the chain was 22mm. Depth of cut varied between 2 and 3 1/2 inches. Capacity of the plow was approximately 1,350 t/hour.

B. Roof Support

A 4-leg frame of Westfalia (Type K13A) was used. The yielding load of these frames was 560 tons. The setting load, working with a pump pressure of 2500 psi is about 50 percent of the yielding load. The spacing between the center of the supports was 4 1/2 ft. The yielding power was 9.4 Mp/sq ft. Each of the four legs supported one part of the two double-unit canopies.

Two hydraulic pumps were installed in the maingate to provide the support with the hydraulic oil. They were working with a pressure of 2500 psi and had a capacity of 32 gal/min each.

Rams for advancing the face conveyor were not in use. The conveyor was moved by the frames and pieces of wood between frames and conveyor.

C. Conveyors

Westfalia triple-chain conveyors (Type PFI, MIV-600) were installed at the face and headgate. They were equipped with 24 inch high spillplates. A 125 hp motor drew the 18mm chain of the face conveyor. A Westfalia gearbox with a fluid coupling was installed. The speed of the face conveyor was 220 ft/min, and that of the stage loader was 280 ft/min. The capacity of the face conveyor was about 27 t/min, that of the stage loader was about 34 t/min. All figures about the capacities of plow and conveyor are average figures. For operating the longwall fluently it is very important to have the speed of the plow in accordance to the speed of the conveyor.

IV. CREW

Working time at the face was 390 min/shift and 1170 min/day. Two winning shifts and one maintenance shift were in operation every day. The winning shifts had:

- 1 foreman
- 6 frame operators & snakers
- 2 headgate - cornermen
- 2 tailgate - cornermen
- 1 mechanic

The maintenance shift usually had:

- 1 supervisor
- 4 mechanics

Kopperston No. 1, Eagle Seam
Eastern Associated Coal Corp.
Kopperston, West Virginia

Survey Report No. P-2
Survey Date: Aug. 29, 1974

The longwall mining system has been used in the Kopperston Mine since 1962. The average production of clean coal from the mine is about 4700 t/day. The observed longwall was started in January, 1974.

I. GEOLOGICAL CONDITIONS

The seam was 56 inches thick. In the lower part of the seam the coal was hard, but not so hard that it could not be planed. The cleats had an inclination of nearly 80° to the face and their orientation was about 10° to the maingate. Spacing of the cleats was less than one inch.

The roof of the seam changed from sandy shale to clay shale. Typical bedding planes were observed in the roof at a distance of about 12 inches and 30 inches. Often the location of these bedding planes changes.

The floor was an equal and flat-lying fireclay. The overburden in this area was about 800 to 1000 feet.

II. OPERATIONS

The retreating face was 600 ft long. In the last few weeks the average production of the retreating longwall face was about 1800 t/day. On good running days a production of nearly 2200 t/day or 1100 t/shift was reached. The average daily advance was about 10 ft.

Coal was planed by long drafts except for the corners of the face. At the corners the plow shuttled as long as the gearheads (drive units) were snaked (moved) over. The plow could run out of the face into the tailgate because of a specially constructed tail-end drive. A stable was not necessary. At the main-end drive the plow could not reach the main gate by about 1 1/2 ft. The crushed coal was pushed out by the plow. There was no stable at the main gate.

Because of the change of the bedding planes there were small to large local cavities. At these cavities it was sometimes necessary to put timber on the roof bars.

III. LONGWALL EQUIPMENT

A. Winning Machine

The winning machine was a Westfalia guide-plank plow of Mining Progress Inc. Heavy rectangular "plank" guides at the face side of the conveyor replaced the tubes. A large, three-part base-plate stabilized the plow. The plow body was of the S3 type. The height was adjustable by extension blocks. In this face the height was 50 inches. The 26mm haulage chain ran free on the face side of the conveyor. It was driven through two K27 gearboxes. The drives were powered by 150 hp motors. Plow speed could be selected, but this possibility was not used. The plow ran with one speed of 120 ft/min. It was controlled by the head-end operator. When it reached the tail-end drive it was stopped by a tail-end operator. The dust suppression was accomplished by water nozzles mounted on the conveyor spillplate. The drive unit construction made it possible to plane without a stable at the tail-end.

B. Roof Support

The longwall was supported by an older Mining Progress, Inc. heavy duty frame support, type A-K-2. The frames were generally set at 59 inch centers. The yielding load was 560 tons, the setting load 320 tons. The jacks were double acting for rapid and positive lowering. The operations were controlled by a semi-adjacent control system. Working pressure was 3,000 psi. The hydraulic pumps were WOMA made. The anchor chocks at the face ends provided efficient roof control at the critical face end areas.

The rams for pushing the conveyor and the plow were made by Mining Progress, Inc. They worked with a pressure of 500 to 700 psi at a distance of 15 ft, direct control, and were not interconnected to groups. The head-end and tail-end drives of conveyor and plow are firmly anchored between roof and floor. Two anchor chocks fulfilled this function at each end of the face. They are equipped with tension rams to correct for conveyor creep. Each tension ram is capable of moving the entire panline in either direction.

C. Conveyors

The face conveyor was a triple-chain conveyor (18mm) of Mining Progress, Inc. (MIV-600) type with manganese steel ended pans. The chain had a strength of 30 ton and a speed of 213 ft/min. The face conveyor was driven by two S27 VES gearboxes. The electric motors were protected by fluid couplings. Whereas the head drive was powered by a 175 hp motor, the tailgate was powered by a 75 hp motor. The height of the brackets was 36 inches. At the end of the conveyor there was a hole in the deck plate to get out fine coal from the bottom race. Much fine coal came into the bottom race because the height between the face conveyor and the intermediate conveyor was very small. Therefore, the conveyor had sometimes gone solid. The height between these conveyors should be as big as possible. Further, the unit drive of the face conveyor should be kept as far as possible over the intermediate conveyor.

IV. CREW

The working time at the face was 380 min/shift and 1140 min/day. This includes special time for repair and maintenance. The two winning shifts had:

- 2 men at the headgate
- 2 men at the tailgate
- 6 jack setters
- 1 plow and conveyor operator
- 1 mechanic and 1 foreman
- 4 men and 1 foreman on the maintenance shift

Altogether 31 men were engaged.

Pocahontas No. 3, 2nd Panel, 5th South
Island Creek Coal Company
Keene Mt., Virginia

Survey Report No. P-3
Survey Date: Aug. 30, 1974

The Pocahontas No. 3 is working in the Pocahontas No. 3 seam and has a coal reserve of 40 years. Longwall mining in this mine has been carried out for two years and this particular face started May 5, 1974.

I. GEOLOGICAL CONDITIONS

The Pocahontas No. 3 seam averages 60 inches in thickness. The coal bed is rather soft and has several distinct bedding planes. There are two shale bands in the seam; one in the upper part of the seam with a thickness of one-half inch and the other four inches above the floor with a thickness of four inches. The cleats have an inclination of 90°, an orientation of about 80° to the face running to the the tailgate and have a spacing of less than half an inch.

The immediate roof varies from shale to sandy shale and finally to sandstone at the tailgate and gives distinct parting to the seam. The thickness of both of these strata in the headgate area is about 30 inches, however, shale diminishes around the middle of the face and sandy shale reduces in thickness to 18 inches and continues to do so, finally becoming zero inches and leaving the immediate roof position to sandstone. The caving characteristic of the roof varies in accordance with the change of the roof strata. Around the headgate area the roof caves immediately after advancing the roof supports. However, it hangs like a cantilever with an increase in length toward the tailgate where it hangs over about 30 feet and caves in a rather blocky form.

The floor of the seam was relatively flat-lying sandy shale. The total overburden was about 1200 feet.

II. OPERATIONS

The length of the retreating face is 450 feet. The average production is 2200 t/day. The maximum production was 2700 t/day.

The coal was cut bi-directionally with a depth of 3 inches along the face and plowed onto the conveyor with a minimum degradation which is important in methane liberation and dust production. The plow was able to cut the whole face so a stable hole was not necessary. The plow shuttled at each end while the drive units were advanced. The extracted coal was not uniform, which is not unusual for the plow operation. Sometimes sudden pressure of the roof produced or aided to produce big chunks which required crushing. The crushing was done by manpower with the use of sledge hammers.

III. LONGWALL EQUIPMENT

A. Winning Machine

As a winning machine a Westfalia hook plow (Type 3S) of Mining Progress, Inc. was in use. The plow was powered by two electric motors having a continuous rating of 125 hp at each end. The cutting and loading components of the plow are arranged on an articulated base that slides under the conveyor. The 26 x 92mm haulage chain is attached to the base on the gobside of the conveyor where it runs in covered guides. As drawbar pull is applied to the chain, the leverage to the plow bit causes the plow to penetrate the coal. Fragmentation occurs mostly along the cleats in the coal resulting in the production of rather large sizes, decreasing the dust and methane liberation.

The plow is arranged on a three-part base. The bottom bits are mounted on an adjustable segment which is presented to the coal in a rigid manner. This plow is equipped with adjustable loading head, with which the excavated coal is plowed onto the conveyor. It carries a floor cutter for rapid steering adjustment. Seam heights are accommodated by ranging top cutters.

The plow was remotely controlled from the corner. An end shut off switch was in use at both ends to keep the plow from running into the drive units and other equipment in the gates.

Dust suppression was accomplished by water spray nozzles mounted on the spillboards which started to spray water 20 feet ahead of the plow and stopped after the plow had passed.

The plow had three speeds but only the medium speed was used.

B. Roof Supports

ig. -14 The face roof was supported by Westfalia heavy duty Helvetia type double frame supports. Each unit had a double unit canopy which was the most effective on an irregular roof. They had 2 double acting legs with a yielding load of 140 t/leg and setting load of 40 t/leg. The frames had a maximum of 126 inch and a minimum of 54 1/2 inch heights. They were spaced 4 ft 11 inches center to center and had a direct control system.

The roof behavior was very good and caving between the canopies was about 2 percent. The working pressures to set and retract the frames were 2000 and 1000 psi respectively. These pressures were supplied by the Model MPPP-5 pumping station which was equipped with one 25-X and one Denison 900 series axial piston pump. The 900 series Denison pump was used to set the roof supports at the flow rate of 42 gpm. The pump could deliver a pressure up to 3000 psi but was set at 2000 psi. This pump is controlled by a sequence valve which delivers oil only as needed by the system.

The gear pump has two sections, both rated at 7.5 gpm. One section pumps to 1000 psi and is used for lowering the roof control supports and runs against a relief valve set at 1000 psi. The other section pumps to 200 psi and is used to operate the rams and cylinders used on the anchorage and belt tension system.

The rams for moving the conveyor were Westfalia made. They had a stroke of 36 inches and the working pressure was 200 psi.

C. Conveyors

The face was equipped with a Westfalia PFI, MIV-600 conveyor. The chain strings were triple and had a diameter of 18mm and a speed of 225 ft/min. The spacing of the flights was 3 ft. The spillboard had a height of 48 inches which was high enough to keep coal from spilling out of the conveyor. The conveyor was powered at both ends by two electric motors, each rating 125 hp. A Westfalia gearbox and fluid coupling were used.

At the face end strong anchorage was required for successful plowing. Here the beam-type anchorage is in use. This anchorage was able to prevent the buckling and jackknifing of the panline. The bottom beam was used as a guide while advancing the drive unit. At both ends of the beam anchorage a double prop unit was in use. These were supporting the roof at the same time. The hydraulic cylinders on the anchorage system were utilized to advance the anchorage units. A specially supported ram, which was mounted on a frame in the headgate, serves to advance the drive unit.

Lights were installed every 45 feet on the spillboard of the conveyor and also were being used as a means of giving signals for communication. Therefore, only 3 telephones were being used: one at the headgate, one at the tailgate and one in the middle of the face.

The conveyor was aligned visually.

The stage loader at the headgate was a Westfalia PFI type conveyor which was powered by a 125 hp motor. The distance of the flights was 1.5 feet and spillplates were 15 inches high. The crusher was designed and manufactured by the operating company and performed the task very well.

IV. CREW

The working time at the face was 400 min/shift or 1200 min/day. Daily maintenance is included in this working time.

The crews consisted of the following:

1 foreman
2 headgate men
2 tailgate men
6 jack setters
1 mechanic
1 plow-man

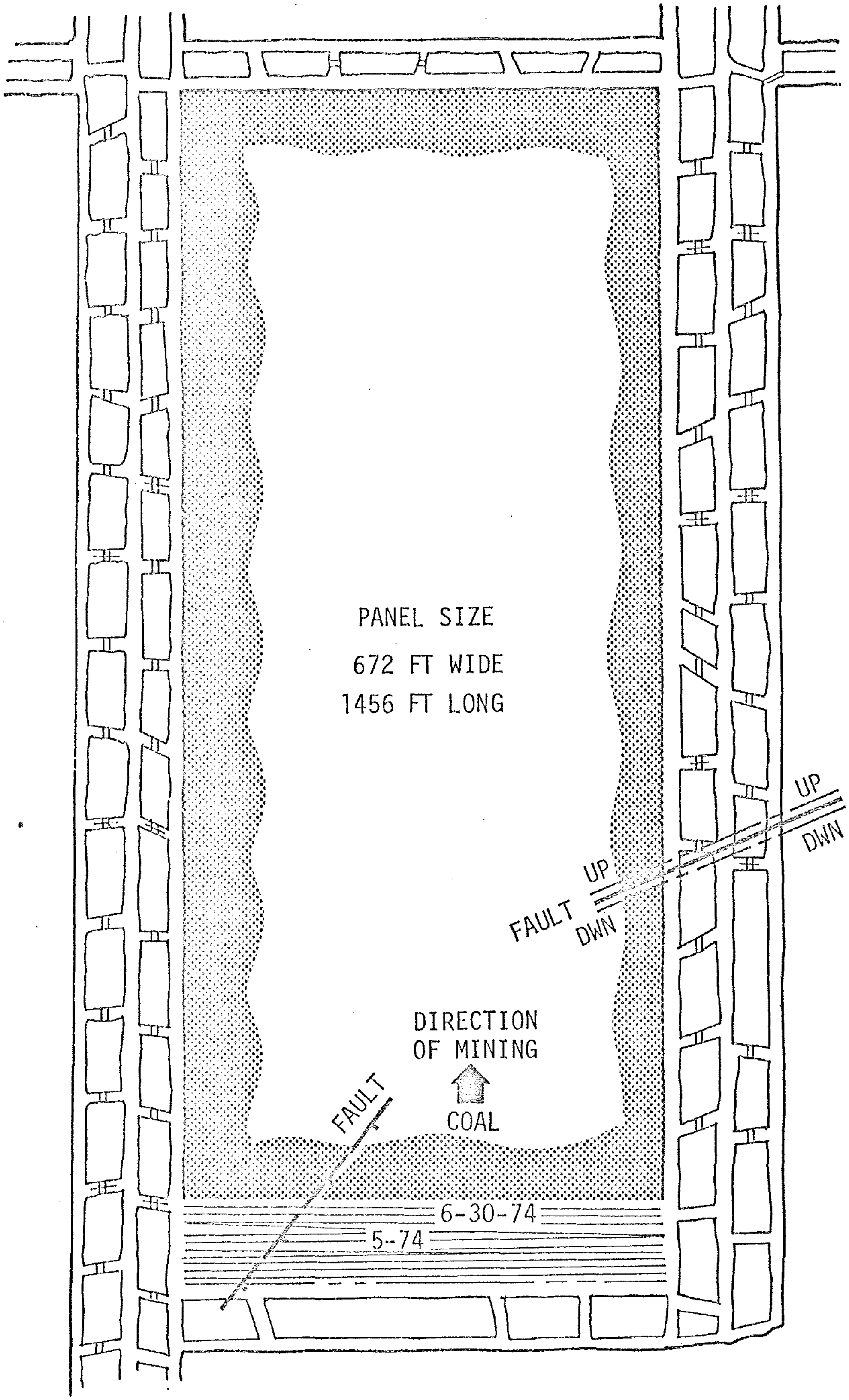


Figure A-1 Longwall Panel Layout - York Canyon Mine
(Survey Report No. S-1)

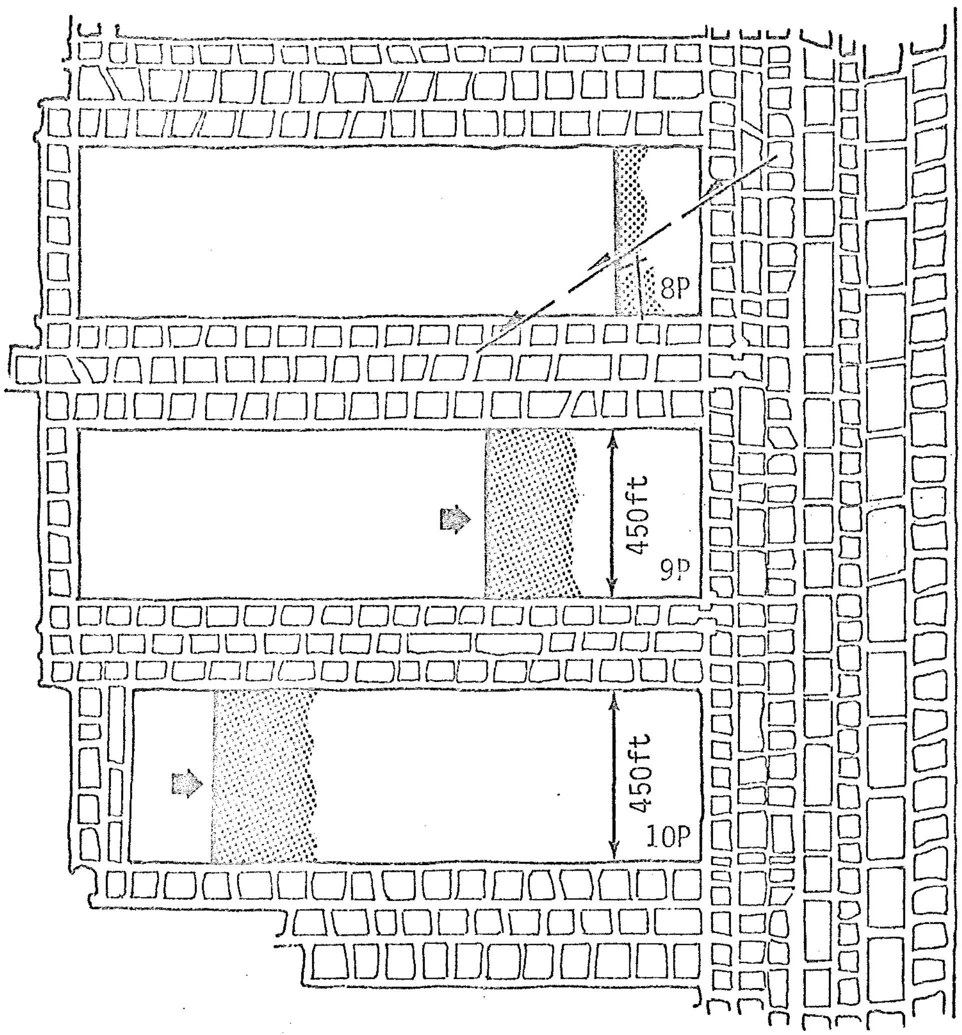


Figure A-2 Longwall Panel Layout; Allen Mine, 9th & 10th Panel
(Survey Report Nos. 2 & 3)

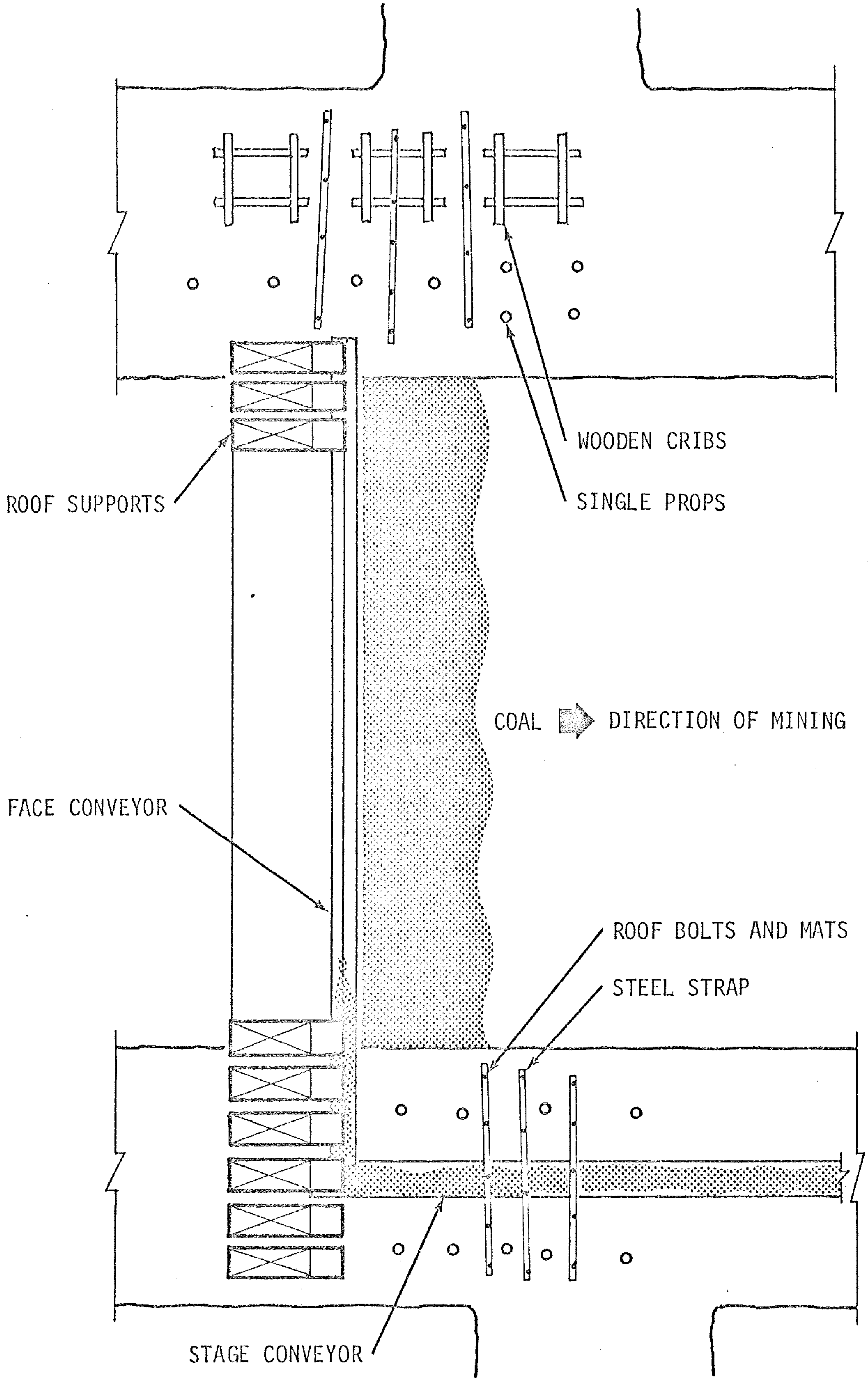


Figure A-3 Gate Supports Plan View; York Canyon Mine (Survey Report No. S-1)

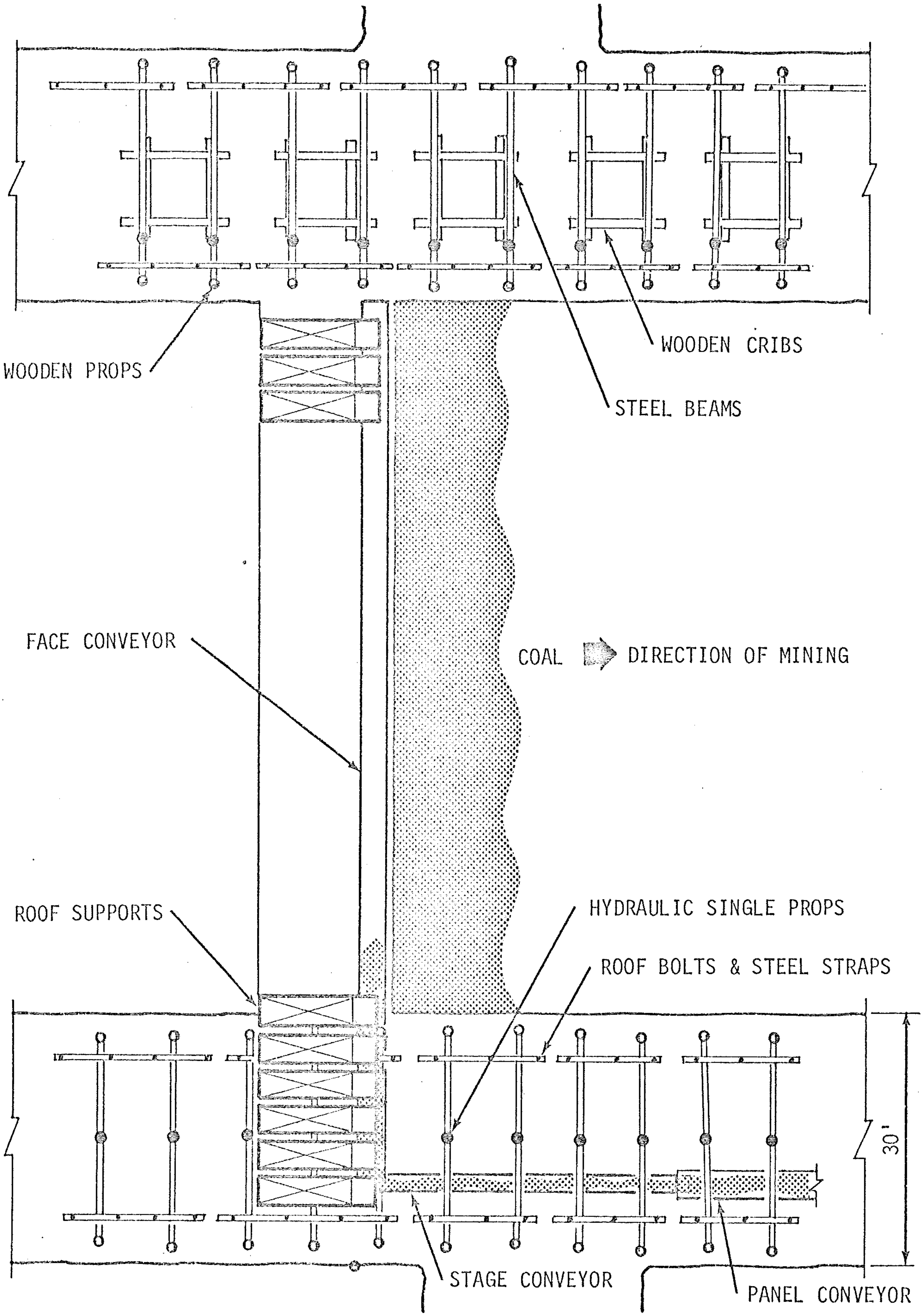


Figure A-4 Gate Supports Plan View - Allen Mine, 10th Panel (Survey Report No. S-3)

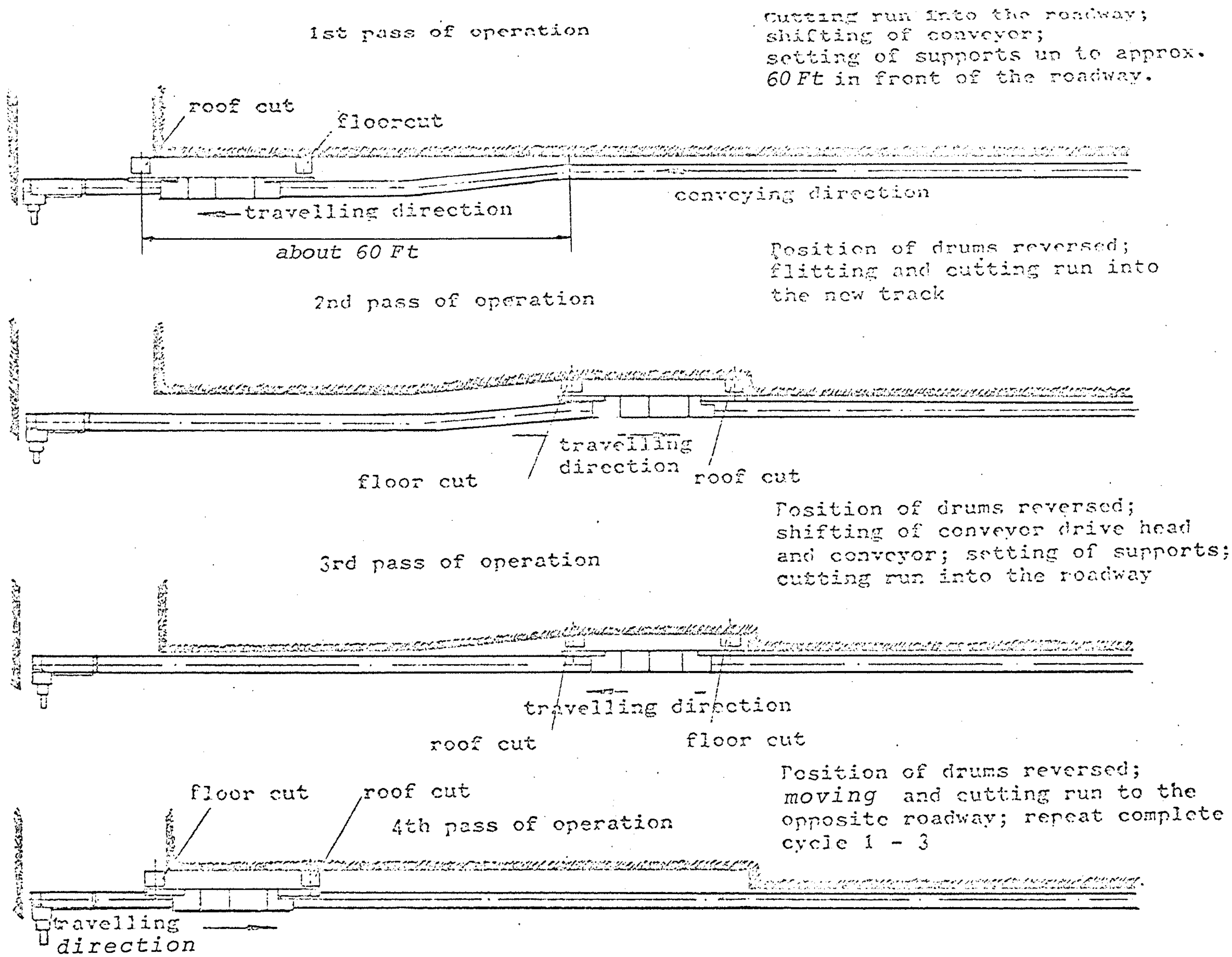
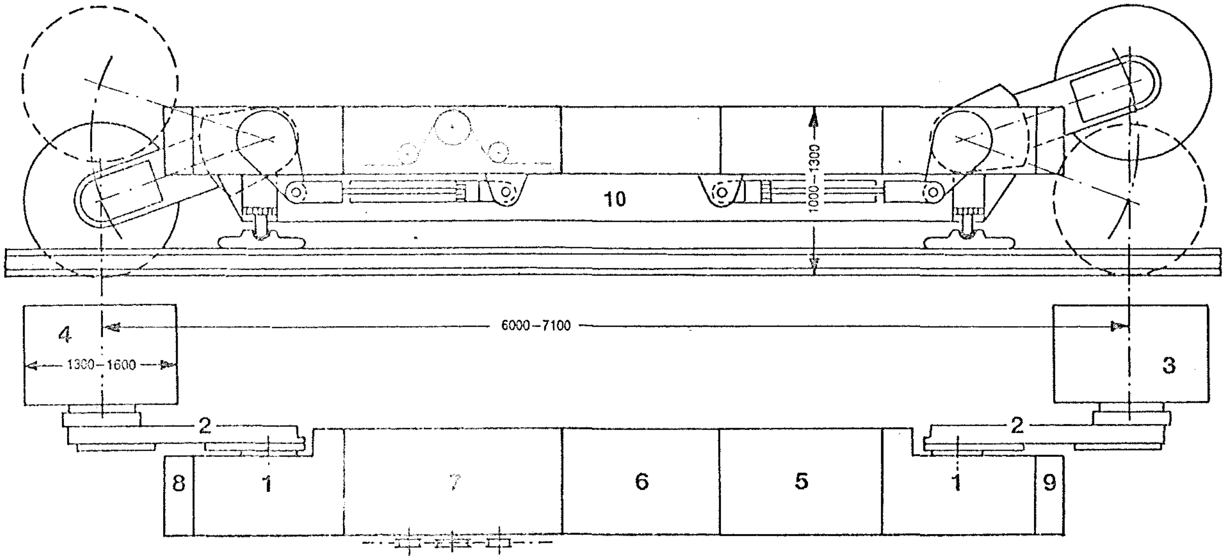
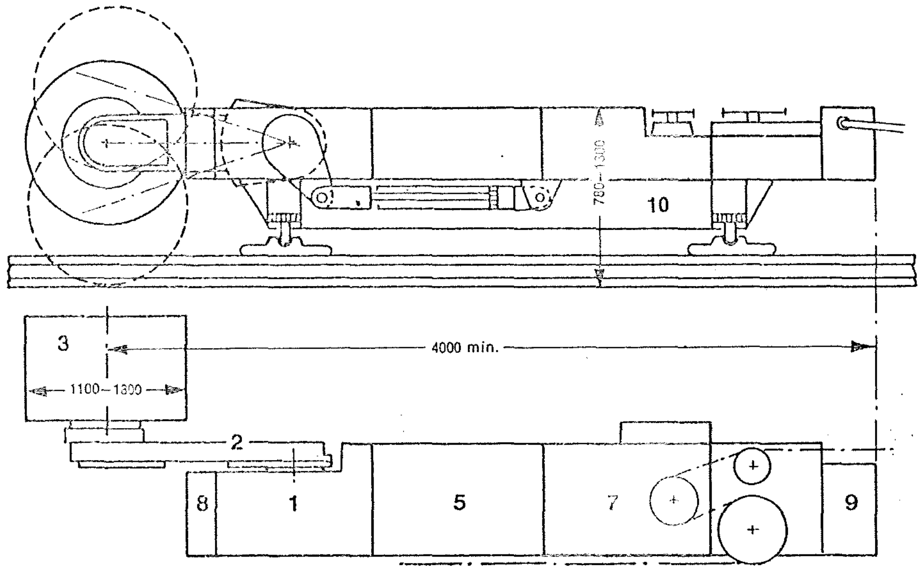


Figure A-5 Cutting Cycle; Allen Mine, 9th Panel
(Survey Report No. S-2)



1 GEARHEAD
2 RANGING ARM
3 SCREW DRUM, RIGHT-HAND HELIX
4 SCREW DRUM, LEFT-HAND HELIX
5 ELECTRIC MOTOR
6 CONTROL UNIT, CENTRE
7 EICOMATIK HAULAGE BOX
8 CONTROL UNIT, LEFT-HAND
9 CABLE ENTRY AND CONTROL UNIT, RIGHT-HAND
10 UNDERFRAME

Figure A-6 Double-Ended Ranging Shearer - Eickhoff EDW 170-L; Allen Mine, 9th Panel (Survey Report No. S-2)



1 GEARHEAD
2 RANGING ARM
3 SCREW DRUM, RIGHT-HAND OR LEFT HAND HELIX
5 ELECTRIC MOTOR
7 EICOMATIK HAULAGE BOX
8 CONTROL UNIT, LEFT-HAND
9 CABLE ENTRY AND CONTROL UNIT, RIGHT-HAND
10 UNDERFRAME

Figure A-7 Single-Ended Ranging Shearer; Eickhoff EW 170-L; Sunnyside Mine, 3rd Panel (Survey Report No. S-4)

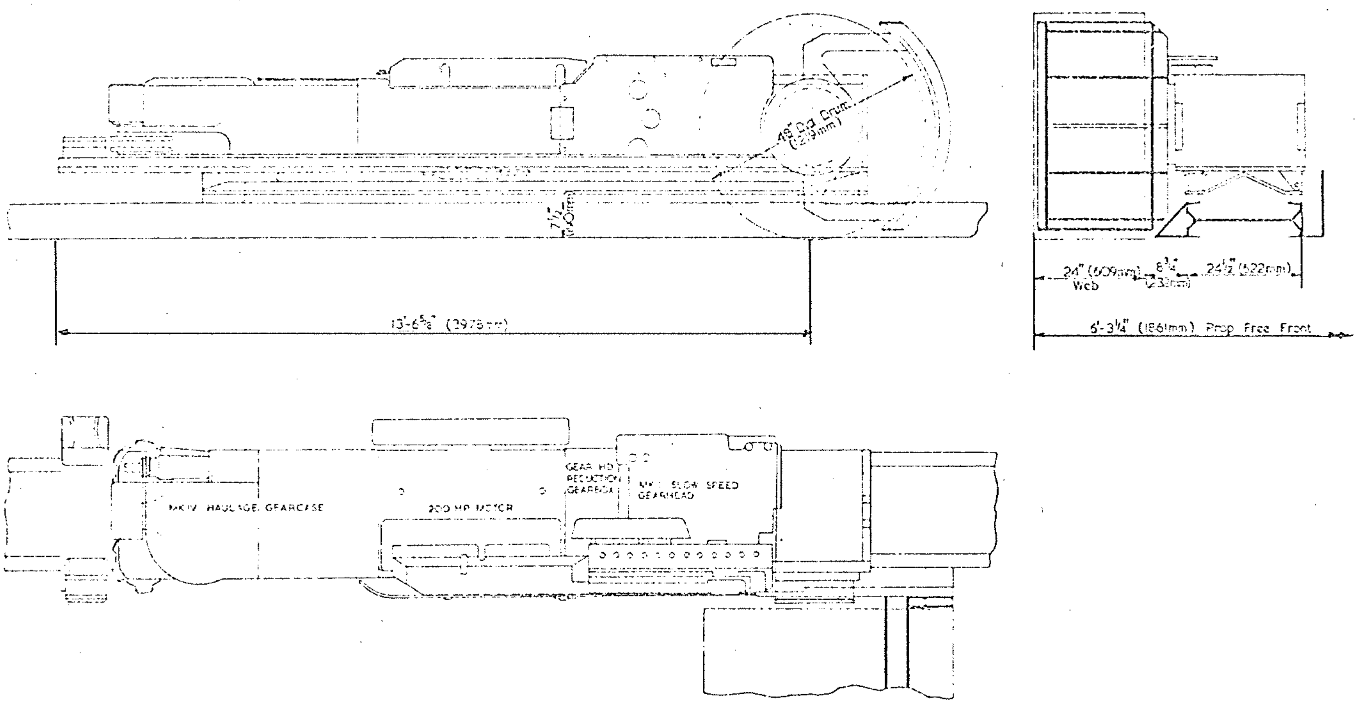


Figure A-8 Bidirectional Shearer Loader

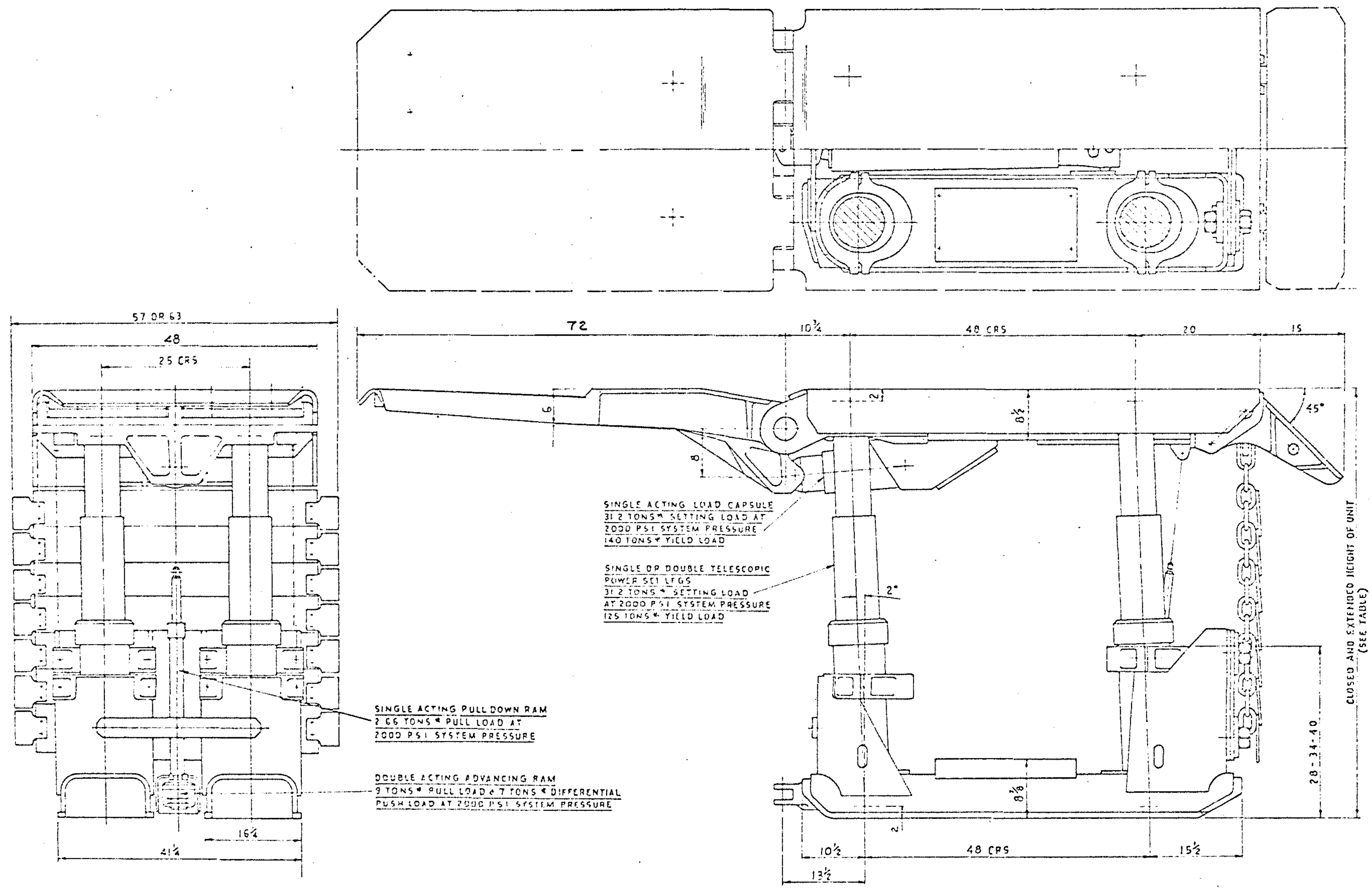
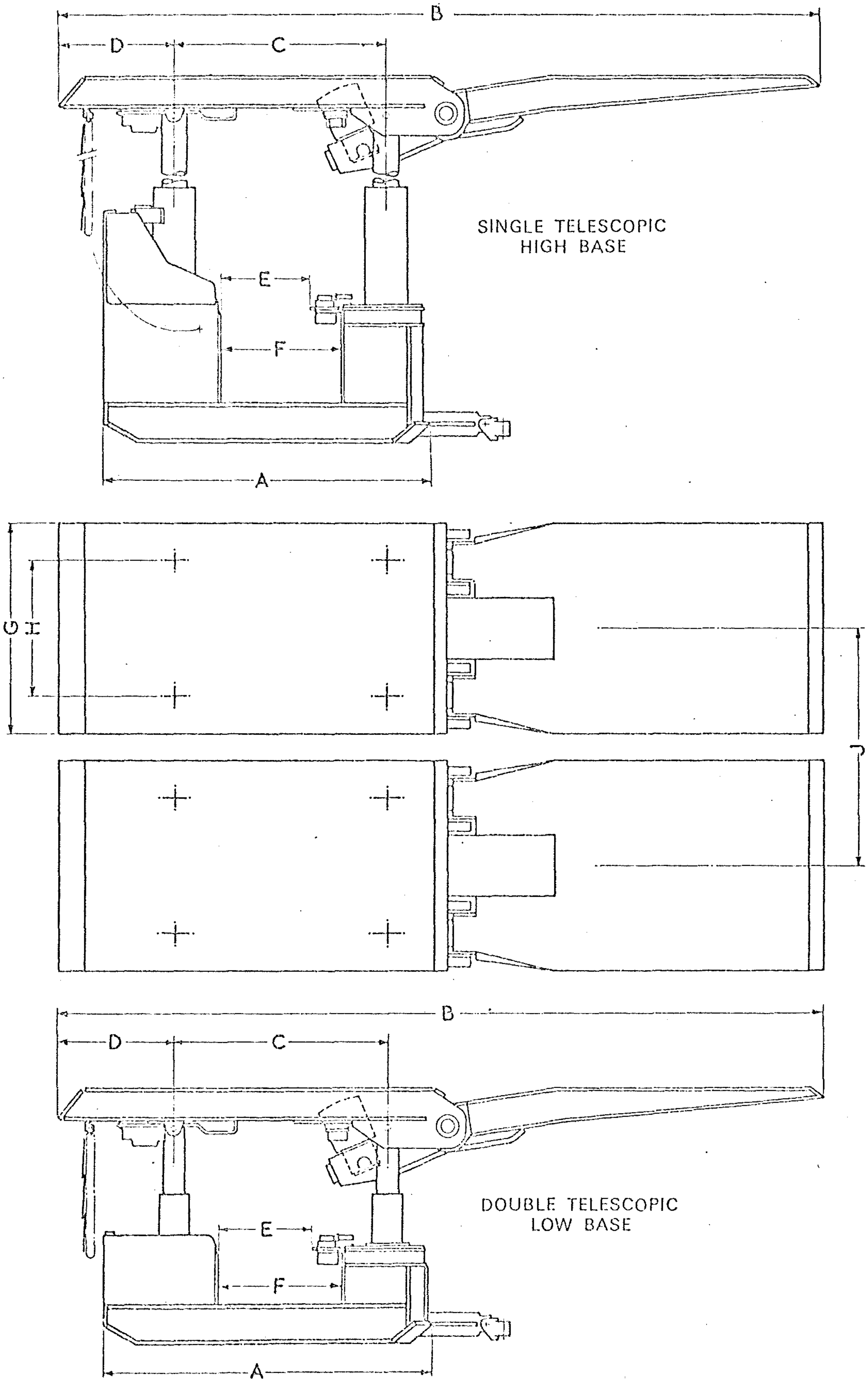


Figure A-9 Dowty 4-leg 500-ton Chocks; York Canyon Mine
(Survey Report No. S-1)



Support Dimensions

	inches
A	64¾
B1	152
B2	146
B3	126
B4	119
C	42
D	23½
E	18
F	24½
G	42
H	27
J	47-59

B1—87″ Forward Bar
B2—81″ Forward Bar
B3—61″ Forward Bar
B4—54″ Forward Bar

Figure A-10 Gullick 4-leg 500-ton Chocks; Allen Mine, 9th Panel (Survey Report No. S-2)

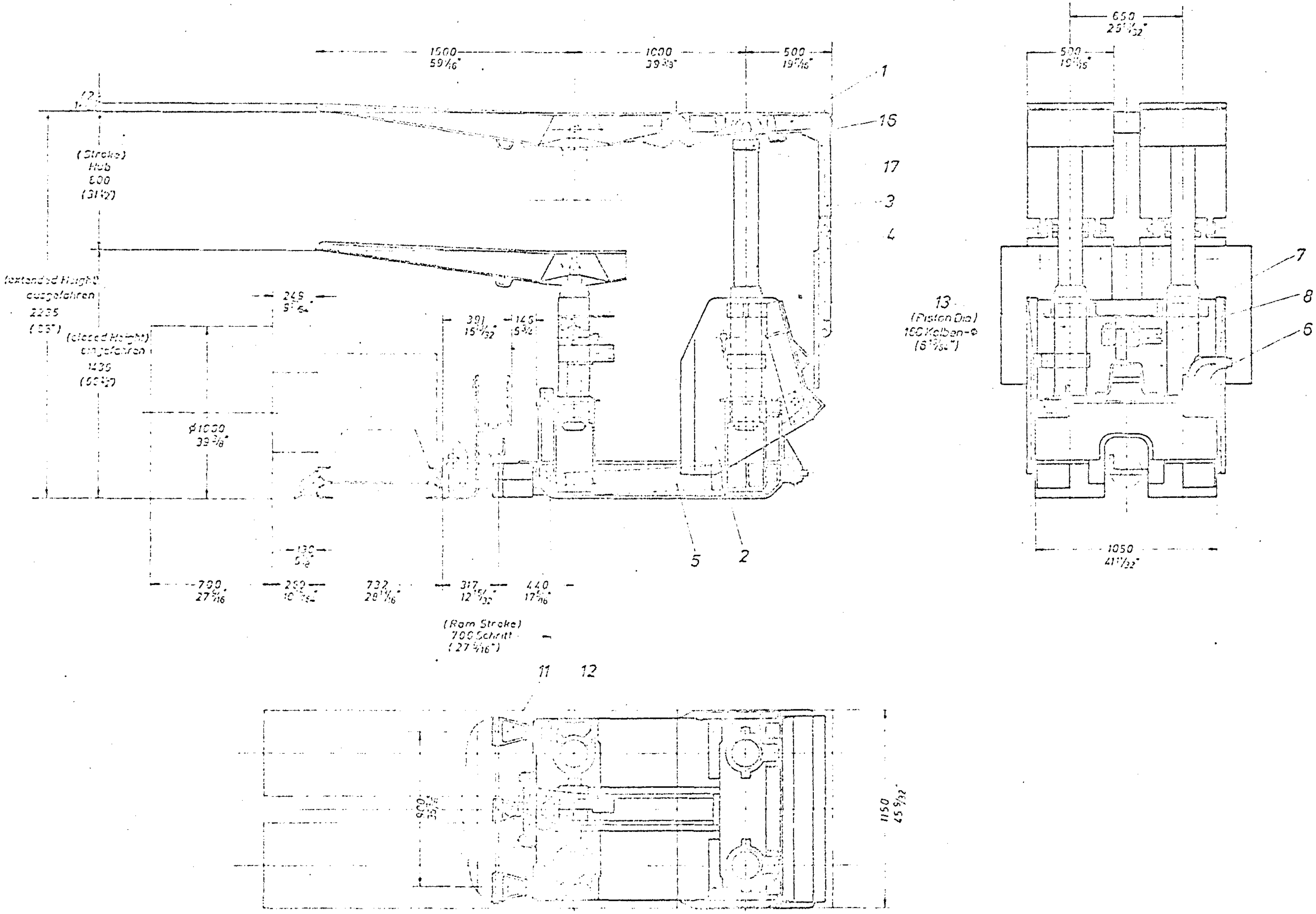
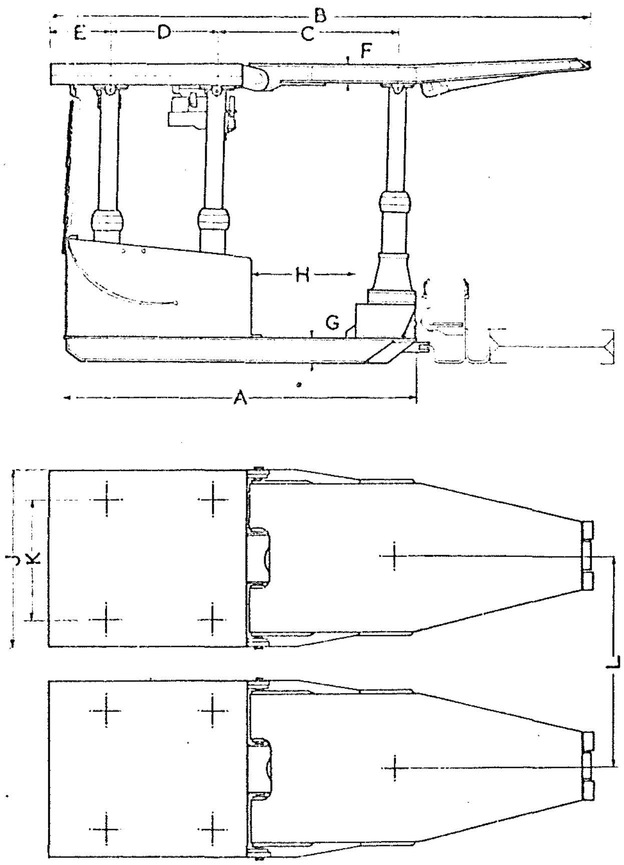


Figure A-11 Westfalia 4-leg 460-ton Chocks Type B2.1; Federal #2
(Survey Report No. S-6)



Support Dimensions

	inches	mm
A	70	1778
B	112	2845
C	36	914·4
D	21	533·4
E	$12\frac{1}{4}$	311
F	$4\frac{1}{8}$	104·8
G	5	127
H	26	660
J	36	914·4
K	24	609·6
L	42–48	1067–1219

Figure A-12 Gullick 5-leg 200-ton Chock; Lancashire #24D
(Survey Report No. S-8)

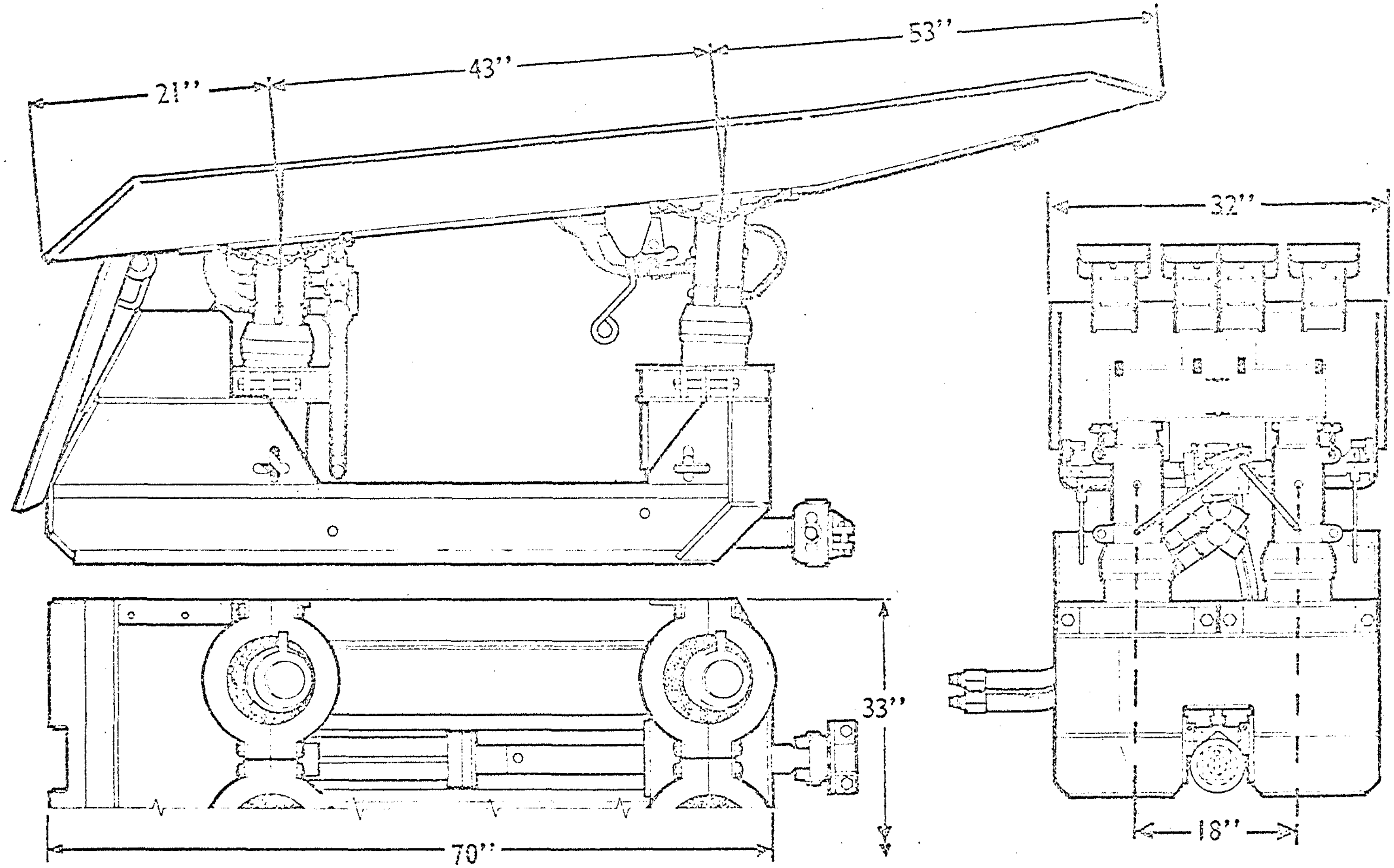


Figure A-13 Huwood Mastabar 280-ton Chocks; Pike #26
(Survey Report No. S-10)

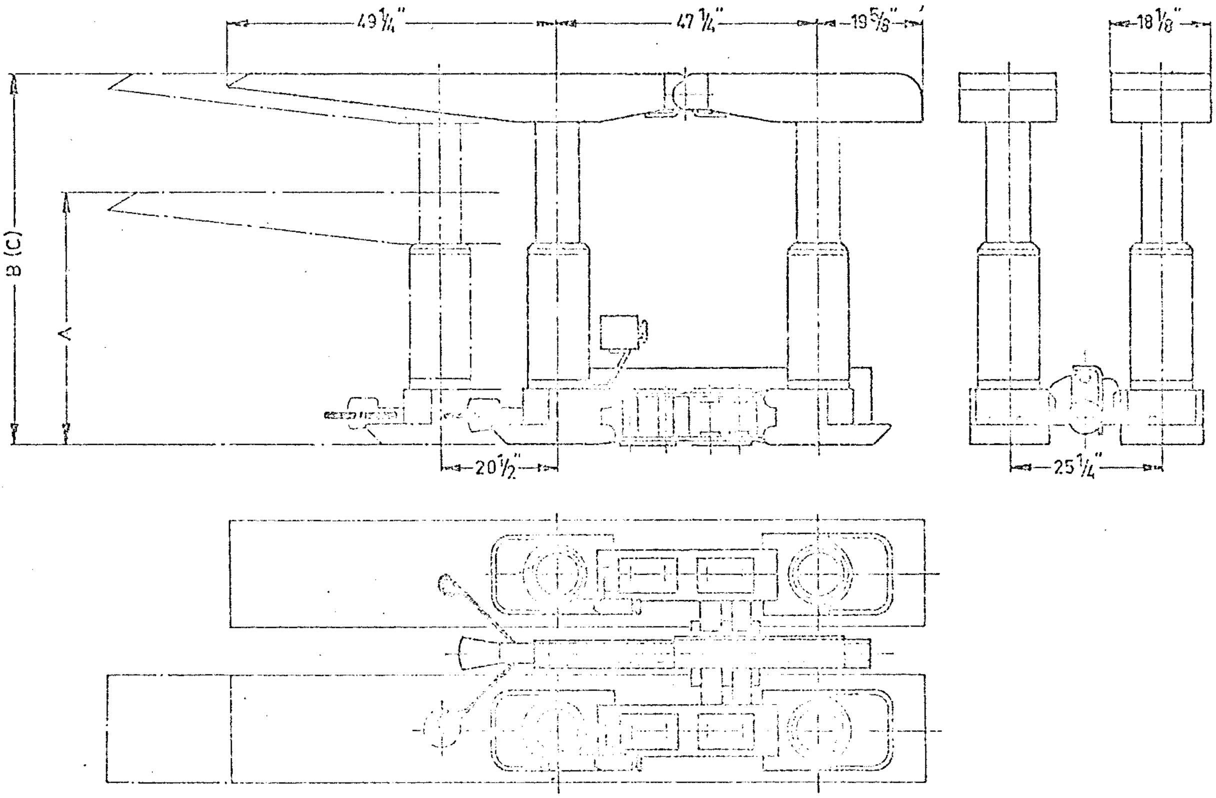


Figure A-14 Westfalia 560-ton Double Frame; Pocahontas #3
(Survey Report No. P-3)

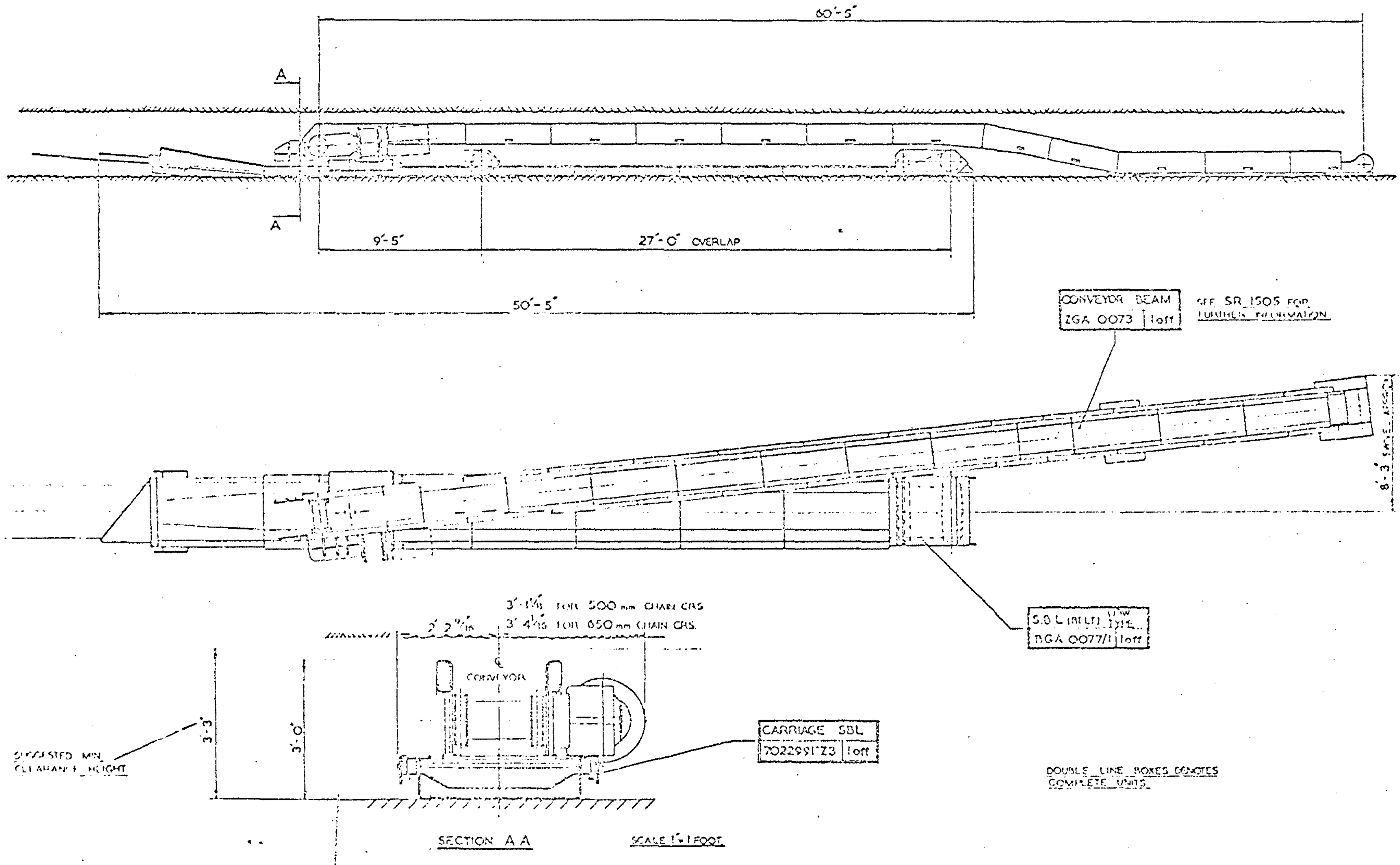


Figure A-15 Meco Stage Loader; York Canyon Mine
(Survey Report No. S-1)

APPENDIX B

APPENDIX B-1

Motion Study No. 1A

Shearer-Tailgate Drum

MOTION STUDY NO: 1-A | PAGE NO: 1 | DATE: 9-6-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: LENSING-HEBBEN

PANEL: 15TH RIGHT

SHEARER
MAN-TRIP: 27½ MIN
LUNCH: 30 MIN
EFF WORKING TIME: 416 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ← = UP TO THE TAIL GATE
4. → = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 CHECKING OF SHEARER	1 MIN	2 STOP FROM ELSEWHERE	3 POWER THE SHEARER	4 DRUM LIFT	5 DRUM LOWER	6 WINCH SLOWER	7 WINCH FASTER	8 SHEARER CUTS MIN	9 SHEARER MOVES NO CUT MIN	10 COAL TURNOVER	11 MAN IS WAITING	12 MAN WORKING AT THE SHEARER MAN	12 M-MIN	13 MAN WATCH OPERATION AND WALKING MAN	13 M-MIN	14 STOPPAGES OF SHEARER	14 MIN	15 OTHERS MIN	REMARKS
(CONT'D)																						
7	27																					
7	5[illegible]	20	1	20											1	20						← OIL CONTROL, CHANGE PICKS
8	05	8				X		X		X		8					1	8				OPERATIONS LESS
																						9 SECONDS
																						1. CLEAN CABLE BELT
																						2. PUT BIG CHUNKS OUT OF CHOCKS
																						ONTO THE CONVEYOR
																						3. CONTROL WATER NOZZLES
																						4. WATCH FOR BIG CHUNKS IN
																						FRONT OF SHEARER AND STOP
																						SHEARER WHEN NECESSARY
8	05	0.5						X							1	0.5			1	0.5		BIG CHUNKS
8	03	2.5						X		X		2.5					1	2.5				
8	08	0.5						X							1	0.5			1	0.5		BIG CHUNKS
8	10	1.5								X	1.5						1	1.5				CUT IN
8	11	0.5													1	0.5			1	0.5		BIG CHUNKS
8	16	5.5					X			X	5.5						1	5.5				OPERATIONS LESS 9 SECONDS:
																						1. NEARLY EVERY 5TH SECOND
																						LIFT OR POWER THE DRUM
																						BECAUSE ROOF IS NOT EQUAL
		39.0		20							7.0	10.5			1	21.5	1	17.5		1.5		

MOTION STUDY NO: 1-A		PAGE NO: 2	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE	SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: LENSING-HEBBEN
PANEL: 15TH RIGHT				

SHEARER
MAN-TRIP: 27/37 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 416 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ← = UP TO THE TAIL GATE
4. → = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 CHECKING OF SHEARER (MIN)	2 STOP FROM ELSEWHERE (MIN)	3 POWER THE SHEARER	4 DRUM LIFT	5 DRUM LOWER	6 WINCH SLOWER	7 WINCH FASTER	8 SHEARER CUTS (MIN)	9 SHEARER MOVES NO CUT (MIN)	10 COWL TURNOVER	11 MAN IS WAITING (MAN)	11 (M-MIN)	12 MAN WORKING AT THE SHEARER (MAN)	12 (M-MIN)	13 MAN WATCH OPERATION AND WALKING (MAN)	13 (M MIN)	14 STOPPAGES OF SHEARER	14 (MIN)	15 OTHERS (MIN)	REMARKS
(CONT'D)		39	20							[illegible]	10.5				1	21.5	1	17.5		1.5		
																						2. SHORT STOPPAGES BECAUSE OF THE BIG CHUNKS
																						3. NEARLY EVERY 3 MINUTES MEASURE THE HEIGHT THAT IS CUT
																						4. WATCH AND CORRECT THE CHAIN OF THE CABLE BELT
																						5. WATCH THE SUPPORT AND LOWER THE DRUM IF IT REACHES THE ROOF BAR
																						6. LOWER THE DRUM OR LIFT THE CANTILEVER IF THE SHEARER REACHES THE CANTI-LEVER
8	22	6		6									1	6								
8	22	7			X	X			X	7.00							1	7				
8	31	2				X	X	X		1.65					1	0.15	1	1.65	1	0.15		BIG CHUNKS, SHEARER REACHED THE TAILGATE AND CUT THE END OF THE FACE
8	32	1				X	X	X			1	X					1	1				SHEARER RETURNS FOR SHORT TIME TO MAINGATE
8	33	4		4									1	4								
8	37	1			X		X	X			1	X					1	1				SHEARER RETURNS TO TAILGATE
8	42	5					X	X			5						1	5				SHEARER CLEANS FACE END
		65 26	20	10						5.65 15.65	7 17.5		1	10 10	1	0.15 21.65	1	15.85 33.35		0.15 1.65		

MOTION STUDY NO: 1-A	PAGE NO: 3	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: LENSING-HEBBEN
PANEL: 15TH RIGHT			

SHEARER
MAN-TRIP: 27/37 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 415 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←= UP TO THE TAIL GATE
4. →= DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 CHECKING OF SHEARER MIN	2 STOP FROM ELSEWHERE MIN	3 POWER THE SHEARER	4 DRUM LIFT	5 DRUM LOWER	6 WINCH SLOWER	7 WINCH FASTER	8 SHEARER CUTS MIN	9 SHEARER MOVES NO CUT MIN	10 COWL TURNOVER	11 MAN IS WAITING MAN	11 M-MIN	12 MAN WORKING AT THE SHEARER MAN	12 M-MIN	13 MAN WATCH OPERATION AND WALKING MAN	13 M-MIN	14 STOPPAGES OF SHEARER	14 MIN	15 OTHERS MIN	REMARKS
(CONT'D)		6.5	20	10						15.85	17.5		1	10	1	21.65	1	33.35		1.65		
8	43	1					X	X			1	X					1	1				→
8	47	4		4									1	4								ADVANCING OF THE CHOCKS AT THE TAILGATE FACE END
8	48	1			X		X		X		1						1	1				
8	58	10		10									1	10								
9	04	6			X		X		X		6						1	6				
9	07	3				X		X		3							1	3				CUT IN SLOW SPEED BECAUSE OF THE CAPACITY OF THE FACE CONVEYOR
9	08	1													1	1			1	1.00		BIG CHUNKS
9	08	0.5				X		X		0.5							1	0.5				
9	13	4.5								0.15					1	4.35	1	0.15	1	4.35		BIG CHUNKS
9	15	2													1	2			1	2.00		BIG CHUNKS
9	23	8				X		X		8		X					1	8				SHEARER REACHES THE MAINGATE
9	30	7													1	7			1	7.00		GEARBOX DEFECT OIL INTO THE SHEARER
9	34	4			X		X		X		4						1	4				←
9	55	21											1	21					1	21.00		WATERPIPE BROKEN
10	01	6			X		X		X		6						1	6				
10	02	1				X		X		0.85					1	0.15	1	0.85	1	0.15		CUT IN ; BIG CHUNKS
10	15	13						X		12.55					1	0.45	1	12.55	3	0.45		BIG CHUNKS
10	15	0.2					X	X X			0.2						1	0.2				SHEARER RETURNS BECAUSE OF BIG CHUNKS
10	20	4.2								4.2							1	4.2				
10	21	0.5													1	0.5			1	0.5		BIG CHUNKS
10	22	2.5						X		2.5							1	2.5				
		101		14						21.75	18.8		1	35	1	15.45	1	50.55		36.45		
		166	20	24						47.60	[illegible]		1	45	1	37.10	1	83.90		38.10		

MOTION STUDY NO: 1-A | PAGE NO: 4 | DATE: 9-6-74 | TIME FROM: 7⁰⁰ TO: 15⁰⁰ (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: LENSING-HEBBEN

PANEL: 15TH RIGHT

SHEARER
MAN-TRIP: 27/37 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 416 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ← = UP TO THE TAIL GATE
4. → = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 CHECKING OF SHEARER MIN	2 STOP FROM ELSEWHERE MIN	3 POWER THE SHEARER	4 DRUM LIFT	5 DRUM LOWER	6 WINCH SLOWER	7 WINCH FASTER	8 SHEARER CUTS MIN	9 SHEARER MOVES NO CUT MIN	10 COWL TURNOVER	11 MAN IS WAITING MAN	11 M-MIN	12 MAN WORKING AT THE SHEARER MAN	12 M-MIN	13 MAN MATCH OPERATION AND WALKING MAN	13 M-MIN	14 STOPPAGES OF SHEARER	14 MIN	15 OTHERS MIN	REMARKS
(CONT'D)		166	20	24						47.60	26.30		1	45	1	38.10	1	[illegible]		[illegible]		
10	26	3				X				3							1	3				CUT FACE END
10	27	1					X	X			1	X					1	1				REMOVE TO MAINGATE
10	29	2					X	X			2	X					1	2				CLEAN TO TAILGATE
10	33	4					X		X		4	X					1	4				→
10	34	1					X		X		1						1	1				
10	39	5		5									1	5								ADVANCING OF CHOCKS AT TAIL-
10	40	1			X		X		X		1						1	1				GATE END
10	41	1													1	1.0			1	1.0		BIG CHUNKS
10	46	5					X		X		5						1	5				
10	51	5				X		X		4.55					1	.15	1	4.85	1	.15		CUT IN
10	51	0.2													1	.20			1	.20		BIG CHUNKS
10	55	3.5				X		X		3.50					1	.30	1	3.5	2	.30		BIG CHUNKS
11	00	5				X		X		5							1	5				REACHING MAINGATE
11	02	2													1	2.0			1	2.0		PUT IN OIL
11	20	18		18									1	18								
11	22	2			X		X		X		1.85	X			1	.15	1	1.85	1	.15		← BIG CHUNKS
11	23	1					X		X		1						1	1				
11	33	10		10									1	10								NO WATER
11	37	4			X		X		X		4						1	4				
11	37	0.5													1	.50			1	.50		BIG CHUNKS
11	42	4.5					X		X		4.2				1	.30	1	4.2	1	.30		BIG CHUNKS
11	46	4				X			X	4							1	4				CUT IN
11	46	0.5													1	.50			1	.50		BIG CHUNKS
11	48	1.5				X			X	1.5							1	1.5				
12	03	15		15									1	15								
12	05	2			X	X			X	2							1	2				
12	05	0.2													1	.20			1	.20		BIG CHUNKS
12	07	1.8				X			X	1.8							1	1.8				
12	15	8		8									1	8								
		112		56						25.65	25.05		1	56	1	5.30	1	5.02		5.30		
		278	20	80						73.25	51.35		1	101	1	43.40	1	34.60		43.40		

MOTION STUDY NO: 1-A		PAGE NO: 5	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE	SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: LENSING-HEPBEN
PANEL: 15TH RIGHT				

SHEARER
MAN-TRIP: 2 3/4 37 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 476 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ← = UP TO THE TAIL GATE
4. → = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

Column headings: 1 CHECKING OF SHEARER; 2 STOP FROM ELSEWHERE; 3 POWER THE SHEARER; 4 DRUM LIFT; 5 DRUM LOWER; 6 WINCH SLOWER; 7 WINCH FASTER; 8 SHEARER CUTS; 9 SHEARER MOVES NO CUT; 10 COAL TURNOVER; 11 MAN IS WAITING; 12 MAN WORKING AT THE SHEARER; 13 MAN WATCH OPERATION AND WALKING; 14 STOPPAGES OF SHEARER; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MIN	2 MIN	3	4	5	6	7	8 MIN	9 MIN	10	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 MIN	15 MIN	REMARKS
(CONT'D)		279	20	20						72.2	113.5		1	101	1	42.4	1	[illegible]		114.5		
12	16	1				X			X	1							1	1				
12	17	3					X	X			3	X					1	3				→ RETURN IN THE MIDDLE
																						OF THE FACE TO THE MAINGATE
12	20	1					X		X		1						1	1				
12	25	5				X		X		5							1	5				CUT IN
12	25	2.5													1	2.5			1	6.5		BIG CHUNKS
12	35	2.5				X		X		2.05					1	.45	1	2.05	3	.45		REACH MAINGATE
12	36	1					X	X			1	X			1	1.0						RETURN TO TAILGATE
12	54	18													1	15.0			1	18.0		PUT OIL IN SHEARER
12	56	2			X		X	X			2						1	2				
13	00	4					X	X			4	X					1	4				SHEARER RETURNS TO CUT &
																						CLEAN THE FACE END
13	04	4					X	X	X		4	X					1	4				←
13	11	7		7									1	7								
13	12	1			X				X		1						1	1				
13	13	1		1									1	1								
13	15	2					X		X		2						1	2				
13	20	5		5									1	5								
13	23	3			X				X		3						1	3				
13	24	1					X	X			1						1	1				RETURNS A FEW FEET BECAUSE
																						OF BIG CHUNKS
13	27	3					X		X		3						1	3				
13	30	3		3									1	3								
		75		16						15.25	25.0		1	16	1	19.95		39.45		16.35		
		353	20	96						88.39	86.35		1	117	1	62.35		173.43		62.35		

MOTION STUDY NO: 1-A | PAGE NO: 6 | DATE: 9-6-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: LENSING-HERBEN

PANEL: 15TH RIGHT

SHEARER
MAN-TRIP: 27/37 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 416 MIN

Column headings: 1 CHECKING OF SHEARER; 2 STOP FROM ELSEWHERE; 3 POWER THE SHEARER; 4 DRUM LIFT; 5 DRUM LOWER; 6 WINCH SLOWER; 7 WINCH FASTER; 8 SHEARER CUTS; 9 SHEARER MOVES NO CUT; 10 COWL TURNOVER; 11 MAN IS WAITING; 12 MAN WORKING AT THE SHEARER; 13 MAN WATCH OPERATION AND WALKING; 14 STOPPAGES OF SHEARER; 15 OTHERS

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←— = UP TO THE TAIL GATE
4. —→ = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MIN	2 MIN	3	4	5	6	7	8 MIN	9 MIN	10	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14	14 MIN	15 MIN	REMARKS
[illegible]	[illegible]	353	20	26						[illegible]	163.3		1	117	1	[illegible]	1	[illegible]		[illegible]		
13	22	2			X	X			X	2							1	2				
13	33	1													1	1.0			1	1		BIG CHUNKS
13	34	3				X			X	3							1	3				
13	37	1													1	1.0			1	1		BIG CHUNKS
13	42	5				X	X	X		4.7					1	0.3	1	4.7	2	.30		DRUM LOWERS BEFORE REACHING THE TAILGATE
13	45	3				X	X	X		1	2	X					1	3				CUTTING, MOVING & CLEANING AT FACE END
13	48	3					X	X		1	2	X					1	3				" " "
13	50	2					X	X			2	X					1	2				——→
13	57	7		7									1	7								ADVANCING OF THE CHOCKS AT THE TAILGATE FACE END
14	02	5			X		X				5						1	5				
14	04	2				X		X	X	2							1	2				BIG CHUNKS
14	04	0.5													1	0.5				.40		BIG CHUNKS
14	11	6.5				X		X	X	6.05					1	0.40	1	6.05	3	.45		
14	12	0.5													1	0.5			1	.50		BIG CHUNKS
14	17	5.5				X		X	X	5.5							1	5.5				MAINGATE REACHED
14	21	4													1	4.0			1	4.0		MAINTENANCE
14	26	5			X		X		X		5	X					1	5				PUT OIL INTO THE SHEARER
14	32	6		6									1	6								
14	33	1			X		X		X		1	X					1	1				
14	33																					END OF SHIFT
		63		13						25.25	17		1	13	1	7.75	1	42.25	1	7.75		
		416	20	109						133.55	163.35		1	130	1	79.12	1	315.90	1	79.10		

B-7

APPENDIX B-2

Motion Study No. 1B

Shearer-Winch Headgate Drum

MOTION STUDY NO: 1-6	PAGE NO: 1	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE / SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

SHEARER
MAN-TRIP 23/27 MIN
LUNCH: (30) MIN
EFF WORKING TIME: 415 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←— = UP TO THE TAIL GATE
4. —→ = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

Columns: 1 CHECKING OF SHEARER; 2 STOP FROM ELSEWHERE; 3 POWER THE SHEARER; 4 DRUM LIFT; 5 DRUM LOWER; 6 WINCH SLOWER; 7 WINCH FASTER; 8 SHEARER CUTS; 9 SHEARER MOVES NO CUT; 10 COWL TURNOVER; 11 MAN IS WAITING; 12 MAN WORKING AT THE SHEARER; 13 MAN WATCH OPERATION AND WALKING; 14 STOPPAGES OF SHEARER; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1	1 MIN	2	2 MIN	3	4	5	6	7	8	8 MIN	9	9 MIN	10	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14	14 MIN	15	15 MIN	REMARKS
(CONT'D)																											
7	[illegible]																										
7	[illegible]	21	1	21															1	21.0							OIL, PICKS
[illegible]	[illegible]	7												1	7.0						1	7.0					
[illegible]	[illegible]																1	1.0					1	.25			
[illegible]	[illegible]	3												1	3.0						1	3.0					TO MUCH COAL FOR CONVEYOR
																							1	.25			
[illegible]	[illegible]	1										1	1.0								1	1.0					—→
[illegible]	[illegible]																				1	0.5					
[illegible]	[illegible]	7												1	7.0				1	6.5					1	3.0	CORRECTING CABLE CHAIN BY HAND
																											BIG CHUNKS IN FRONT OF MACHINE NO EMPTY CARS
[illegible]	[illegible]																										
[illegible]	[illegible]	6			1	6.0											1	6.0									
[illegible]	[illegible]	7					X					1	7.0								1	7.0					
[illegible]	[illegible]							X																			FOR COWL CORRECTING
[illegible]	[illegible]	1							X														1	.25			
[illegible]	[illegible]	1						X								X							1	.25			
[illegible]	[illegible]	1					X					1	1.0								1	1.0					—→
[illegible]	[illegible]	4			1	4.0											1	3.0									LOOP FOR CLEANING FLOOR
[illegible]	[illegible]	2			1	2.0													1	3.0							OIL INTO SHEARER, NO EMPTY CARS
[illegible]	40	2					X	X				1	2.0			X					1	2.0					←— LOOP
												1	1.0			X			1	1.0							—→ FOR ALIGNING THE CONVEYOR
		63		21		12.0							12.0		17.0			10.0		31.5		21.5		1.0		3.0	

MOTION STUDY NO: 1-B	PAGE NO: 2	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE · SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ——→ UP TO THE TAIL GATE
4. ←—— DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

SHEARER
MAN-TRIP: 37 MIN
LUNCH: (30) MIN
EFF WORKING TIME: 415 MIN

ADVANCING TIME (h)	ADVANCING TIME (MIN)	EFF TIME (MIN)	1 CHECKING OF SHEARER (MIN)	2 STOP FROM ELSEWHERE	2 (MIN)	3 POWER THE SHEARER	4 DRUM LIFT	5 DRUM LOWER	6 WINCH SLOWER	7 WINCH FASTER	8 SHEARER CUTS	8 (MIN)	9 SHEARER MOVES NO CUT	9 (MIN)	10 COWL TURNOVER	11 MAN IS WAITING (MAN)	11 (M-MIN)	12 MAN WORKING AT THE SHEARER (MAN)	12 (M-MIN)	13 MAN WATCH OPERATION AND WALKING (MAN)	13 (M-MIN)	14 STOPPAGES OF SHEARER	14 (MIN)	15 OTHERS (MIN)	REMARKS
																									LOOP AT ENTRY ONLY FOR
(CONT'D)		[illegible]	21		[illegible]							12		17			10		[illegible]		[illegible]		1.0		ALIGNING FACE
[illegible]	[illegible]										1	0.5						1	0.5						←—— 2ND LOOP
[illegible]	[illegible]							X					1	3.0	X			1	3.0						——→
[illegible]	[illegible]				[illegible]											1	4.0								ADVANCING TAILGATE DRIVE
[illegible]	[illegible]												1	0.5						1	0.5				
[illegible]	[illegible]			1	15.											1	5.0	1	5.0						
[illegible]	[illegible]												1	6.0							6.0				
[illegible]	[illegible]										1	5.0								1	3.0				HALF FACE
[illegible]	[illegible]			1	[illegible]											1	1.0								CLEANING THE CABLE CHANNEL
[illegible]	[illegible]			1	[illegible]													1	5.0						BIG CHUNKS BEHIND SHEARER
[illegible]	[illegible]										1	[illegible]								1	[illegible]				
[illegible]	[illegible]			1	[illegible]											1	1.7								
[illegible]	[illegible]										1	[illegible]						1	0.5						BIG CHUNKS
[illegible]	[illegible]			1	[illegible]											1	1.7								CRUSHING WITH HAMMER
[illegible]	[illegible]						X	X			1	[illegible]								1	[illegible]				BOTTOM COAL TO HIGH
							X	X																	
																		1	3.0			1	5.0		OIL INTO SHEARER; GEARBOX
[illegible]	[illegible]																								DEFECT
[illegible]	[illegible]			1	1.[illegible]											1	1.0								
													1	2.0				1	[illegible]						
[illegible]	[illegible]						X																		
								X			1	[illegible]			X			1	[illegible]						←——
[illegible]	[illegible]																								NEW CUT CORRECT CABLE CHAIN
[illegible]	[illegible]																	1	15.			1	16.		
[illegible]	[illegible]												1	3.0						1	3.0				WATER PIPE BROKEN
[illegible]	[illegible]										1	1.0						1	1.0						HALF FACE
																									CORRECT CABLE CHAIN
		[illegible]		1	[illegible]						1	16.5	1	19.5		1	14.4	1	42	1	25.[illegible]	1	2.3		
		145	21		25							28.5		36.5			24.4		73.5		47.1		24		

MOTION STUDY NO: 1-B | PAGE NO: 3 | DATE: 9-6-74 | TIME FROM: 7⁰⁰ TO: 15⁰⁰ (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: HOLDEFLEISS

PANEL: 15TH RIGHT

SHEARER

MAN-TRIP: 28/37 MIN

LUNCH: (30) MIN

EFF WORKING TIME: 415 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←— = UP TO THE TAIL GATE
4. —→ = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

Columns: 1 CHECKING OF SHEARER; 2 STOP FROM ELSEWHERE; 3 POWER THE SHEARER; 4 DRUM LIFT; 5 DRUM LOWER; 6 WINCH SLOWER; 7 WINCH FASTER; 8 SHEARER CUTS; 9 SHEARER MOVES NO CUT; 10 COWL TURNOVER; 11 MAN IS WAITING; 12 MAN WORKING AT THE SHEARER; 13 MAN WATCH OPERATION AND WALKING; 14 STOPPAGES OF SHEARER; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1	1 MIN	2	2 MIN	3	3	4	4	5	5	6	6	7	7	8	8 MIN	9	9 MIN	10	10	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14	14 MIN	15	15 MIN	REMARKS
(CONT'D)		[illegible]		21		25												[illegible]		36.5				[illegible]		73.5		47.1		24.0		3.0	
[illegible]	[illegible]																																
12	[illegible]																								1	1.0			1	1.0			BIG CHUNKS IN FRONT OF
																																	SHEARER
[illegible]	[illegible]							/									1	4.0									1	4.0					CRUSHING BY HAND WITH BIG
																																	HAMMER
[illegible]	[illegible]																1	1.0									1	1.0					
[illegible]	[illegible]																								1	1.0			1	1.0			" " "
[illegible]	[illegible]							X		X							1	0.5							1	2.0							←— GUIDING CABLE CHAIN
[illegible]	[illegible]											X					1	6.5				X					1	5.0					—→
																									1	2.0			1	0.1			
[illegible]	[illegible]							X		X							1	[illegible]															—→ BIG CHUNKS
[illegible]	[illegible]											X					1	2.0				X					1	2.0					←—
10	21																								1	2.0			1	1.0			" "
[illegible]	[illegible]							X									1	2.0									1	1.0					CRUSHED WITH HAMMER
[illegible]	[illegible]				1	1.0				X													1	1.0									
[illegible]	[illegible]											X							1	3.0		X					1	[illegible]					—→ CLEANING FLOOR BY THE
										X												X											←— DRUM
										X																							
[illegible]	[illegible]											X							1	2.0		X					1	2.0					—→
[illegible]	[illegible]																		1	3.0		X					1	3.0					←→
[illegible]	[illegible]											X							1	2.0		X					1	2.0					—→ " " "
[illegible]	[illegible]				1	[illegible]																	1	4.0									ADVANCING
[illegible]	[illegible]							X											1	1.0							1	1.0					TAILGATE FACE AND SUPPORT
[illegible]	[illegible]				1	1.0													1	5.0			1	1.0									
[illegible]	[illegible]							X																			1	5.0					CLEAN CABLE CHANNEL
		414			1	16											1	17.9	1	17.0			1	4.0	1	8.0	1	30.		3.1			
		[illegible]39		21		41												46.4		53.5				20.4		81.5		77.1		27.1		3.0	

MOTION STUDY NO: 1-B	PAGE NO: 4	DATE: 9-6-74	TIME FROM: 7⁰⁰ TO: 15⁰⁰ (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE / SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

SHEARER
MAN-TRIP: 33 37 MIN
LUNCH: (30) MIN
EFF WORKING TIME: 415 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←— = UP TO THE TAIL GATE
4. —→ = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

Columns: 1 CHECKING OF SHEARER; 2 STOP FROM ELSEWHERE; 3 POWER THE SHEARER; 4 DRUM LIFT; 5 DRUM LOWER; 6 WINCH SLOWER; 7 WINCH FASTER; 8 SHEARER CUTS; 9 SHEARER MOVES NO CUT; 10 COAL TURNOVER; 11 MAN IS WAITING; 12 MAN WORKING AT THE SHEARER; 13 MAN WATCH OPERATION AND WALKING; 14 STOPPAGES OF SHEARER; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1	1 MIN	2	2 MIN	3	4	5	6	7	8	8 MIN	9	9 MIN	10	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14	14 MIN	15	15 MIN	REMARKS
(CONT'D)		[illegible]		[illegible]									[illegible]		52.[illegible]			[illegible]		91.[illegible]		[illegible]		[illegible]		3.0	
[illegible]	[illegible]																										
[illegible]	[illegible]							X				1	5.0									5.0			1	0.5	CLEAN CABLE CHANNEL
[illegible]																			1	1.0			1	1.0			OVERLOADING CONVEYOR
[illegible]	[illegible]				1	1.0											1	1.0									
[illegible]	[illegible]						X		X			1	1.0								1	1.0					BIG CHUNKS
[illegible]	[illegible]				1	1.0																					″ ″
10	[illegible]						X					1	0.5								1	1.0					
[illegible]	[illegible]				1	1.0											1	1.0									″ ″
[illegible]	[illegible]						X		X			1	3.0						1	4.0					1	0.3	CLEAN CABLE CHANNEL
								X																			
[illegible]	[illegible]								X										1	4.0			1	2.5			OIL SHEARER, GEAR DEFECT
[illegible]	[illegible]				1	15.0											1	16									
[illegible]	[illegible]						X	X						1	2.0	X					1	2.0					←—
[illegible]	[illegible]																		1	11.0			1	11.0			NO WATER
[illegible]	[illegible]						X	X						1	4.0						1	4.0					
[illegible]	[illegible]																		1	1[illegible]			1	1.[illegible]			TO MUCH COAL IN FRONT OF
																											SHEARER
[illegible]	[illegible]						X							1	4.0						1	4.0					CRUSHING BIG CHUNKS BY HAMMER
[illegible]	[illegible]											1	4.0								1	4.0					
[illegible]	[illegible]											1	2.0				1	3.0									
[illegible]	[illegible]				1	15.[illegible]	X														1	15.0			1	0.5	GUIDE THE CABLE CHAIN
[illegible]	[illegible]											1	2.0								1	2.0					
[illegible]	[illegible]						X	X				1	1.0								1	1.0					←—
[illegible]	[illegible]								X					1	4.0	X			1	4.[illegible]							—→
[illegible]	[illegible]							X	X			1	5.0								1	5.0					″ ″
[illegible]	[illegible]				1	1											1	1.0			1	2.0					
12	[illegible]						X	X				1	3.0														
12	31								X					1	1.0	X					1	1.0					←— ″ ″
		110										1	13.5	1	15		1	21		2.5	1	64	1	15.5	1	1.5	
		209		21									89.9		62.5			51.4		106.5		141.1		112.6		4.5	

B-12

MOTION STUDY NO: 1-B		PAGE NO: 5	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE	SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT				

SHEARER
MAN-TRIP: 23/37 MIN
LUNCH: (30) MIN
EFF WORKING TIME: 415 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←— = UP TO THE TAIL GATE
4. —→ = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

Advancing time K	Advancing time MIN	Lift time MIN	1 Checking of shearer (MIN)	2 Stop from elsewhere (MIN)	3 Power the shearer	4 Drum lift	5 Drum lower	6 Winch slower	7 Winch faster	8 Shearer cuts (MIN)	9 Shearer moves no cut (MIN)	10 Coal turnover	11 Man is waiting (MAN / M-MIN)	12 Man working at the shearer (MAN / M-MIN)	13 Man watch operation and walking (MAN / M-MIN)	14 Stoppages of shearer (MIN)	15 Others (MIN)	Remarks
(CONT'D)		299	21	77						89.9	68.3		51.4	104.?	141.1	42.?	41.5	
[illegible]	[illegible]																	
[illegible]	[illegible]													1 19.		1 13.		OIL FOR THE SHEARER GEARBOX
[illegible]	[illegible]				X	X					1 1.0				1 1.0			
[illegible]	[illegible]													1 3.0		1 6.1		MAINTENANCE
[illegible]	[illegible]				X		X				1 0.9							←— 20 FT.
						X												
							X											
[illegible]	[illegible]				X						1 5.0	X			1 3.0			—→ CLEAN FACE END
[illegible]	[illegible]					X								1 2.0		1 1.0		BIG CHUNKS
[illegible]	[illegible]						X					X						
[illegible]	[illegible]				X						1 1.0							←—
[illegible]	[illegible]			1 3.0									1 3.0					
[illegible]	[illegible]				X	X					1 1.0			1 1.0				
[illegible]	[illegible]			1 1.0									1 1.0					
[illegible]	[illegible]				X						1 2.0				1 2.0			
[illegible]	[illegible]			1 6.0									1 6.0					
[illegible]	[illegible]				X	X					1 2.0				1 3.0			←— TO MUCH COAL
[illegible]	[illegible]										1 1.0	X		1 3.0				—→
[illegible]	[illegible]				X		X				1 1.0	X						←—
[illegible]	[illegible]			1 3.0									1 3.0					
[illegible]	[illegible]									1 2.0				1 3.0				HALF FACE —→ BIG CHUNKS
[illegible]	[illegible]				X											1 1.0		
[illegible]	[illegible]									1 3.0					1 3.0			
[illegible]	[illegible]				X									1 4.0		1 1.0		
[illegible]	[illegible]					X				1 5.0					1 2.0			
[illegible]	[illegible]					X					1 3.0	X		1 6.0				—→ GUIDING CABLE CHAIN
[illegible]	[illegible]						X				1 1.0	X						←—
[illegible]	[illegible]					X					1 1.0	X						—→
[illegible]	[illegible]						X				1 1.0	X						←—
		72		1 18						1 10.	1 22.9		1 18.	1 40.?	1 14.?	1 21.1		
		371	21	95						99.9	91.?		69.4	144.?	155.1	63.7	41.5	

MOTION STUDY NO: 1-B	PAGE NO: 6	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MIN: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

SHEARER
MAN-TRIP: 37MIN
LUNCH: (30) MIN
EFF WORKING TIME: 415 MIN

LEGEND

1. A = SHEARER DRUM AT THE TAIL GATE SIDE
2. B = SHEARER DRUM AT THE MAIN GATE SIDE
3. ←— = UP TO THE TAIL GATE
4. —→ = DOWN TO THE MAIN GATE
5. LUNCH 30 MIN. - MAN RELEASED BY MECHANIC

Columns: 1 CHECKING OF SHEARER; 2 STOP FROM ELSEWHERE; 3 POWER THE SHEARER; 4 DRUM LIFT; 5 DRUM LOWER; 6 WINCH SLOWER; 7 WINCH FASTER; 8 SHEARER CUTS; 9 SHEARER MOVES NO CUT; 10 COWL TURNOVER; 11 MAN IS WAITING; 12 MAN WORKING AT THE SHEARER; 13 MAN WATCH OPERATION AND WALKING; 14 STOPPAGES OF SHEARER; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1	1 MIN	2	2 MIN	3	4	5	6	7	8	8 MIN	9	9 MIN	10	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14	14 MIN	15	15 MIN	REMARKS
(CONT'D)		371		[illegible]		95							[illegible]		[illegible]			[illegible]		[illegible]		[illegible]		[illegible]		41.5	
13	4.2						X	X																			
13	5.0													1	2.0	X			1	2.0							→ ADVANCING TAILGATE DRIVE
									X																		
13	[illegible]				1	7											1	7.0									
[illegible]	[illegible]													1	41.0						1	41.0					HALF FACE
[illegible]	[illegible]						X	X				1	10.								1	10.					
[illegible]	[illegible]				1	2			X								1	2.0									
[illegible]	[illegible]						X					1	46						1	41.0							
[illegible]	[illegible]																		1	5.0			1	5.0			OIL TO SHEARER GEAR
[illegible]	[illegible]													1	5.0	X					1	5.0					
[illegible]	[illegible]				1	5											1	5.0									MAINTENANCE
		44			1	14						1	14.	1	11.		1	14.	1	11.	1	19.	1	5.			
		415		21		109							139		102.4			93.4		157.5		174.1		68.7		41.5	

APPENDIX B-3

Motion Study No. 2 and No. 3

Advancing Supports and Conveyor

MOTION STUDY NO: 2 | PAGE NO: 1 | DATE: 9-6-74 | TIME FROM: 7[00] TO: 15[00] (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 2 | OBSERVER: SALVIS

PANEL: 15TH RIGHT

SUPPORT & CONVEYOR

MAN-TRIP: 75 MIN

LUNCH: 65 MIN

EFF WORKING TIME: 405 MIN

ADVANCING TIME		EFF TIME	1 LOWERING SUPPORT		2 ADVANCING SUPPORT		3 PRESSURIZE SUPPORT & CANTILEVER		4 WALKING TO THE NEXT SUPPORT		5 CLEANING UP BETWEEN SUPPORT		6 CRUSHING BIG CHUNKS		7 PUTTING TIMBER ON TOP OF CANOPY		8 WALKING TO NEXT RAM		9 OPERATING CONVEYOR RAM		10 MOVING MAINGATE DRIVES		11 MOVING TAILGATE DRIVE		12 WAITING TIME		13 ALIGNING PAN LINE		14 RAISING CANTI-LEVER PREVENTING PRESS. TO LEGS		15 OTHERS		REMARKS
FT	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)																																	
7	40	.2															1	.2									1	.2					
		.2															1	.2									1	.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2															1	.2										.2					
		.2																								.2		.2					
7	3	.8							1	.8							1	.8															
8	5	27																							2	54							MAINTENANCE OF FACE EQUIPMENT
		.1							1	.1									1	.1													
		.1	1		1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
		.1							1	.1									1	.1													
		.1	1		1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
		.1							1	.1									1	.1													
8	11	.1	1		1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
		.1							1	.1									1	.1													
		31.3				.3		.6		1.2								3.1		.4						54.5		2.2		.3			

B-16

MOTION STUDY NO: 2		PAGE NO: 2	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE	SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: SALVIS
PANEL: 15TH RIGHT				

SUPPORT & CONVEYOR
MAN-TRIP: 75 MIN
LUNCH: 66 MIN
EFF WORKING TIME: 405 MIN

Advancing Time #	Advancing Time Min	Eff Time Min	1 Lowering Support Man	1 M-Min	2 Advancing Support Man	2 M-Min	3 Pressurize Support & Cantilever Man	3 M-Min	4 Walking to the Next Support Man	4 M-Min	5 Cleaning Up Between Support Man	5 M-Min	6 Crushing Big Chunks Man	6 M-Min	7 Putting Timber on Top of Canopy Man	7 M-Min	8 Walking to Next Ram Man	8 M-Min	9 Operating Conveyor Ram Man	9 M-Min	10 Moving Maingate Drives Man	10 M-Min	11 Moving Tailgate Drive Man	11 M-Min	12 Waiting Time Man	12 M-Min	13 Aligning Pan Line Man	13 M-Min	14 Raising Canti-lever Preventing Press. to Legs Man	14 M-Min	15 Others Man	15 M-Min	REMARKS
(CONT'D)		[illegible]				.3		.6		1.2								8.1		.4						[illegible]		2.2		.5			
[illegible]	[illegible]	.1	1		1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
		.1								.1									1	.1													
		.1	1		1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
[illegible]	[illegible]	.1								.1									1	.1													
[illegible]	[illegible]	18.4				4.6		3.2		4.6							1	4.6	1	4.6						4.6				4.6			ADVANCE THE CHOCKS - ROTATED 4.6X
		.1	1	.1																					1	.1							
		.1			1	.1			1	.1																							
[illegible]	[illegible]	1													2	2																	AT THE TAIL END OF THE FACE
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
					2	2																											IRREGULARITIES ON THE FLOOR
[illegible]	[illegible]	1.1	1		1	.1																				.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
		.1							1	.1									1	.1													
		.1	1		1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
6	[illegible]	.1							1	.1									1	.1													
		53.7		.1		7.4		10.8		6.3						2		8.2		5.4						59.6		2.2		5.4			

B-17

MOTION STUDY NO: 2	PAGE NO: 3	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE / SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: SALVIS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 75 MIN
LUNCH: 65 MIN
EFF WORKING TIME: 405 MIN

ADVANCING TIME		EFF TIME	1 LOWERING SUPPORT		2 ADVANCING SUPPORT		3 PRESSURIZE SUPPORT & CANTILEVER		4 WALKING TO THE NEXT SUPPORT		5 CLEANING UP BETWEEN SUPPORT		6 CRUSHING BIG CHUNKS		7 PUTTING TIMBER ON TOP OF CANOPY		8 WALKING TO NEXT RAM		9 OPERATING CONVEYOR RAM		10 MOVING MAINGATE DRIVES		11 MOVING TAILGATE DRIVE		12 WAITING TIME		13 ALIGNING PAN LINE		14 RAISING CANTI-LEVER PREVENTING PRESS. TO LEGS		15 OTHERS		REMARKS
H	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)		[illegible]		.1		7.4		10.9		3.3						2		3.0		5.4						[illegible]		2.2		5.4			
9	[illegible]	10																							2	20							
9	17	3.3																					2	6.6									
9	25	16																							2	32							
																			1	1.5													ADVANCE CONVEYOR 14X
																											1	2.2					
																	2	3.2															
																									1	.8							
9	27	4																															
9	27	20									2	40																					
9	57	30																							2	30							STOPPED SOMEWHERE ELSE
			1		1	.1																	1	.1									
							1	.1																					1	.1			
							1	.1									1	.1															
									1	.1									1	.1													
9	[illegible]	2				.4		.8		.4								.4		.4				.4						.4			ADVANCE THE CHOCKS REPEATED 4X
			1		1	2.1																	1	2.1									VALVE STOCK
							1	.1																						.1			
							1	.1									1	.1															
10	[illegible]	2.4							1	.1									1	.1													
10	[illegible]	8.4				2.1		[illegible]		2.1								2.1	1	2.1			1	2.1					1	2.1			ADVANCE THE CHOCKS REPEATED 21X
			1		1	2.1																			1	2.1							IRREGULARITIES ON THE FLOOR
							1	.1																					1	.1			
							1	.1									1	.1															
10	22	2.4							1	.1									1	.1													
		152.2		.1		14.2		15.4		9.1		40				2		14.2		10				11.3		174.5		4.4		8.2			

MOTION STUDY NO: 2	PAGE NO: 2	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: SALVIS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 75 MIN
LUNCH: 66 MIN
EFF WORKING TIME: 405 MIN

Operations: 1 LOWERING SUPPORT; 2 ADVANCING SUPPORT; 3 PRESSURIZE SUPPORT & CANTILEVER; 4 WALKING TO THE NEXT SUPPORT; 5 CLEANING UP BETWEEN SUPPORT; 6 CRUSHING BIG CHUNKS; 7 PUTTING TIMBER ON TOP OF CANOPY; 8 WALKING TO NEXT RAM; 9 OPERATING CONVEYOR RAM; 10 MOVING MAINGATE DRIVES; 11 MOVING TAILGATE DRIVE; 12 WAITING TIME; 13 ALIGNING PAN LINE; 14 RAISING CANTILEVER PREVENTING PRESS. TO LEGS; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		52.2		.1		14.2		5.4		9.1		40				2		14.2		10				11.5		172.5		4.4		9.2			
10	3.2		1		1	.1																			1	.1							
							1	.1																					1	.1			
							1	.1									1	.1															
10	[illegible]	.4							1	.1									1	.1													
10	[illegible]	4				1.		2		1.								1		1						1.				1.			ADVANCE THE CHOCKS REPEATED 10X
		.1	1		1	.1																			1	.1							DIRT BETWEEN CHOCKS AND CONVEYOR
		1							1	.1		1.1																					
											2	1.8																					
		.1			1	.1																			1	.1							
		.1					1	.1																					1	.1			
		.1					1	.1									1	.1															
10	5.1	.1							1	.1									1	.1													
10	[illegible]	4									2	8																					ADVANCE THE CHOCKS REPEATED 10X
10	[illegible]	4				1.		2		1								1		1						1				1.			
10	35	8.9																							2	11.3							WAITING FOR WEB CUT
			1	.1					1	.1																							
					1	.1	1	.1																									
															2	5																	
															1		1	.1															
							1	.1																					1	.1			
							1	.1									1	.1															
10	[illegible]	3							1	.1									1	.1													
10	[illegible]	1.2			3	.3	1	.6	1	.3							1	.3		.3						.3			1	.3			ADVANCE THE CHOCKS REPEATED 3X
10	[illegible]	1.5																					2	3			2	.6					
10	44	5																							2	6							
																			1	1.7													ADVANCE THE CONVEYOR REPEATED 17X
																											1	6.9					
																	2	3.5															
10	54	10									1	4.7																					
10	[illegible]	2									2	4																					
11	29	33																														66	LUNCH BREAK
		229		.2		14.9		21.6		11.0		53.6				7		23.7		14.3				14.3		200.9		11.8		10.8		66	

B-19

MOTION STUDY NO: 2	PAGE NO: 5	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: SALVIS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 75 MIN
LUNCH: 66 MIN
EFF WORKING TIME: 405 MIN

1 LOWERING SUPPORT; 2 ADVANCING SUPPORT; 3 PRESSURIZE SUPPORT & CANTILEVER; 4 WALKING TO THE NEXT SUPPORT; 5 CLEANING UP BETWEEN SUPPORT; 6 CRUSHING BIG CHUNKS; 7 PUTTING TIMBER ON TOP OF CANOPY; 8 WALKING TO NEXT RAM; 9 OPERATING CONVEYOR RAM; 10 MOVING MAINGATE DRIVES; 11 MOVING TAILGATE DRIVE; 12 WAITING TIME; 13 ALIGNING PAN LINE; 14 RAISING CANTI-LEVER PREVENTING PRESS. TO LEGS; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		229.0		0.2		16.9		21.6		11.9		58.6				7.0		23.7		14.3				14.3		200.9		11.8		10.8		66.0	
11	29																									32.0							CUT THE WED
11	45	16.0																							1	0.1							
					1	0.1																											
								0.1																					1	0.1			
								0.1									1	0.1															
11		0.4							1	0.1									1	0.1													
11	49	3.6				0.9		1.8		0.9								0.9		0.9						0.9				0.9			ADVANCE THE CHOCKS. REPEATED 9 TIMES
12	04	15.0																								30.0							STOP ELSEWHERE
12	06	2.0				0.5		1.0		0.5							1	0.5		0.5						0.5				0.5			REPEATED 5 TIMES
12	25	2.0							2	4.0																							RELEASE OTHERS FOR LUNCH
12	15	7.0																								14.0							
12	31	16.0			1	4.0	1	8.0	1	4.0							1	4.0	1	4.0						4.0				4.0			
12	55	24.0									2	48.0																					
									2	0.4																							
13	10	15.0																							2	26.0							
13	30	20.0									2	40.0																					
13	[illegible]	14.4			1	3.6	1	3.6	1	7.2							1	3.6	1	3.6					1	3.6			1	3.6			ADVANCE CHOCKS. REPEATED 36 TIMES
			1	0.1					1	0.1																							
					1	0.1									1	0.1																	
															2	4.0																	
							1	0.1																					1	0.1			
13	[illegible]	2.4					1	0.1									1	0.1															
13	[illegible]	0.8				0.2		4.0	1	0.2							1	0.2		0.2					1	0.2			1	0.2			ADVANCE THE CHOCKS. REPEATED 2 TIMES
13	[illegible]	2.4																					2	4.8									
13	[illegible]	6.0																									2	12.0					STOPPED FROM ELSEWHERE
14	[illegible]	4.0																							2	8.0							
		151.0		0.1		9.4		18.8		17.4		88.0				4.1		9.4		9.3				4.8		119.3		12.0		9.4			
		380.0		0.3		24.3		40.4		29.3		146.6				11.1		33.1		23.6				19.1		320.2		23.8		20.2		66.0	

MOTION STUDY NO: 2	PAGE NO: 5	DATE: 9-6-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE / SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: SALVIS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 75 MIN
LUNCH: 66 MIN
EFF WORKING TIME: 405 MIN

Activities: 1 LOWERING SUPPORT; 2 ADVANCING SUPPORT; 3 PRESSURIZE SUPPORT & CANTILEVER; 4 WALKING TO THE NEXT SUPPORT; 5 CLEANING UP BETWEEN SUPPORT; 6 CRUSHING BIG CHUNKS; 7 PUTTING TIMBER ON TOP OF CANOPY; 8 WALKING TO NEXT RAM; 9 OPERATING CONVEYOR RAM; 10 MOVING MAINGATE DRIVES; 11 MOVING TAILGATE DRIVE; 12 WAITING TIME; 13 ALIGNING PAN LINE; 14 RAISING CANTI-LEVER PREVENTING PRESS. TO LEGS; 15 OTHERS

ADVANCING TIME #	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		380.0		0.3		26.3		40.4		29.3		146.6				11.1		33.1		23.6				19.1		320.2		23.8		20.2		66.0	
14	22																																
																			1	1.4													ADVANCE THE CONVEYOR. 12 TIMES
																												2.7					
																	2	2.6															
14	54	4.0																								1.3							
16	25	21.0																							2	42.0							
		405.0		0.3		26.3		40.4		29.3		146.6				11.1		35.7		25.0				19.1		363.5		26.5		20.2		66.0	

MOTION STUDY NO: 3 | PAGE NO: 1 | DATE: 9-10-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 2 | OBSERVER: HOLDEFLEISS

PANEL: 15TH RIGHT

SUPPORT & CONVEYOR

MAN-TRIP: 29/41 MIN

LUNCH: 30 MIN

EFF WORKING TIME: 410.1 MIN

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 LOWERING SUPPORT MAN	1 M-MIN	2 ADVANCING SUPPORT MAN	2 M-MIN	3 PRESSURIZE SUPPORT + CANTILEVER MAN	3 M-MIN	4 WALKING TO THE NEXT SUPPORT MAN	4 M-MIN	5 CLEANING UP BETWEEN SUPPORT MAN	5 M-MIN	6 CRUSHING BIG CHUNKS MAN	6 M-MIN	7 PUTTING TIMBER ON TOP OF CANOPY MAN	7 M-MIN	8 WALKING TO NEXT RAM MAN	8 M-MIN	9 OPERATING CONVEYOR RAM MAN	9 M-MIN	10 MOVING MAINGATE DRIVES MAN	10 M-MIN	11 MOVING TAILGATE DRIVE MAN	11 M-MIN	12 WAITING TIME MAN	12 M-MIN	13 STRAIGHTENING PAN LINE MAN	13 M-MIN	14 RAISING CANTILEVER PREVENTING PRESS TO LEGS MAN	14 M-MIN	15 OTHERS MAN	15 M-MIN	REMARKS
(CONT'D)																																	
7	41																																
8	01	20									1	20													1	20					1		HELPING CORRECT SHEARER CABLE
8	02	1															1	.1													1	1	
		.1																	1	.1													
		.1							1	.1																							
		.1	1	.1		.1																											
		.1					1	.1																									
		.1															1	.1															
		.1																	1	.1													
		.1							1	.1																							
		.1	1	.1		.1																											
		.1					1	.1																									
8	23	.1															1	.1															
		.1																	1	.1													
		.1							1	.1																							
		.1	1	.1		.1																											
		.1					1	.1																									
		.1															1	.1															
		.1																	1	.1													
		.1							1	.1																							
		.1	1	.1		.1																											
		.1					1	.1																									
8	34	.1																															
																																	HELPING MAINTENANCE/[illegible] SHEARER
																	1	4.5															ALWAYS REPEATING 25 X
																			1	4.5													
									1	4.5																							
			1	4.5		4.5																											
8	28	22.25					1	4.5					1	25																			
8	43	20																													2	40	
		65.5	1	4.9		4.9	1	4.9	1	4.9	1	20	1	25			1	4.9	1	4.9					1	20					2	41	

MOTION STUDY NO: 3 | PAGE NO: 2 | DATE: 9-10-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 2 | OBSERVER: HOLDEFLEISS

PANEL: 15TH RIGHT

SUPPORT & CONVEYOR

MAN-TRIP: 2×41 MIN

LUNCH: 30 MIN

EFF WORKING TIME: 410.1 MIN

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 LOWERING SUPPORT MAN	1 M-MIN	2 ADVANCING SUPPORT MAN	2 M-MIN	3 PRESSURIZE SUPPORT + CANTILEVER MAN	3 M-MIN	4 WALKING TO THE NEXT SUPPORT MAN	4 M-MIN	5 CLEANING UP BETWEEN SUPPORT MAN	5 M-MIN	6 CRUSHING BIG CHUNKS MAN	6 M-MIN	7 PUTTING TIMBER ON TOP OF CANOPY MAN	7 M-MIN	8 WALKING TO NEXT RAM MAN	8 M-MIN	9 OPERATING CONVEYOR RAM MAN	9 M-MIN	10 MOVING MAINGATE DRIVES MAN	10 M-MIN	11 MOVING TAILGATE DRIVE MAN	11 M-MIN	12 WAITING TIME MAN	12 M-MIN	13 STRAIGHTENING PAN LINE MAN	13 M-MIN	14 RAISING CANTILEVER PREVENTING PRESS TO LEGS MAN	14 M-MIN	15 OTHERS MAN	15 M-MIN	REMARKS
(CONT'D)		[illegible]		4.9		4.9		4.9		4.9		20		25				4.9		4.9						20	.					41	
8	44																1	.1															
																			1	.1													RAMS OPERATED FOR MOVING
8	[illegible]																1	.1															THE CONVEYOR
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1							1	1.1							
8	47																		1	.2													
									1	.1																							RAMS OPERATED FOR ADVANCING
			1	.1		.1																			1	.1							THE CHOCKS
							1	.1									1	.1															
									1	.1									1	.1													
			1	.1		.1																			1	.1							
							1	.1									1	.1															
									1	.1									1	.1													
			1	.1		.1																			1	.1							
8	43						1	.1									1	.1															REPEATED 6 X
			1	.6		.6	1	.6	1	.6							1	.6	1	.6					1	12.6							
											1	12																					
9	22																																
		1.6	1	.9		.9	1	.9	1	.9	1	12					1	1.7	1	1.7					1	14							
		21.5		5.8		5.8		5.8		5.8		32		25				6.6		6.6						34						41	

MOTION STUDY NO: 3	PAGE NO: 3	DATE: 9-10-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			
SUPPORT & CONVEYOR			
MAN-TRIP: 27/41 MIN			
LUNCH: 30 MIN			
EFF WORKING TIME: 410.1 MIN			

ADVANCING TIME #	ADVANCING TIME MIN	EFF TIME MIN	1 LOWERING SUPPORT MAN	1 M-MIN	2 ADVANCING SUPPORT MAN	2 M-MIN	3 PRESSURIZE SUPPORT + CANTILEVER MAN	3 M-MIN	4 WALKING TO THE NEXT SUPPORT MAN	4 M-MIN	5 CLEANING UP BETWEEN SUPPORT MAN	5 M-MIN	6 CRUSHING BIG CHUNKS MAN	6 M-MIN	7 PUTTING TIMBER ON TOP OF CANOPY MAN	7 M-MIN	8 WALKING TO NEXT RAM MAN	8 M-MIN	9 OPERATING CONVEYOR RAM MAN	9 M-MIN	10 MOVING MAINGATE DRIVES MAN	10 M-MIN	11 MOVING TAILGATE DRIVE MAN	11 M-MIN	12 WAITING TIME MAN	12 M-MIN	13 STRAIGHTING PAN LINE MAN	13 M-MIN	14 RAISING CANTI-LEVER PREVENTING PRESS TO LEGS MAN	14 M-MIN	15 OTHERS MAN	15 M-MIN	REMARKS
(CONT'D)		81.5		5.8		5.8		5.8		5.8		32		2.5				6.6		6.6						34				41			
2	12																																
2	25	3									2	6																					
2	25	.1	1	.1		.2																			1	.4							ADVANCING CHOCKS AT THE HEAD GATE
		.2																															
		.1					1	.1																									
		.4	1	.35		.35																			1	.1							
2	[illegible]	.1					1	.1																	1	.4							
2	10	4									1	4													1	4							
2	20	10																							2	20							
2	42	22									2	44																					
									1	.1							1	.1															
																			1	.1					1	.1							1. CHOCKS
			1	.1		.1																			1	.1							
							1	.1																					1	.1			
		.6					1	.1																	1	.1							
		.1							1	.1							1	.1															
																			1	.1													
2	427		1	.55		.35	1	.4	1	.2	5	54					1	.2	1	.2					1	25.2			1	.1			
		122.2		6.35		6.45		6.2		6.0		86		2.5				6.8		6.8						59.2				41.1			

MOTION STUDY NO: 3	PAGE NO: 4	DATE: 9-10-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 25/41 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 410.1 MIN

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 LOWERING SUPPORT		2 ADVANCING SUPPORT		3 PRESSURIZE SUPPORT + CANTILEVER		4 WALKING TO THE NEXT SUPPORT		5 CLEANING UP BETWEEN SUPPORT		6 CRUSHING BIG CHUNKS		7 PUTTING TIMBER ON TOP OF CANOPY		8 WALKING TO NEXT RAM		9 OPERATING CONVEYOR RAM		10 MOVING MAINGATE DRIVES		11 MOVING TAILGATE DRIVE		12 WAITING TIME		13 STRAIGHTING PAN LINE		14 RAISING CANTI-LEVER PREVENTING PRESS TO LEGS		15 OTHERS		REMARKS
H	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)		122.2		[illegible]		[illegible]		5.2		6		86		25				6.8		6.5						59						41.1	
9	[illegible]								1	.1									1	.1					1	.1							2. CHOCK
9	[illegible]		1	.1		.1																			1	.1							
							1	.1																					1	.1			
							1	.1																	1	.1							
									1	.1							1	.1															3. CHOCK
																			1	.1					1	.1							
									1	.1															1	.1							REPEATED 46x
			1	.1		.1																			1	.1							
							1	.1																					1	.1			
							1	.1																	1	.1							
10	10	27.3	1	4.6		4.6	1	9.2	1	9.2							1	4.6	1	4.6					1	18.5			1	4.6			
		.9									1	1.9																					
																	1	.1															WHEN THE SHEARER HAS PASSED
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
											1	.1									1	1											
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
10	17																																REPEATED 13x
																	1	1.3	1	1.3					1	3.8							
		34.4	1	4.8		4.8	1	9.6	1	9.5	1	2.5					1	6.6	1	6.7		1			1	23			1	4.8			
		153.6		11.15		11.25		15.8		15.5		88.8		25				13.4		13.5		1				82.2				4.8		41.1	

MOTION STUDY NO: 3	PAGE NO: 5	DATE: 9-10-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 22/41 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 430.1 MIN

Activities: 1 LOWERING SUPPORT; 2 ADVANCING SUPPORT; 3 PRESSURIZE SUPPORT + CANTILEVER; 4 WALKING TO THE NEXT SUPPORT; 5 CLEANING UP BETWEEN SUPPORT; 6 CRUSHING BIG CHUNKS; 7 PUTTING TIMBER ON TOP OF CANOPY; 8 WALKING TO NEXT RAM; 9 OPERATING CONVEYOR RAM; 10 MOVING MAINGATE DRIVES; 11 MOVING TAILGATE DRIVE; 12 WAITING TIME; 13 STRAIGHTING PAN LINE; 14 RAISING CANTI-LEVER PREVENTING PRESS TO LEGS; 15 OTHERS

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		154.6		11.15		[illegible]		15.9		15.5		88.5		25				13.4		18.5		1				[illegible]				4.6		41.1	
10	17																																
.0	22	5																							2	10							MAINTENANCE AT HEADGATE, NO
10	22	15									2	30																					EMPTY CARS
									1	.1							1	.1															
																			1	.1					1	.1							
			1	.1		.1																			1	.1							
							1	.1																					1	.1			
							1	.1																	1	.1							REPEATED 48X
11	[illegible]	24.5	1	4.8		4.8	1	9.6	1	4.8							1	4.8	1	4.8					1	14.4				4.8			
11	04	3									1	6																					
11	25	1																							2	2							
									1	.1							1	.1															MACHINE LEAVES HEADGATE
																			1	.1					1	.1							
									1	.1															1	.1							
			1	.1		.1																			1	.1							MOVING THE LAST CHOCKS OF THE FACE
							1	.1																					1	.1			
							1	.1																	1	.1							REPEATED 7X
[illegible]	[illegible]	[illegible]	1	.7		.7	1	1.4	1	1.4							1	.7	1	.7													
																	1	.1															WHEN SHEARER HAS PASSED
																			1	.1													
																	1	.1															REPEATED 17X
																			1	.1													
																	1	1.7							1	3.4							
11	[illegible]	[illegible]																	1	1.7													
11	21	8.2									2	17.5																					
		64.0	1	5.7		5.7	1	11.4	1	6.5	2	13.8					1	7.6	1	7.6					2	[illegible]			1	5			
		220.6		16.55		16.55		27.2		22		142.6		25				21		21.1		1				127.7				9.6		41.1	

MOTION STUDY NO: 3 | PAGE NO: [illegible] | DATE: 9-10-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 2 | OBSERVER: HOLDEFLEISS

PANEL: 15TH RIGHT

SUPPORT & CONVEYOR

MAN-TRIP: [illegible] MIN

LUNCH: 30 MIN

EFF WORKING TIME: [illegible] MIN

ADVANCING TIME		EFF TIME	1 LOWERING SUPPORT		2 ADVANCING SUPPORT		3 PRESSURIZE SUPPORT + CANTILEVER		4 WALKING TO THE NEXT SUPPORT		5 CLEANING UP BETWEEN SUPPORT		6 CRUSHING BIG CHUNKS		7 PUTTING TIMBER ON TOP OF CANOPY		8 WALKING TO NEXT RAM		9 OPERATING CONVEYOR RAM		10 MOVING MAINGATE DRIVES		11 MOVING TAILGATE DRIVE		12 WAITING TIME		13 STRAIGHTING PAN LINE		14 RAISING CANTI-LEVER PREVENTING PRESS TO LEGS		15 OTHERS		REMARKS
H	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)		220.3		[illegible]		[illegible]		[illegible]		22.0		[illegible]		[illegible]				21.0		[illegible]		[illegible]				[illegible]				[illegible]		[illegible]	
11	[illegible]		1	0.1		0.1					1	0.1																					ADVANCING THE HEAD GATE
							1	0.1																									CHOCKS
									1	0.1																							
			1	0.1		0.1																											
11	[illegible]	.5					1	0.1																									
11	[illegible]	1.0																													2	2.0	TRANSPORT OF WOOD
11	[illegible]	[illegible]																													2	[illegible]	BUILDING WOODEN CRIBS
		[illegible]																							2	2.0							
		[illegible]																							1	1.0					1	1.0	ALIGNING FACE CONVEYOR BY
		[illegible]																							2	[illegible]							THE RAMS
									1	0.1							1	0.1															
																			1	0.1					1	0.1							
									1	0.1															1	0.1							SHEARER ARRIVES AT HEAD
			1	0.1		0.1																			1	0.1							GATE
							1	0.1																	1	0.1							REPEATED 48 X
[illegible]	[illegible]	[illegible]	1	[illegible]		[illegible]	1	[illegible]	1	[illegible]							1	[illegible]	1	[illegible]					1	[illegible]							
[illegible]	[illegible]	[illegible]																							2	5.0							
		[illegible]																							2	[illegible]							
	[illegible]	[illegible]									2	[illegible]																					
									1	0.1							1	0.1															SHEARER LEAVES HEAD GATE
																			1	0.1					1	0.1							←—
									1	0.1															1	0.1							ADVANCING THE LAST CHOCKS
			1	0.1		0.1																			1	0.1							OF THE FACE
							1	0.1																	1	0.1							REPEATED 5 X
[illegible]	[illegible]	[illegible]	1	0.5		0.5	1	0.5	1	1.0							1	0.5	1	0.5					1	[illegible]							
[illegible]	[illegible]	[illegible]									2	6.0																					
		[illegible]	1	5.7	1	5.7	1	5.7	1	11.1	2	[illegible]													2	[illegible]					2	2.2	
		[illegible]		[illegible]		[illegible]		[illegible]		33.1		[illegible]		25.0				26.5		[illegible]		1.0				[illegible]				[illegible]		[illegible]	

MOTION STUDY NO: 3	PAGE NO: 7	DATE: 9-10-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 2		OBSERVER: HOLDEFLEISS
PANEL: 15TH RIGHT			

SUPPORT & CONVEYOR
MAN-TRIP: 28/40 MIN
LUNCH: 30 MIN
EFF WORKING TIME: 410 MIN

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 LOWERING SUPPORT MAN	1 M-MIN	2 ADVANCING SUPPORT MAN	2 M-MIN	3 PRESSURIZE SUPPORT + CANTILEVER MAN	3 M-MIN	4 WALKING TO THE NEXT SUPPORT MAN	4 M-MIN	5 CLEANING UP BETWEEN SUPPORT MAN	5 M-MIN	6 CRUSHING BIG CHUNKS MAN	6 M-MIN	7 PUTTING TIMBER ON TOP OF CANOPY MAN	7 M-MIN	8 WALKING TO NEXT RAM MAN	8 M-MIN	9 OPERATING CONVEYOR RAM MAN	9 M-MIN	10 MOVING MAINGATE DRIVES MAN	10 M-MIN	11 MOVING TAILGATE DRIVE MAN	11 M-MIN	12 WAITING TIME MAN	12 M-MIN	13 STRAIGHTING PAN LINE MAN	13 M-MIN	14 RAISING CANTILEVER PREVENTING PRESS TO LEGS MAN	14 M-MIN	15 OTHERS MAN	15 M-MIN	REMARKS
(CONT'D)		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]				[illegible]		[illegible]		1				[illegible]				[illegible]		[illegible]	
[illegible]	[illegible]																1	.2							1	1							
																			1	.2	1	.1											
																	1	.1															
																			1	.1													
																	1	.1															
																			1	.1													
																	1	.1															FOLLOWING THE SHEARER
13	[illegible]	1																	1	.1													
																	1	1.5															REPEATED 15X
[illegible]	[illegible]	3									1	3							1	1.5													
									1	.1							1	.1															
																			1	.1					1	.1							
									1	.1															1	.1							
			1	.1		.1																			1	.1							ADVANCING HEXAGATE CHOCKS
							1	.1									1	.1															
									1	.1									1	.1													
			1	.1		.1																			1	.1							
[illegible]	[illegible]	.5					1	.1																	1	.1							
13	[illegible]	[illegible]									2	[illegible]																					
13	[illegible]	2																											2	[illegible]			
13	37	9									2	18																					
13	[illegible]	17																							2	[illegible]							
		50	1	.2		.2	1	.2	1	.3	2	41.4					1	2.2	1	2.2	1	.1			2	35.5			2	15			
		373.1		[illegible]		22.65		33.1		33.4		[illegible]						23.7		28.5		1.1				265.2				27.8		73.1	

MOTION STUDY NO: 3 | PAGE NO: 8 | DATE: 9-10-74 | TIME FROM: 7⁰⁰ TO: 15⁰⁰ (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 2 | OBSERVER: HOLDEFLEISS

PANEL: 15TH RIGHT

SUPPORT & CONVEYOR

MAN-TRIP: 27/31 MIN

LUNCH: 30 MIN

EFF WORKING TIME: 419.1 MIN

ADVANCING TIME		EFF TIME	1 LOWERING SUPPORT		2 ADVANCING SUPPORT		3 PRESSURIZE SUPPORT + CANTILEVER		4 WALKING TO THE NEXT SUPPORT		5 CLEANING UP BETWEEN SUPPORT		6 CRUSHING BIG CHUNKS		7 PUTTING TIMBER ON TOP OF CANOPY		8 WALKING TO NEXT RAM		9 OPERATING CONVEYOR RAM		10 MOVING MAINGATE DRIVES		11 MOVING TAILGATE DRIVE		12 WAITING TIME		13 STRAIGHTENING PAN LINE		14 RAISING CANTILEVER PREVENTING PRESS TO LEGS		15 OTHERS		REMARKS
H	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]				[illegible]		[illegible]		1.1				[illegible]				[illegible]		[illegible]	
12	[illegible]								1	.1							1	.1															
																			1	.1									1	.1			
									1	.1															1	.1							
			1	.1		.1																			1	.1							
							1	.1																					1	.1			
							1	.1																	1	.1							REPEATED 4.9X
[illegible]	[illegible]	[illegible]	1	3.8		3.8	1	3.9	1	3.4							1	4.5	1	4.9					1	14.4			1	3.4			
									1	.1																							SHEARER LEAVES HEADGATE DURING
			1	.1		.1																											THE LAST CHOCKS IN THE FACE
							1	.1																									REPEATED 7X
14	[illegible]	2.4	1	.7		.7	1	.7	1	.7																							
											1	.5					1	.1			1	.1											
																			1	.1													
																	1	.1															
																			1	.1													REPEATED 13X
																	1	1.3															
[illegible]	[illegible]	3																	1	1.3													
									1	.1	1	.25																					ADVANCING HEADGATE CHOCKS
			1	.1		.1																											
							1	.1																									
									1	.1																							
			1	.1		.1																											
		2.2					1	.1																	1	.5							
14	[illegible]	.57	1	5.9		5.9	1	3.9	1	12.9	1	6.5					1	4.4	1	6.4	1	.1			1	13.2			1	3.6			
		419.1		32.6		32.9		48.5		48.2		20.1		2.5				59.1		53.2		1.2				274.4				57.7		73.1	

APPENDIX B-4

Motion Study No. 4

Activities at the Tailgate Corner

MOTION STUDY NO: 4	PAGE NO: 1	DATE: 9-9-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 3		OBSERVER: LENSING-HERBEN
PANEL: 15TH RIGHT			

TAILGATE CORNERMAN
MAN-TRIP: 34/25 MIN
LUNCH: 36 MIN
EFF WORKING TIME: 375 MIN

Activities: 1 = CLEAN FACE SIDE (4 CHOCKS); 2 = CLEAN GOB SIDE (4 CHOCKS); 3 = CLEAN FRONT OF DRIVE; 4 = ADVANCE OF DRIVE (4 CHOCKS); 5 = PULL THE FIRST CHOCK; 6 = PULL THE SECOND CHOCK; 7 = PULL THE THIRD CHOCK; 8 = PULL THE FOURTH CHOCK; 9 = KEEP TIMBER READY OR PICK IT UP; 10 = MEASURE METHANE; 11 = HANG UP CURTAIN; 12 = COVER GATE FLOOR WITH ROCK DUST; 13 = WAITING TIME; 14 = OTHERS; 15

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)																																	
7	34																																
7	52	18	1	18																	2	26											
7	56	4											2	8							1	4											
8	00	4			1	4	1	4																									
8	02	2									2	4																					
8	04	2																	2	4													
8	10	6			1	6															1	6											
8	12	2							2	4																							WITH 4 RAMS
8	20	8																			1	8					1	8					
8	48	28																					1	52			2	56					
9	05	17			1	17															1	17			1	17							
9	10	5																			1	5			1	5	1	5					
9	14	4																			1	4					2	8					
9	16	2																									3	6					
9	18	2																											3	6			PUT TIMBER OFF THE SHEARER
9	27	9																									3	27					SHEARER CUTS AT TAILGATE
9	30	3											1	3					2	6													PICK UP TIMBER ON THE CANTILEVER
9	33	3																									2	6					
																	1	1															
															1	1																	
											1	1																					
		119		18		27		4		4		5		11		1		1		10		30		52		22		116		6			

TIME STUDY NO: 4 | PAGE NO: 2 | DATE: 9-9-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 3 | OBSERVER: LENSING-HEBBEN

LEVEL: 15TH RIGHT

TAILGATE CORNERMAN
MAN-TRIP: [illegible] MIN
LUNCH: 36 MIN
EFF WORKING TIME: 275 MIN

TIME		EFF TIME	1 CLEAN FACE SIDE (4 CHOCKS)		2 CLEAN GOB SIDE (4 CHOCKS)		3 CLEAN FRONT OF DRIVE		4 ADVANCE OF DRIVE (4 CHOCKS)		5 PULL THE FIRST CHOCK		6 PULL THE SECOND CHOCK		7 PULL THE THIRD CHOCK		8 PULL THE FOURTH CHOCK		9 KEEP TIMBER READY OR PICK IT UP		10 MEASURE METHANE		11 HANG UP CURTAIN		12 COVER GATE FLOOR WITH ROCK DUST		13 WAITING TIME		14 OTHERS		15		REMARKS
H	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)		119		18		27		4		4		5		11		1		1		10		80		52		27		115		6			
9	59	26	3	78																													PICK AND SHOVEL THE COAL
10	10	11																															
																													3	33			DRILL 2 HOLES WITH AIR HAMMER;
																																	SHEARER DID NOT CUT THE CORNER
10	22	12																															
																													3	30			PREPARE BLASTING AND BLAST THE
																																	COAL AT THE CORNER OF THE FACE
10	45	25	3	75																													
10	47	2							2	4																	1	2					20" ADVANCING
10	48	1															1	1															
10	49	1													1	1																	
10	50	1											1	1																			
10	51	1									1	1																					
10	52	1			2	10			1	1																							7" ADVANCING
10	54	2																	2	4	1	2											
11	30	35																											3	105			LUNCH
11	50	20			2	40															1	20											
12	00	10																							1	10	2	20					
12	9	9																									3	27					SHEARER AT THE TAILGATE PICK UP
12	12	3											1	3					2	6													TIMBER AND CORRECT THE POSITION
12	14	2											1	1					2	4							1	1					OF THE TIMBER
12	15	1															1	1									2	2					
	16	1													1	1											2	2					
	17	1									1	1															2	2					
12	43	26	3	78																													
		140/309		231/249		56/77		4		5/9		2/7		5/16		2/3		2/3		14/24		22/102		52		10/37		58/172		171/172			

[illegible] STUDY NO: 4 | PAGE NO: 3 | DATE: 9-9-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

[illegible]: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 3 | OBSERVER: LENSING-HEBBEN

[illegible]: 15TH RIGHT

TAILGATE CORNERMAN
[illegible]-TRIP: [illegible] MIN
LUNCH: 35 MIN
EFF WORKING TIME: 375 MIN

1. CLEAN FACE SIDE (4 CHOCKS)
2. CLEAN GOB SIDE (4 CHOCKS)
3. CLEAN FRONT OF DRIVE
4. ADVANCE OF DRIVE (4 CHOCKS)
5. PULL THE FIRST CHOCK
6. PULL THE SECOND CHOCK
7. PULL THE THIRD CHOCK
8. PULL THE FOURTH CHOCK
9. KEEP TIMBER READY OR PICK IT UP
10. MEASURE METHANE
11. HANG UP CURTAIN
12. COVER GATE FLOOR WITH ROCK DUST
13. WAITING TIME
14. OTHERS
15.

[illegible] TIME H	MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		[illegible]		242		77		4		9		7		16		3		3		24		102		52		32		172		177			
12	45	2							2	4											1	2											22''
12	48	3			3	9																											
12	49	1															1	1															
12	50	1													1	1																	
12	51	1											1	1																			
12	52	1									1	1																					
12	53	1			1	5	1	5	1	1																							5''
12	55	2			1	5					1	1	1	1					2	4													CORRECT NO. 1 & 2 CHOCKS AND
13	00	5	1	5																									1	5			PUSH THE CONVEYOR FROM CHOCK 5-
																																	10 (CORRECTING)
13	22	2							1	2																			2	4			SET A SINGLE ANCHOR LEG AT THE
																																	FACE SIDE
13	23	24																									3	72					
13	27	1																											3	3			TAKE TIMBER OFF THE SHEARER
13	27	10																									3	30					SHEARER AT THE TAILGATE
13	39	2											1	2													2	4					
13	41	2											1	1					2	4							1	1					PRESSURE TO NO. 2 CHOCK
13	42	0.7															1	0.7															
13	42	0.7													1	0.7																	
13	43	0.6	2	4							1	0.6																					
14	06	23	3	69																													
14	27	1																									1	1	2	2			PUT AWAY SINGLE LEG
14	39	2							2	4											1	2											21''
		35 / 325		75 / 327		17 / 95		5 / 9		11 / 20		2.6 / 9.6		5 / 21		1.7 / 4.7		1.7 / 4.7		8 / 32		4 / 104		52		32		103 / 232		14 / 191			

MOTION STUDY NO: 4	PAGE NO: 4	DATE: 9-9-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 3		OBSERVER: LENSING-HEBBEN
PANEL: 15TH RIGHT			

TAILGATE CORNERMAN
MAN-TRIP: 35/35 MIN
LUNCH: 35 MIN
EFF WORKING TIME: 375 MIN

Activities: 1 CLEAN FACE SIDE (4 CHOCKS); 2 CLEAN GOB SIDE (4 CHOCKS); 3 CLEAN FRONT OF DRIVE; 4 ADVANCE OF DRIVE (4 CHOCKS); 5 PULL THE FIRST CHOCK; 6 PULL THE SECOND CHOCK; 7 PULL THE THIRD CHOCK; 8 PULL THE FOURTH CHOCK; 9 KEEP TIMBER READY OR PICK IT UP; 10 MEASURE METHANE; 11 HANG UP CURTAIN; 12 COVER GATE FLOOR WITH ROCK DUST; 13 WAITING TIME; 14 OTHERS; 15

ADVANCING TIME H	MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		335		327		96		12		20		9.6		21		4.7		4.7		32		106		52		32		282		191			
14	12	3			2	6	1	3																									
14	12	0.6															1	0.6															
14	12	0.6													1	0.6																	
14	13	0.6											1	0.6																			
14	14	0.6									1	0.6																					
14	15	0.6			1	3	1	3	1	0.6																							6"
14	[illegible]	10																									3	30					
15	00																																MAN-TRIP
		76 / 411		327		9 / 105		3 / 15		0.6 / 20.6		0.6 / 10.2		0.6 / 21.6		0.6 / 5.3		0.6 / 5.3		32		106		52		32		30 / 312		191			

APPENDIX B-5

Motion Study No. 5

Activities at the Headgate Corner

MOTION STUDY NO: 5 | PAGE NO: 1 | DATE: 9-10-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: SALVIS

PANEL: 15TH RIGHT

HEADGATE CORNERMAN
MAN-TRIP: 61 MIN
LUNCH: 24 MIN
EFF WORKING TIME: 419 MIN

OBSERVE THE OPERATION

ADVANCING TIME		EFF TIME	1 STAY IN PLACE		2 CRUSH BIG CHUNKS		3 TAIL SITE CLEAN UP STAGE LOADER		4 HEAD SITE CLEAN UP FACE CONVEYOR		5 WATER TO THE FACE ON-OFF-REGULATE		6 ADVANCE LINES		7 OTHERS		8 STOP FACE CONVEYOR		9 STOP FACE CONVEYOR CRUSH BIG CHUNKS		10 STOP FACE CONVEYOR AND STAGE LOADER		11 INFORM FACE CREW START CONVEYOR		12 OTHERS		13 WALKING TO THE NEXT JOB		14 WAIT		15		REMARKS
#	MIN	MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	MAN	M-MIN	
(CONT'D)																																	
7	32																																
	36	2.0																									1	2.0					ASSIGNED TO TRANSPORT CREEPS WOOD.
	33	5.0																							1	5.0							TRANSPORT CREEPS WOOD.
	41	2.0																									1	2.0					TO HIS ORIGINAL JOB.
	54	13.0																							1	13.0							CHECK BITS OF THE SHEARER & CHANGE
																					1	0.1											SOME
			1	1.4																													
					1	0.1																											
8	05	11.0	1	9.4																													
																							1	0.1									CALL UP THE LOADER HEAD. FIND REASON FOR
																					1	0.1											STOPPING
					1	1.7																											
8	07	2.0																	1	0.1													LARGE CHUNKS, JAMBED UP.
	25	18.0	1	18.0																			1	—									
	34	9.0																								9.0							HELP WELDER WELD'G PART ON SHEARER
	35	1.0																							1	1.0							PUT OIL IN TRANSMISSION OF SHEARER
	[illegible]	[illegible]																							1	3.0							TRANSPORT CREEP STOCKS ACROSS
	—	—																															STAGE LOADER
	46	8.0																											1	8.0			WAITING TO FINISH WELDING.
																					1	0.1											
8	48	2.0					1	1.9																									
	50	2.0											1	2.0																			
	59	9.0	1	9.0																													
9	01	2.0													1	2.0																	FILL UP HYDRAULIC TANK.
	05	4.0	1	4.0																													
	07	2.0								2.0																							
	16	9.0	1	9.0																													
	17	1.0													1	1.0																	TRANSPORT CREEP STOCKS ACROSS
	30	13.0	1	12.9															1	0.1													STAGE LOADER.
9	35	5.0																											1	5.0			PUT'G TIMBER ON CANOPY @ TAIL GATE
		123.0		63.7		1.8		1.9		2.0				2.0		3.0				0.2				0.3		31.1		4.0		13.0			

MOTION STUDY NO: 5 | PAGE NO: 2 | DATE: 9-10-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: SALVIS

PANEL: 15TH RIGHT

HEADGATE CORNERMAN
MAN-TRIP: 61 MIN
LUNCH: 24 MIN
EFF WORKING TIME: 419 MIN

OBSERVE THE OPERATION

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 STAY IN PLACE MAN	1 M-MIN	2 CRUSH BIG CHUNKS MAN	2 M-MIN	3 TAIL SITE CLEAN UP STAGE LOADER MAN	3 M-MIN	4 HEAD SITE CLEAN UP FACE CONVEYOR MAN	4 M-MIN	5 WATER TO THE FACE ON-OFF-REGULATE MAN	5 M-MIN	6 ADVANCE LINES MAN	6 M-MIN	7 OTHERS MAN	7 M-MIN	8 STOP FACE CONVEYOR MAN	8 M-MIN	9 STOP FACE CONVEYOR CRUSH BIG CHUNKS MAN	9 M-MIN	10 STOP FACE CONVEYOR AND STAGE LOADER MAN	10 M-MIN	11 INFORM FACE CREW START CONVEYOR MAN	11 M-MIN	12 OTHERS MAN	12 M-MIN	13 WALKING TO THE NEXT JOB MAN	13 M-MIN	14 WAIT MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		23.0		63.7		1.8		1.9		2.0				2.0		3.0				0.2				0.3		31.1		4.0		13.0			
9	35																																
	43	14.0	1	14.0																													
	50	1.0																	1	1.0													
																					1	0.5											CRUSH LARGE CHUNKS
			1	3.0																													
9	54	4.0																					1	—	1	0.5							STOP STAGE LOADER & FACE CONVEYOR,
																																	CHECK BELT CONVEYOR.
			1	4.6																													
																					1	0.3											
9	61	5.0																					1	0.1									
10	02	3.0	1	3.0																													
												0.1																					WATER TURNED OFF.
	07	5.0																												4.9			W. FOR WATER, SPRAY NOZZLE ON SHEARER
																					1	0.2											
	15	8.0		7.8																													
																									1	0.5							CUT OFF WATER
	21	6.0																							1	5.5							BLASTING @ TAIL GATE
																							1	0.1									POWER BACK TO FACE.
					1	1.0																											
10	31	10.0	1	8.9																													
					1	0.1																											
	41	10.0		9.9																													
				2.8																													
	44	5.0																			1	0.2	1	—									
						6.8																											
	51	7.0																				0.2											
			1	2.8																													
10	54	3.0									1	0.2																					REGULATE THE WATER, SHEARING
																																	@ TAIL GATE.
		79.0		56.8		7.9						0.3								1.0		1.4		0.2		6.5				4.9			
		202.0		120.5		9.7		1.9		2.0		0.3		2.0		3.0				1.2		1.4		0.5		37.6		4.0		17.9			

MOTION STUDY NO: 5	PAGE NO: 3	DATE: 9-10-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE — SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: SALVIS
PANEL: 15TH RIGHT			

HEADGATE CORNERMAN
MAN-TRIP: 61 MIN
LUNCH: 24 MIN
EFF WORKING TIME: 419 MIN

OBSERVE THE OPERATION

Operations: 1 STAY IN PLACE; 2 CRUSH BIG CHUNKS; 3 TAIL SITE CLEAN UP STAGE LOADER; 4 HEAD SITE CLEAN UP FACE CONVEYOR; 5 WATER TO THE FACE ON-OFF-REGULATE; 6 ADVANCE LINES; 7 OTHERS; 8 STOP FACE CONVEYOR; 9 STOP FACE CONVEYOR CRUSH BIG CHUNKS; 10 STOP FACE CONVEYOR AND STAGE LOADER; 11 INFORM FACE CREW START CONVEYOR; 12 OTHERS; 13 WALKING TO THE NEXT JOB; 14 WAIT; 15

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		202.0		120.5		9.7		1.9		2.0		0.3		2.0		3.0				1.2		1.4		0.5		37.6		4.0		17.9			
10	54																																
10	57	3.0															1	–							1	3.0							MANUVERING CARS@LOADER HEAD.
																																	CHANGE HYDRAULIC PROPS
																							1	0.1									
												0.2																					REGULATE THE WATER.
11	05	8.0		7.7																													
11	10	5.0							1	5.0																							
		16.0		7.7						5.0		0.2												0.1		3.0							
		218.0		128.2		9.7		1.9		7.0		0.5		2.0		3.0				1.2		1.4		0.6		40.6		4.0		17.9			

MOTION STUDY NO: 5 | PAGE NO: 4 | DATE: 9-10-74 | TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS

MINE: SUNNYSIDE | SEAM: LOWER SUNNYSIDE SEAM | MANPOWER OBSERVED: 1 | OBSERVER: SALVIS

PANEL: 15TH RIGHT

HEADGATE CORNERMAN
MAN-TRIP: 61 MIN
LUNCH: 24 MIN
EFF WORKING TIME: 419 MIN

OBSERVE THE OPERATION

1 = STAY IN PLACE; 2 = CRUSH BIG CHUNKS; 3 = TAIL SITE CLEAN UP; 4 = STAGE LOADER HEAD SITE; 5 = CLEAN UP FACE CONVEYOR; 6 = WATER TO THE FACE ON-OFF-REGULATE; 7 = ADVANCE LINES; 8 = OTHERS; 9 = STOP FACE CONVEYOR; 10 = STOP FACE CONVEYOR CRUSH BIG CHUNKS; 11 = STOP FACE CONVEYOR AND STAGE LOADER; 12 = INFORM FACE CREW START CONVEYOR; 13 = OTHERS; 14 = WALKING TO THE NEXT JOB; 15 = WAIT

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		219		23.3		2.7		1.9		7		0.5		2		3				1.2		1.4		0.6		40.6		4		17.4			
11	2	3	1	3																													
11	[illegible]	2												2																			
11	[illegible]	4	1	4																													
11	22	9																											1	9			STOP, WAIT, NO EMPTY CANS
11	[illegible]	17	1	17																													
11	[illegible]	1					1	1																									
11	[illegible]	1									1	1																					ADJUST WATER AMOUNT; TURN OFF
11	[illegible]	3																											1	3			PUT THE TIMBER ON THE
																							1	.1									CANOPY
																									1	.2							TURN ON THE WATER
11	[illegible]	[illegible]	1	2.7																													
12	[illegible]	15	1	13																													
12																									1	.1							STOP THE CONVEYORS
12																									1	.1							CUT OFF THE POWER
12																									1	.1							TURN OFF THE WATER
12	[illegible]	8																												7.7			REASON UNKNOWN; AT TAILGATE
12																							1	.1									
12	[illegible]	1	1	5.9																													
12	[illegible]	24																								24							LUNCH BREAK
13	[illegible]	21					1	21																									
13	[illegible]	9	1	17										3																			
13	[illegible]	17																															
												0.1																					
13	[illegible]	4																											1	2.9			FROM LOADER HEAD, PROBLEM
13	[illegible]																						1	.1									ON SPROCKET
13	[illegible]	5	1	41.0																													
13	[illegible]	1	1	5																													
																								.1									
13	[illegible]	5																											1	4.9			WAITING TO PUT TIMBER ON
																																	THE CANOPY AT TAILGATE
		54		[illegible]				22				1.1		5										.4		24.5				28.5			
		273		[illegible]		2.7		23.9		7		1.6		7		3				1.2		1.4		1.0		65.1		4		46.[illegible]			

MOTION STUDY NO: 5		PAGE NO: 5	DATE: 9-10-74	TIME FROM: 700 TO: 1500 (SHIFT-TIME) 8 HRS
MINE: SUNNYSIDE	SEAM: LOWER SUNNYSIDE SEAM	MANPOWER OBSERVED: 1		OBSERVER: SALVIS
PANEL: 15TH RIGHT				

HEADGATE CORNERMAN
MAN-TRIP: 61 MIN
LUNCH: 24 MIN
EFF WORKING TIME: 419 MIN

OBSERVE THE OPERATION: 1 = STAY IN PLACE; 2 = CRUSH BIG CHUNKS; 3 = TAIL SITE CLEAN UP STAGE LOADER; 4 = HEAD SITE CLEAN UP FACE CONVEYOR; 5 = WATER TO THE FACE ON-OFF-REGULATE; 6 = ADVANCE LINES; 7 = OTHERS; 8 = STOP FACE CONVEYOR; 9 = STOP FACE CONVEYOR CRUSH BIG CHUNKS; 10 = STOP FACE CONVEYOR AND STAGE LOADER; 11 = INFORM FACE CREW START CONVEYOR; 12 = OTHERS; 13 = WALKING TO THE NEXT JOB; 14 = WAIT; 15 =

ADVANCING TIME H	ADVANCING TIME MIN	EFF TIME MIN	1 MAN	1 M-MIN	2 MAN	2 M-MIN	3 MAN	3 M-MIN	4 MAN	4 M-MIN	5 MAN	5 M-MIN	6 MAN	6 M-MIN	7 MAN	7 M-MIN	8 MAN	8 M-MIN	9 MAN	9 M-MIN	10 MAN	10 M-MIN	11 MAN	11 M-MIN	12 MAN	12 M-MIN	13 MAN	13 M-MIN	14 MAN	14 M-MIN	15 MAN	15 M-MIN	REMARKS
(CONT'D)		373		201.7		8.7		23.9		7		1.6		7		3				1.2		1.4		1		65.1		4		46.3			
13	50	5	1	5																													
13	53	3																											1	3			STOP WHOLE SYSTEM REPAIR
13	56	2																	1	3			1										SPROCKET AT LOADER HEAD
13	58	2			1	2																											
14	00	1	1	1																													
14	[illegible]	6	1	5																													
14	06	1			1	1																											
											1	.1																					TURN WATER OFF SHEARER AT
											1	.1																					TAILGATE
14	[illegible]	5							1	4.8																							TURN WATER ON SHEARER AT
14	[illegible]	6								6																							TAILGATE
14	[illegible]	2														2																	SET SHEARED TIMBER OUT OF
[illegible]	[illegible]	2											1	2																			CONVEYOR
[illegible]	[illegible]	10	1	10																													
		46		21		4				10.8		.2		2		2				3										3			
		419		222.7		12.7		23.9		17.8		1.8		9		5				4.2		1.4		1		65.1		4		49.3			

APPENDIX C

Automated Longwall - Related Bureau Of Mines Research

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts

A. MINING SYSTEMS

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Master Environmental Control & Mine System Design Simulator for Underground Coal Mines"	G. Schottler DMRC	G0111606 Penn State University $434,729	6/1/71 39 mo 9/1/74	Current contract.
2.	"Systems Analysis of an Inherently Explosion-Proof Coal Mining Operation"	T. Johnson MSED PB211980	H0110079 Westinghouse Electric Corp. $109,642	7/24/70 14 mo 9/24/71	COMINEC library.
3.	"Inherently Safe Mining Systems"	D. Rogisch WO	H0111670 FMC Corp. $9,217,392	6/18/71 42 mo 12/18/75	Current contract.
4.	"Develop an Underground Coal Mine Systems Model"	F. Ball MSED	H0122005 Computer Science Corp. $303,348	8/16/71 20 mo 4/16/73	Final report not submitted. Contractor out of money.

B. MINING SYSTEM COMPONENTS

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Evaluation of Mine Electrical Systems"	G. Conray PMSRC PB225475/1AS	G0101729 Penn State University $306,972	6/19/70 38 mo 8/19/74	Work continued under grant G0133077 for $79,048.
2.	"Feasibility of Remote Control & Development of Remote Control Devices & Sensors"	M. Bowser PMSRC PB224257 thru 263	H0111194 Bendix Research Lab. $1,180,491	6/10/71 33 mo 3/10/74	COMINEC library.
3.	"Design and Construction of Continuous Mining Machine"	R. Schmidt TCMRC	H0122039 Ingersoll-Rand Research $778,495	1/1/72 34 mo 1/1/74 Extended 8/75	Current Contract.
4.	"Circuit Breaker Development & Application"	E. Litchfield PMSRC	H0122058 Westinghouse Electric Corp. $259,822	6/30/72 23 mo 5/30/74 8/75	Phase I 10/73, Phase II 6/74. Final report delayed by patent dispute.
5.	"Research in Advanced Power Systems for Mining"	C. Mason PMSRC PB214277	H0220004 Aerojet Liquid Rocket Co. $106,980	8/25/71 9 mo 5/25/71	COMINEC library.
6.	"Study on Continuous Mining Machine Bit Technology"	K. Strebig TCMRC PB225-633	H0220061 Bituminous Coal Research $58,145	6/22/72 9 mo 5/22/73	COMINEC library.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts (continued)

C. GROUND CONTROL

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Development & Design of a Mine Roof Simulator"	L. Wade PMSRC	H0122067 Wyle Laboratories $312,770	6/28/72 21 mo 3/28/74 8/74	Final report in process 8/74
2.	"Feasibility Study of Pnuematic Stowing for Ground Control in Coal Mines"	Soderberg SPO Open file only	H0210057 ITT Research Institute $68,649	6/18/71 9 mo 3/18/72	COMINEC library.
3.	"Development of a Permissible-Type Remote Reading Automatic Data Acquisition System for Absolute Ground Pressure Measuring Devices"	W. Tesch DMRC	H0220002 Bendix Corp. $104,982	8/17/71 12 mo 8/17/72	Final report abstracted 5/73 MRCR.
4.	"Comprehensive Ground Control Study of a Mechanized Longwall Operation"	P. Lu DMRC	H0230012 Harza Engineering Co. $686,390	5/24/73 34 mo 3/24/76	Current contract.

D. DUST CONTROL

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Experience Survey of Engineering Methods Used to Control Respirable Dust in Underground Coal Mines"	W. Courtney PMSRC PB219615	H0111464 Apt, Bramer, Conrad, & Assoc. $50,212	6/22/71 8 mo 2/22/72	COMINEC library.
2.	"Coal Mine Vacuum Sweeper"	E. Divers PMSRC	H0122057 Envirotech Corp. $483,811	4/21/72 24 mo 4/21/74 12/74	Phase I Final report (10/73) not available.
3.	"Survey of Dust Control Research"	K. Strebig TCMRC PB222-831	H0230015 Bituminous Coal Research $21,696	11/15/72 3 mo 2/15/73	COMINEC library.
4.	"A Mine Dust Control Program"	PB197739 (AP/71)	SO100231 Garrett Research & Development Corp.		
5.	"Dust Control on Longwall Shearers Using Water Through the Shearer Drum"	K. Strebig TCMRC	H0230031 Bituminous Coal Research $224,713	5/23/73 24 mo 5/23/75	Current contract.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts (continued)

E. COMMUNICATION & MONITORING

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Mine Communications & Monitoring"	M. Bowser PMSRC PB225862/AS	G0101702 West Virginia University $623,584	6/5/70 50 mo 8/5/74	COMINEC library.
2.	"Mine Surveillance & Communication System"	J. Murphy PMSRC	H0110845 Mine Safety Appliances $758,414	6/15/71 24 mo 6/15/73	Final report in process. 8/74
3.	"System Study of Coal Mine Communications"	H. Parkinson PMSRC	S0122076 Collins Radio Co. $98,333	6/13/72 12 mo 6/13/73	Final report in review by BuMines. 8/74

F. ILLUMINATION

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Exploration of Illumination Concepts for Underground Coal Mines"	J. Murphy PMSRC PB212070	H0111403 (H0220065) Crouse-Hinds Co. $577,375	6/20/72 23 mo 5/20/74	COMINEC library.
2.	"Development of Minimum Luminance in Underground Coal Mining Tasks"	J. Murphy PMSRC PB230447/AS	H0111069 U. S. Dept. of Navy $199,000	5/25/71 18 mo 11/25/72	COMINEC library.
3.	"Portable Task Luminaire System"	F. Scott PMSRC	H0220055 Ocean Energy Inc. $171,329	6/20/72 17 mo 11/20/73	Draft final report submitted 4/74. Final report approximately 8/74. In review by BuMines.
4.	"Development of Illumination System for Longwall Coal Mines"	F. Scott PMSRC	H0230020 Ocean Energy, Inc. $167,591	5/10/73 14 mo 7/10/74	Phase I extended. Current contract.

Table 6-1 and C-1
Automated Longwall
Pertinent Coal Mine Health and Safety Contracts (continued)

G. HEALTH & SAFETY

	CONTRACT TITLE	TPO AND DOCUMENT NUMBER	CONTRACT NO., CONTRACTOR, & AMOUNT	INITIATION/ DURATION/ COMPLETION	STATUS
1.	"Aspects of Noise Generation & Hearing Protection in Underground Coal Mines"	J. Murphy PMSRC PB219087	G0122004 Penn State University $61,416	9/20/71 13 mo 10/20/72	Final Report abstract 4/73 MRCR.
2.	"A Comprehensive Study of Intrinsic Safety Criteria"	E. Litchfield PMSRC PB219799	H0111585 University of Denver $240,758	4/27/71 40 mo 8/27/74	Interim report 3/72.
3.	"The Miner, His Job, and His Environment"	J. Church TCMRC PB211732	H0122019 National Bureau of Standards $75,000	9/15/71 10 mo 7/15/72	COMINEC library.
4.	"The Development of Health and Safety Indices for the Evaluation of Underground Coal Mining Systems"	M. Sikich TCMRC Open file only	H0122028 University of Minnesota $86,990	10/1/71 25 mo 11/1/73	COMINEC library.
5.	"Suppression of Fire on Underground Coal Mine Conveyor Belts"	Don Mitchell PMSRC	H0122086 Walter Kidde & Co., Inc. $258,346	6/26/72 20 mo 2/26/74	Final draft report being reviewed by BuMines.

A-1 MASTER ENVIRONMENTAL CONTROL AND MINE SYSTEMS DESIGN SIMULATOR FOR COAL MINES

Report Date: Current Contract

During this quarter (April-June, 1974) considerable time was spent on a variety of modifications to the portion of the simulator referred to as UGMHS, Underground Materials Handling Simulator and on assembling the free standing sub-systems into the Master Design Simulator (MDS). The Section Coordinate Generator subsystem was joined to the Geology and Reserves subsystem; the output from this portion of the model is currently being fed to the roof support routine which in turn is interacting with the production subsystem. Similarily, the Methane Generator subsystem is being built into the skeletal MDS. Also, the Rail Haulage subsystem was linked into the MDS, and case studies are progressing.

Work was completed on the Subsidence Model, Roof Support Model, and the Cost-Generator, and reports are being prepared. MRCR July, 1974.

A-2 SYSTEMS ANALYSIS OF AN INHERENTLY EXPLOSION-PROOF COAL MINING OPERATION

Report Date: August 1972

ABSTRACT:

The inherently explosion-proof mine (EPM) concept is based upon the non-flammability of certain combustible-oxidant-inert gas mixtures and the effect of partial pressure of gases on physiological reactions. In a properly controlled underground environment, gas explosions are impossible, men can do work, and relatively high concentrations of methane would be permitted. A systems analysis has been performed to examine the physiological, engineering, and economic feasibility of such a concept, and methods and equipment are recommended for maintaining an EPM atmosphere in a bituminous coal mine producing a nominal two million tons of clean coal per year.

It is concluded that: engineering feasibility can be demonstrated using subsystems and components that can be designed and built within the present state-of-the-art, that economic feasibility is possible within approximately five years, and that physiological feasibility is sufficiently promising to warrant continued investigation.

A-3 INHERENTLY SAFE MINING SYSTEMS

Report Date: Current Contract

Excerpts from an article in COAL AGE, July 1973 by Dan Rogish

The concept of initiating a large action-oriented contract, directed toward obtaining coal mining systems with greatly improved safety characteristics was conceived by the Bureau in January 1971.

Based on a competitive procurement process, the Inherently Safe Mining Systems contract was awarded by the FMC Corp., San Jose, California, on June 18, 1971. The major goal of this contract is to develop and demonstrate improved safety operations in the area from the working face to the first point of coal transfer in underground bituminous coal mines with seam heights of 4 to 8 ft. The program is being conducted in three phases. Phase I involved data accumulation and analysis leading to problem definition and the development of concepts to alleviate these problems. In Phase II all the basic equipment elements are being procured and modified and new equipment fabrications completed. Phase III is the one-year operational demonstration.

Given the time and duration and extent of the demonstration phase of this program, it was considered desirable to integrate to the maximum extent all research and development results that could be incorporated in this phase. The additional items under consideration for incorporation are:

Roof Monitoring

1. Horizontal Roof Strain Indicator (HORSI) system
2. Three-in-one roof deformation and failure warning device
3. U-type bolt tension indicator
4. Micro seismic roof-fall warning system
5. Helix pressure gage
6. Hand-held infrared scanner for detection of loose material
7. Mobile shield - during experimental phases of system development in SRCM, Bruceton, and at ISMS mine, if applicable.

Monitoring, communications, lighting

1. Automatic monitoring of methane, air velocity, temperature and CO
2. Advanced carrier phone systems and portable pocket paging equipment for section personnel
3. New lighting systems including wide-angle incandescent, mercury vapor and, as development permits, polarized and/or fluorescent for face area illumination and electroluminescent for machine identification. Hardware includes machine-mounted portable and personal units.

A-3 (cont'd)

Dust control and monitoring

1. Application of foam in both coal cutting and handling
2. Air curtain respiratory device for personnel protection
3. Wet-drilling for automated roof drills
4. Continuous miner equipped with integral respirable dust scrubber and water sprays at cutter bits
5. Portable dust meters
6. Portable rock dust-coal dust analyzer, development permitting

A-4 DEVELOP AN UNDERGROUND COAL MINE SYSTEMS MODEL

No report submitted. Contractor out of money.

B-1 (1) EVALUATION OF MINE ELECTRICAL SYSTEMS WITH RESPECT TO SAFETY, TECHNOLOGY, ECONOMICS, AND LEGAL CONSIDERATIONS. VOLUME 1. TEXT, TABLES, AND ANALYSES.

Report Date: July 1973

ABSTRACT:

Volume 1 of this study is basically narrative and includes tabular results and analyses. Electrical parameters of underground coal mine power systems were measured. The aim of the original proposal was to develop instruments and techniques and then make measurements of suitable power parameters, ground fault currents, and ground resistance beds. Thus, it was possible to develop a meaningful simulator that would permit investigating electrical systems and components on paper without costly trial error procedures. In the third year, a cable splice testing program was added to the project. Evaluation of several mine electrical systems and components are presented. It is hoped that increased electrical knowledge resulting from this investigation will improve electrical safety and efficiency. The analysis is based on power parameter and ground fault studies of 18 continuous miner sections using strip chart recorder and transducer circuitry. Cable splice test measuring techniques are also presented.

B-1 (2) EVALUATION OF MINE ELECTRICAL SYSTEMS WITH RESPECT TO SAFETY TECHNOLOGY, ECONOMICS, AND LEGAL CONSIDERATIONS. VOLUME 2. APPENDICES.

Report Date: July 1973

ABSTRACT:

Volume 2 consists of 11 appendices covering detailed information resulting from the study. In this research, electrical parameters of underground coal mine power systems were measured and summarized. Measurement equipment assemblies are described. A computer model of a mine power system is given. Trailing cable splice evaluation techniques that were developed are reported, together with test data on various splices. The 11 appendices cover expected power parameters, power parameter dynamic curves, cable splice sample description, cable splice data, mine electrical system simulator user's handbook, mine electrical system simulator software, strip chart software, digital recorder analysis program, digital recorder analysis program job control and data input parameters, glossary of digital recorder analysis, and digital recorder program output examples.

B-2 (1) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES AND SENSORS: SHUTTLE CAR SENSOR SYSTEM

Report Date: March 1973

ABSTRACT:

Study and development of sensing techniques and sensors were performed to aid shuttle car drivers in detecting obstacles and in guiding the car along the face haulage route.

Microwave, acoustic, and optical sensing techniques were considered as part of the feasibility study for obstacle detection. Various guidance techniques, including wire-following and rib-ranging were investigated. Active optical sensing was selected for obstacle detection to obtain the beam coverage and sharp angular cutoff characteristics required within the packaging limitations defined by the shuttle car configuration. Rib-ranging guidance was selected to achieve a completely self-contained shuttle car system which responds to the existing mine geometry without need for wires, stripes, or other path defining devices.

Extensive hybrid computer simulation runs were performed to evaluate various guidance techniques during the feasibility study. Subsequent simulation runs were performed to establish parameter values for the rib-ranging guidance system.

The obstacle detection and guidance system was designed, fabricated and installed on a standard shuttle car. The system satisfied all applicable permissibility requirements of Schedule 2G. An experimental permit was issued to Bendix for operation in an underground coal mine.

System evaluation tests were performed first above ground at the Bendix Research Laboratories. The simulation model was validated by these runs. Final testing was performed underground in an operating mine with an experienced shuttle car driver.

All sensors successfully demonstrated the predicted performance capability during underground face haulage tests. Dust did not impair system performance and lens cleaning was not required during working shifts. Further development is required to achieve the desired obstacle detection performance. Closed loop steering control with manual override is recommended for the lateral guidance system. The guidance system should be an invaluable aid to low-coal shuttle car drivers where continuous minine machines are utilized.

B-2 (2) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES AND SENSORS. 2. SHUTTLE CAR SENSOR SYSTEM. APPENDIX A--TECHNICAL DESCRIPTION

Report Date: March 1973

ABSTRACT:

Appendix A covers lateral guidance subsystem sensors, obstacle detector sensors, and processing, displays, and controls. Study and development of sensing techniques and sensors were performed to aid shuttle car drivers in detecting obstacles and in guiding a car along a face haulage route. Microwave, acoustic, and optical sensing techniques were considered as part of the feasibility study for obstacle detection. Various guidance techniques, including wire-following and rib-ranging were investigated. Active optical sensing was selected for obstacle detection to obtain the beam coverage and sharp angular cutoff characteristics required within the packaging limitations defined by the shuttle car configuration. Rib-ranging guidance was selected to achieve a completely self-contained shuttle car system that responds to the existing mine geometry without need for wires, stripes, or other path defining devices. The obstacle detection and guidance system was designed, fabricated and installed on a standard shuttle car, satisfying all permissibility requirements. All sensors successfully demonstrated the predicted capability during underground face haulage tests.

B-2 (3) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES AND SENSORS. 3. SHUTTLE CAR SENSOR SYSTEM. APPENDIX B--SYSTEM TESTS

Report Date: March 1973

ABSTRACT:

Appendix B covers above ground tests and field demonstration. Study and development of sensing techniques and sensors were performed to aid shuttle car drivers in detecting obstacles and in guiding a car along a face haulage route. Microwave, acoustic, and optical sensing techniques were considered as part of the feasibility study for obstacle detection. Various guidance techniques, including wire-following and rib-ranging were investigated. Active optical sensing was selected for obstacle detection to obtain the beam coverage and sharp angular cutoff characteristics required within the packaging limitations defined by the shuttle car configuration. Rib-ranging guidance was selected to achieve a completely self-contained shuttle car system that responds to the existing mine geometry without need for wires, stripes, or other path defining devices. The obstacle detection and guidance system was designed, fabricated and installed on a standard shuttle car, satisfying all permissibility requirements. All sensors successfully demonstrated the predicted capability during underground face haulage tests.

B-2 (4) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES: CONTINUOUS MINING MACHINE SEAM INTERFACE SENSORS

Report Date: July 1972

ABSTRACT:

The report presents the results of the study and experimentation on coal-seam interface sensing using the acoustic pulse-echo technique. This method was chosen for further development subsequent to initial feasibility studies investigating other acoustic, electrical, magnetic, nucleonic, and mechanical techniques. The design and construction of acoustic transducers and coupling techniques are discussed and the electronic equipment used in conjunction with the transducers is described. Laboratory coal simulation experiments are described and the results of acoustic transmission and reflection laboratory experiments, using coal samples from various sources, are presented. It was found that the propagation of acoustic energy varied widely in different coal samples. Because of difficulties encountered in laboratory experiments, an underground field test was performed for the purpose of evaluating the effectiveness of the technique for measuring coal thickness in sity prior to final hardware design and construction. The results of the field test, which showed that detection of the coal seam interface was difficult using state-of-the-art techniques because of competing signal returns, are discussed. Recommendations are made that further development of the acoustic pulse-reflection technique be shelved and that detailed information be obtained from the British Coal Board regarding the nucleonic (gamma-ray) backscattering probe for measuring coal thickness.

B-2 (5) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES: CONTINUOUS MINING MACHINE LASER ENTRY ALIGNMENT SENSOR

Report Date: February 1973

ABSTRACT:

The report describes the development of a laser entry alignment sensor for guiding a continuous mining machine. The history of the design from one using two four-quadrant photodetectors with a servo system to one with an array of optical lens elements and sensors is detailed. Principal design features and the design philosophy are also discussed. The components of the final package (slave laser, master transit, sensor unit, display unit) are described in detail. The results of performance tests on the accuracy of the heading and tracking indications are also presented. Finally, recommendations are made for future work.

B-2 (6) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES AND SENSORS. 6. FEASIBILITY STUDY OF THE APPLICATION OF SOLID STATE DISPLAYS FOR UNDERGROUND MINING MACHINES

Report Date: August 8, 1972

ABSTRACT:

This report discusses an investigation of the application of solid state devices to information displays on underground coal mining machines. The specific purpose of the feasibility study was to consider solid state devices as replacements for conventional electrical or electromechanical devices, to increase the reliability of the machinery, to increase safety in the explosive mine atmosphere, to decrease maintenance requirements, and to increase adaptability of the machinery to automatic and remote control techniques. Solid state displays meet the functional, operational, and environmental requirements for use on underground mine equipment, the report states. It is recommended that the light emitting diode (OED) be used as the basic solid stage device for display design. Replacement of conventional displays with solid state displays is technically feasible, but because of the very limited usage and simplicity of the conventional displays now in use on underground coal mining equipment, the practicality of replacing them with solid state displays is doubtful.

B-2 (7) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES AND SENSORS. 7. FEASIBILITY STUDY OF THE APPLICATION OF SOLID STATE MOTOR CONTROLLERS TO UNDERGROUND MINING MACHINES

Report Date: October 1972

ABSTRACT:

This work was directed toward a general study of solid state control devices available, their potential use on electrical machinery used in underground mines, and the general effect that the use of solid state devices might have on safe operation of machines. The underground mine environment presents rather severe physical and electrical stresses to machinery. Silicon controlled rectifiers that meet the mine equipment requirements are available. While SCR initial costs appear to be higher than costs for electromechanical contactors, savings should result from reduced maintenance requirements, safer operation, higher reliability, elimination of mechanical transmissions, elimination of rectifier centers, and standardization on AC power, the report states.

B-2 (8) FEASIBILITY OF REMOTE CONTROL AND DEVELOPMENT OF REMOTE CONTROL DEVICES AND SENSORS. 8. FEASIBILITY STUDY OF REMOTE/AUTOMATIC CONTROLS FOR CONTINUOUS MINERS

Report Date: October 1972

The objective of this study was to investigate the feasibility of using remote and/or automatic controls for operation of a drum-type continuous mining machine. Based upon the study, it was concluded that on-site automatic or semiautomatic controls is not feasible for this type of machine since it requires a man to be in a high accident zone (within 25 feet of the face). In addition, such control modes are economically unattractive yielding only marginal gains in production efficiency. On-site control for the continuous miner operations that are associated with shuttle car docking and loading is ruled out for the same reasons. A key conclusion of the study identified visual information as being essential for the mining and dock/load functions. Two system concepts are possible: Direct line-of-sight feedback to an operator in an enclosed remote control station near the face, or a closed circuit television system with cameras mounted on the continuous miner with the operator located in a distant remote control station. The latter system was selected for operator safety.

B-3 DESIGN AND CONSTRUCTION OF CONTINUOUS MINING MACHINE

Report Date: Current Contract (June Report - MRCR July, 1974)

The Joanne Mine was opened June 18 and a recovery team sent into the IRRI test site. They found no water, no falls, and the equipment in an undamaged condition. A study of the fly-ashed fire zone will be performed before the closure order is lifted.

The testing required by the contract modification was started at Freeman Coal Co.'s Orient No. 4 mine. Mechanical problems in the oscillating head of one machine required that the bit block test angle being used on that machine (55^o) be replaced by the standard angle (45^o) so that both test machines are now using 45^o blocks. The requirement for testing at 55^o (35^o) angle has, therefore, been deleted from the contract by the Contracting Officer at the request of IRRI.

The Final draft of the Interim Report was again delayed by work on the helical bit contract modification.

B-4 CIRCUIT BREAKER DEVELOPMENT AND APPLICATION

Report Date: Current Contract

OBJECTIVE:

(a) To determine whether or not electrical circuit breakers suitable for 300 and 600 vdc service in underground coal mines were available or could be caused to become available upon the commercial market, and

(b) To develop prototype "discriminating circuit breaker control", for sensing "illegitimate loads" in the presence of legitimate loads, for control of circuit breakers. Results to date are that commercial circuit breakers were evaluated and some were determined to satisfy the above objectives. Several aspects of the engineering of these electrical circuits, and their protective gear, have been advanced. A discriminating control prototype has been developed under the contract.

B-5 RESEARCH IN ADVANCED POWER SYSTEMS FOR MINING HEALTH AND SAFETY

Report Date: July 20, 1972

ABSTRACT:

Systems analytical techniques have been formulated and applied to quantitatively assess the relative safety merits of four shuttle car power systems for use in underground coal mines. Results from two techniques, 1) forced decision analysis and 2) fault tree analysis suggest the open cycle diesel to be the most desirable of the power systems studied, with the closed cycle diesel being next, followed by the battery/motor and the electric cable/reel. Two basic mine shuttle car configurations were considered for incorporation of a closed cycle diesel power plant. Engineering designs, performance parameters, and the logistics of servicing the power systems were formulated. The utilization of the closed cycle diesel shuttle car as an emergency rescue vehicle was discussed. An extensive evaluation was made of the compatability, sensitivity and hazards of closed cycle diesel consumable with materials normally found in a mine environment. The consumables considered were diesel fuel, KOH, O_2 (gas) and O_2 (liquid). An extensive bibliography of reports on these topics was prepared. Experiments were also carried out to evaluate the time and concentration of gaseous oxygen in a simulated mine entry following a liquid oxygen spill.

B-6 THE STATE-OF-THE-ART IN CONTINUOUS MINING MACHINE BIT TECHNOLOGY

Report Date: June 1973

ABSTRACT:

This research provides the results of a significant study of the current status of continuous mining machine bit technology and recommendations for improvements necessary to reduce dust generation. It gives direction for reducing dust generation by making recommendations dealing with the determination of bit performance and the development of new bit designs and material. The recommendations will be used to help direct the Bureau's machine parameter work. Surveys results are as follows: 1. The production of dust is not a major consideration in either the design or application of bits. 2. Limited test data were obtained with correlated bit design and respirable dust. 3. Mine operators generally believe that bit design is not a significant factor in dust production. 4. Because of apparent economic advantages, point attack bits are used on a majority of continuous mining machines in use today. 5. Good bit cost records are not generally available. 6. Although most coal companies interviewed are not involved in any test programs, they expressed willingness to cooperate in development of equipment or techniques for dust control.

C-1 DEVELOPMENT AND DESIGN OF A MINE ROOF SIMULATOR

Report Date: Current Contract

OBJECTIVE:

To develop and design a large testing apparatus which simulates the movements and forces associated with a mine roof. Therefore, the simulator must have unique features to fulfill these performance requirements. These features are a versatile upper platen, the ability to apply large loads throughout a long stroke, rapid response characteristics, complete load programming and control systems, and extensive data recording instruments. The incorporation of compatible components into an integrated testing system which fulfills these requirements will yield a unique and valuable testing apparatus.

April, 1974 Report: (MRCR July, 1974)

The optical carriages are being modified for mounting the equipment selected for sensing vertical and lateral positions. The number of optical carriages has been reduced to one-half by the change in technique for measuring platen twist directly by a sensitive accelerometer. Detail and assembly drawings of the entire Simulator are being reviewed. Preliminary instrumentation and control drawings are 75 percent complete.

C-2 FEASIBILITY STUDY OF PNUEMATIC STOWING FOR GROUND CONTROL IN COAL MINES

Report Date: January 1972

From Report Recommendations pg 103.

"It has become evident during the course of this study that the use of pneumatic stowing in European coal mines is decreasing rapidly. The primary reason for this, of course, is the high cost associated with the operation. Even if stowing is practiced in any given situation, it does not eliminate the costs of surface damage. Past experience, especially in Britain, seems to indicate that surface subsidence costs are lowered only slightly.

It should be borne in mind, throughout any study of West European coal mining, that total coal production is declining at the present time. This necessarily affects all aspects of the industry. Currently, the emphasis is to exploit the most readily obtainable coal and minimize all non-productive operations, such as stowing.

Further, stowing tends to slow the rate of face advance -- a highly undesirable feature in today's competitive market. The new lateral method of pneumatic stowing partially alleviates this problem, and may, therefore, extend the life of the process somewhat. But scope for further improvement exists.

In spite of this curtailment of pneumatic stowing activity in Western Europe, and an estimated cost of $1.00 to $2.00/ton of coal if employed in the United States, it should not be concluded that it need automatically be eliminated from the North American scene. There may be special circumstances in which it may still be beneficial from a safety, conservation, or ecological viewpoint."

C-3 PERMISSIBLE-TYPE REMOTE READING AUTOMATIC DATA-ACQUISITION SYSTEM FOR ABSOLUTE GROUND-PRESSURE MEASURING DEVICES

Report Date: Current Contract

OBJECTIVE:

The purpose of this work was to design and develop a Permissible Automatic Data Acquisition System (PADAS) to measure and record roof stresses in underground mines.

The PADAS is a portable, battery-powered, 24-channel data acquisition system designed for safe, unattended operation for up to 30 days duration in explosive environments. The unit will accommodate 24 pressure transducers or 8 borehole deformation gages, or any combination of these, at distances up to 300 ft to measure pressures to 10,000 psig. All 24 channels as a selected group are scanned, its electrical output is conditioned, scaled, converted to digital form, and recorded on magnetic tape with the channel number, date, and time. The data being recorded can be observed on the front panel digital display, if desired. The recorded data can be played back and observed on the display or converted to an IBM compatible tape. Detailed operating instructions and description of equipment are provided in the final report. MRCR 5/75

C-4 GROUND CONTROL STUDY OF A MECHANIZED LONGWALL OPERATION

Report Date: Current Contract (May Report - MRCR July, 1974)

OBJECTIVE:

During this period, the program of strata control measurements and observations along the face was started. Mining induced ground pressure measurements with the second array of hydraulic pressure cells installed in the longwall panel were completed and pressure cells were destroyed at the end of the month when the operating longwall face approached the instrumentation site. Twenty-three pressure cells installed elsewhere were repressurized. Data collection was continued.

To address the problem of roof control in underground workings requires field investigations to isolate problem areas and often times solution techniques can be developed in the unique underground situation. Sometimes, however, the interaction of many mining variables obscure direct explanation and simulation in a controlled environment is required. Both approaches are being taken in the delineation of longwall ground control problems. A Request for Quotation will be developed for the construction of a mine roof simulator based on the design work completed under Contract No. H0122067. (See C-1) Concurrently, underground investigations will be undertaken to isolate longwall roof control problems. Where applicable, European practice and techniques will be brought to bear on American longwall problems.

D-1 EXPERIENCE SURVEY OF ENGINEERING METHODS USED TO CONTROL DUST IN UNDERGROUND COAL MINES. VOLUME 1. REPORT OF CONTRACT PERFORMANCE

Report Date: August 1972

ABSTRACT:

The Federal Coal Mine Health and Safety Act of 1969 required each mine operator to continuously maintain the average concentration of dust in the mine atmosphere during each shift to which every miner was exposed at or below 3.0 mg of dust per cubic meter of air and thereafter at 2 mg/m^3 from June 30, 1970, through December 31, 1972. The application of the most successful engineering method for respirable dust control developed in this country must be utilized by mine operators to maintain dust concentrations within the limits required by law. Work in the past has covered 1) ventilation; 2) water and wetting agents; 3) dust collectors, both dry and wet; and 4) mining equipment design. With the desired goal of reducing respirable dust in all coal operations, it became mandatory that as much information as possible be assembled, evaluated, and consolidated into a format that could be utilized by all coal operators. The scope of the survey includes identifying, defining, evaluating, and assembling in meaningful form, all engineering methods developed to control respirable dust in coal mines in the past 20 years.

D-2 COAL MINE VACUUM SWEEPER

Report Date: Current Contract

OBJECTIVE:

Self propelled battery powered in-mine vacuum sweeper designed to clean coal and rock dust, plus other rubble up to 1-1/4 inch particle size, primarily from the material handling systems of an operating coal mine, is to be designed, fabricated and tested. The purpose of the machine is to reduce both the chance of explosions and fires that feed off the rubble and reduce rock dusting requirements. Maximum height of the sweeper is to be 42 inches with a boom-like pickup suction nozzle on the front end that lifts and conveys the dust and rubble through two wet cleaning stages. The first is to remove coarse particulate and the second to remove fines. The collected material can be retained for later disposal or loaded directly to the conveyor belt. Clean-up rate is approximately 100 pounds of dust and rubble per minute.

D-3 SURVEY OF DUST CONTROL RESEARCH

Report Date: May 1973

ABSTRACT:

This report reviews, from the point of view of selected coal producers, the contribution made by both in-house and contract research by the Bureau of Mines and other governmental agencies in meeting the needs of the industry for accurate dust sampling instrumentation and for improved dust control technology. This review, combined with an evaluation of coal industry research, has been utilized to make recommendations for future research to overcome remaining technologic difficulties. The survey includes a review of 17 research projects conducted in-house by the Bureau of Mines involving a 1972 cost of $1,762,650; 23 contract research projects funded by the Bureau at a 1972-73 cost of $2,928,000; 17 projects funded by NIOSH and other governmental organizations at a cost of $538,000; and 89 company-funded projects conducted by coal producers. The survey recommends that the Bureau establish an industry advisory group experienced in coal mine health and safety work to aid the Bureau in establishing priority research projects.

D-4 A COMPREHENSIVE STATE-OF-THE-ART EVALUATION FOR ALL TYPES OF DUST COLLECTION EQUIPMENT THAT MAY BE APPLICABLE IN UNDERGROUND COAL MINES

Report Date: December 1970

ABSTRACT:

Basic dust collection mechanisms are reviewed, and inertial collection is selected as the most applicable to the respirable coal mine dust problem. Coal mine dust data are evaluated and an estimate is made of the respirable dust loading and size distribution typical of the continuous miner environment. Manufacturers of dust collection equipment are surveyed and several units selected for pilot plant tests with coal dust. The experimental results indicate that the collection mechanisms can be characterized by the state-of-the-art technology. Recommendations are presented for the design of a dust collection system for the coal mine environment.

D-5 DUST CONTROL ON LONGWALL SHEARERS USING WATER THROUGH THE SHEARER DRUM

Report Date: Current Contract (January-May Report - MRCR July, 1974)

The Phase II Report was submitted and describes the work effort during this period. The longwall shearer was modified to incorporate four spray systems. One system, which simulates the original Eickhoff shearer with no drum sprays, consists of five fixed sprays in a header mounted on the miner behind the drum and directed toward the panel face. The second system is the present Eickhoff spray system consisting of five sprays mounted on the panel side of each of two scrolls (a total of ten sprays), and positioned to spray in the direction opposite the drum rotation. The final two systems are both located on the drum and consist of jet spray nozzles installed in the bit blocks. The jets located ahead of the bits comprise the third system and those behind the bits, the fourth.

A Test Program and a method for data analysis were also developed.

E-1 ANALYSIS OF COMMUNICATION SYSTEMS IN COAL MINES

Report Date: May 1, 1973

ABSTRACT:

The results of a two-year research effort aimed at improving communication systems in coal mines is reported. A review of communication methods presently used in coal mines is presented. Theoretical and experimental results of a four pronged effort in the areas of (1) through-the-earth propagation, (2) paging system design, (3) improvement of wired telephone systems, and (4) carrier current systems are described. Auxiliary systems not included in the above are considered briefly. Various conclusions are drawn in light of practical constraints and the needs of the mining industry.

The study clearly demonstrated the need for mine communications to be designed on system basis. The viability of new technology for providing reliable mine communication for improving mine safety and operating efficiency is shown.

E-2 SURVEILLANCE AND COMMUNICATION SYSTEMS (FOR EXPERIMENTAL COAL MINE AT BRUCETON, PA.

Report Date: January, 1974

This contract effort was to design and install a mine surveillance and communication system for the USBM Bruceton Experimental Mine. The information from this contract will be used to recommend and design monitoring systems for coal mines.

The monitoring system which was installed consists of an aboveground central computer control facility and ten mine monitor stations at selected locations within the mine. It provides continuous local and remote monitoring of various parameters critical to normal mine operation at each of the ten sites. These include surveillance of methane, carbon monoxide, hydrogen, smoke, temperature, rate of temperature rise, ventilation rate, and noise level. Two-way voice communication is provided between the ten locations and between any mine station and the surface monitor station. A data communications link, established by an FSK telemetry polling system, provides remote readout and alarms at the surface monitor station and the capability of remote control of certain mine station operational functions and system checks. This station functions as a central control for the entire system and provides for continuous display of all data and status indications, long-term data storage and computer processing of the data through appropriate software. MRCR 1/74.

E-3 SYSTEM STUDY OF COAL MINE COMMUNICATIONS

Report Date: Final Report in Review (August, 1974)

OBJECTIVE:

Previous work resulted in an initial analysis of the objectives and requirements of mine communications in a proposed system to satisfy objectives and requirements with gross hardware specification. Hardware specifications were detailed and additional investigations made into particular nontypical mine communication requirements.

F-1 EXPLORATION OF ILLUMINATION CONCEPTS FOR UNDERGROUND COAL MINES

Report Date: August 18, 1972

ABSTRACT:

The lack of adequate area lighting in the working places of underground coal mines has been a contributing factor to mine accidents involving damage to equipment and serious injury to personnel. This report describes two prototype lighting systems to demonstrate the feasibility of interim lighting equipment and recommends long-term solutions for working place lighting in underground coal mines. Lighting requirements for high and low coal seams were evaluated and found to be similar, eliminating the necessity for unique lighting systems based on coal seam height. A prototype man-portable area lighting system was developed to meet the operational requirements of conventional mining. A prototype machine-mounted lighting system was developed to meet the operational requirements of mechanized mining. An illumination system concept using portable area lights for entry lighting and roof support mounted lights for face lighting was recommended to meet the operational requirements of longwall mining. Unusual operational conditions would require both machine-mounted and portable luminaries.

F-2 DEVELOPMENT OF MINIMUM LUMINANCE REQUIREMENTS FOR UNDERGROUND COAL MINING TASKS

Report Date: January 31, 1973

ABSTRACT:

This report was prepared under a Bureau of Mines contract with the Naval Ammunition Depot, Crane, Indiana, to develop minimum luminance levels for tasks in work spaces in by the last open crosscut and first transfer point in conventional, continuous, and longwall coal mining operations. Minimum luminance levels were determined for the three types of operations. Visual tasks coupled with associated reflectivity information were determined for the jobs in 12 mining sections. These data were transferred to fullscale models of mining machinery and simulated mine work space where minimum luminance levels were determined by an accepted method of evaluating visual performance in different luminous environments. The minimum luminances measured were corrected to encompass a 99-percent probability of detection for 95 percent of a 55-to-65-year old population. Extensive reflectance measurements were made of coal surfaces, roof shales, and floor materials. The results will be useful in designing future luminaries and illumination systems.

F-3 PORTABLE TASK LUMINAIRE SYSTEM

Report Date: Current Contract

OBJECTIVE:

To develop a portable, intrinsically safe battery-powered task lamp using integral batteries to provide illumination for certain tasks underground such as face operations where only the face need be illuminated, or machine repair. Prototypes have been fabricated and will be evaluated underground.

F-4 DEVELOPMENT OF ILLUMINATION SYSTEM FOR LONGWALL COAL MINES

Report Date: Current Contract

OBJECTIVE:

To develop an illumination system for longwall coal mine in response to the proposed standards of .06 foot lamberts; existing European longwall illumination systems do not provide this level of illumination. The principle direction of development is the use of intrinsically safe fluorescent luminaires. Systems will be installed in operating longwalls for further evaluation.

G-1 ASPECTS OF NOISE GENERATION AND HEARING PROTECTION IN UNDERGROUND COAL MINES

Report Date: November 20, 1972

ABSTRACT:

The objective of this study was to identify quantitatively the spectral and amplitude characteristics of coal mine warning signals and assess the feasibility of using personal ear protection to minimize noise exposure but not impair a miner's safety. Roof warning signals from 11 underground coal mines, principally in the Pittsburgh seam, were studied and analyzed. The character of individual acoustic warning signals is shown to be dependent on spectral distribution of energy. Reverberation times (pulse delay rates) were found to be usually between 0.1 and 0.5 seconds. Listening tests were conducted to assess the miner's ability to discriminate speech and roof talk signals in noise and in quiet, with and without ear protectors and with various levels of hearing loss. The ability to detect roof talk is shown to be generally degraded while wearing ear protection in quiet, although, if ear protectors are worn only when required by high noise levels, the ability to detect roof talk will be preserved at its maximum.

G-2 A COMPREHENSIVE STUDY OF INTRINSIC SAFETY CRITERIA

Report Date: March 1972

ABSTRACT:

Present status of standardization in "intrinsic safety" approvals is examined and the supporting data are evaluated. It is concluded that present standards differ widely between countries and organizations. These considerations comprise the significant body of the report. Modification of the Electrical Circuit Analysis Program (ECAP) to provide guidance in approval testing is also described.

G-3 THE MINER, HIS JOB AND HIS ENVIRONMENT: A REVIEW AND BIBLIOGRAPHY OF SELECTED RECENT RESEARCH ON HUMAN PERFORMANCE

Report Date: August 1972

ABSTRACT:

As one of the early steps in carrying out the provisions of the Coal Mine Health and Safety Act passed by Congress in 1969, the Bureau of Mines commissioned the Behavioral Sciences Group at the National Bureau of Standards to conduct a survey of the state of the art in ergonomics (human factors) as it has been applied to mining. The Group carried out an extensive search both foreign and domestic published literature in ergonomics. About 1,200 references were located and 49 were abstracted on the following topics: Effects of environmental stress on health and productivity; accident prevention measures that have been shown to be effective; protective clothing and equipment; the man-machine relationship in the mining situation; effective training programs for safety and work; effect of informal social organization in underground operations; all aspects of the effect of the physical environment upon the miner; and psychological principles that may have been applied to mine problems. The report concludes that little work has been done in the human factors of mining in the United States.

G-4 THE DEVELOPMENT OF HEALTH AND SAFETY INDICIES FOR THE EVALUATION OF UNDERGROUND COAL MINING SYSTEMS

Report Date:

ABSTRACT:

The primary objectives of the study were to:

1. determine the relationships in underground coal mining systems which affect the health and safety of mine personnel, including consideration of mining methods, unit operations, coal seam characteristics, roof conditions, etc.;

2. develop these relationships into quantitative health and safety indices;

3. develop a computer based model for projecting and evaluating health and safety profiles for specific mining systems;

4. establish the ground work for further studies which would incorporate these data into an overall underground system optimization procedure.

A data bank was established containing information on 203 mines in Illinois, Kentucky, Pennsylvania, and West Virginia. All mines produced in excess of 250,000 tons of coal in each of the three years 1969, 1970, and 1971. Information relating to employment, injuries, geology, and mine characteristics were collected from a variety of sources and included in the data bank.

Analysis of the data bank information indicates the following statistically significant relationships:

1. none between mine fatalities and measured parameters,

2. mines operating in areas of more disturbed geologic conditions had lower injury frequency rates due to roof falls than those in less disturbed regions, and

3. apparent relationships exist between diabling injury rates and the following factors:

seam thickness	haulage method
coal use (coking vs noncoking)	shifts per day
state	productivity
mine ownership (captive vs noncaptive)	number of men
mining method	mandays per year

The singular contribution of the study is the development of Coal Mine Health and Safety Evaluation Model, designed to assess the health and safety aspects of a given mine design. Several variations of the

model are presented so that it may be utilized under a variety of conditions and with various types of data. The model requires user supplied ratings of the health and safety aspects of the mine design. These may be: A, subjective; B, objective; or C, a combined subjective-objective rating.

The Model considers only the health and safety aspects of mine design. It should be used with other methods and techniques of mine planning and evaluation in order to optimize the design of the mining system. A comparison of two alternative designs of a hypothetical mine illustrates how this might be undertaken.

G-5 SUPPRESSION OF FIRE ON UNDERGROUND COAL MINE CONVEYOR BELTS

Report Date: Current Contract

OBJECTIVE:

Determine means of detection and extinguishment that will provide protection in the conveyor belt drive area and to determine if the provision of The Coal Mine Health and Safety Act (re: conveyor belt fires) are satisfactory. Perform tests with full-scale conveyor belt systems in simulated underground haulageways to evaluate fire hazards. Develop flame detection and suppression devices, if necessary. Demonstrate their adequacy with respect to spread of fire to the mine surfaces and along the belt and to their functional survivability in mine environments. Recommend the time in which a fire suppression device must detect flame and operate to quench flame before the device's capabilities are exceeded, or the growing fire poses unacceptable risks to personnel and property. Recommend location of devices, spacing between devices and other relevant characteristics for their installation.