U.S. DEPARTMENT OF LABOR MSHA
00031633

Open file - Foster - Miller

DESIGN, FABRICATION AND FIELD TESTING OF REMOTELY OPERATED LONGWALL HEAD/TAIL SUPPORTS

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

U. S. Bureau of Mines
LIBRARY

by

FOSTER-MILLER ASSOCIATES, INC.
135 SECOND AVENUE
WALTHAM, MASSACHUSETTS 02154

OFR
78-97

Final, Phase IB Report

on

Contract No. H0252020

Design of a Remotely Operated Longwall Entry Support System

September 1978

DISCLAIMER NOTICE

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or of the U.S. Government.

REPORT DOCUMENTATION PAGE

1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle Design of a Remotely Operated Longwall Entry Support System		5. Report Date September 1978
		6.
7. Author(s) Alfred Bellows John Curcio		8. Performing Organization Report No. BM 7522
9. Performing Organization Name and Address Foster-Miller Associates, Inc. 135 Second Avenue Waltham, MA 02154		10. Project/Task/Work Unit No.
		11. Contract or Grant No. HO252020
12. Sponsoring Organization Name and Address Office of the Assistant Director - Mining Bureau of Mines Department of the Interior Washington, D.C. 20241		13. Type of Report Final (Phase IB)
		14.
15. Supplementary Notes		

16. Abstract

The objective of this contract is to design, build and demonstrate a support system to improve roof control in the entries of longwall mines. The objective of this phase has been the detailed design of such a system and the selection of a test site in which to perform the pilot demonstration.

The result is a complete set of detail drawings or specifications which define the three major components of the system. The Gate Support is a variation of a face chock which has an extended canopy and additional hydraulic legs to protect the region of the face-entry intersection. The Entry Support is a steel beam and hydraulic prop set which is reusable and serves to support the first 100 or more feet of entry inby the longwall face. The Transporter is a bolter-like vehicle with a crane used for installing and retreating the beam sets.

The test site selected is CF&I's Allen Mine in Colorado. They presently use similar steel beams and expect the FMA support system to be more effective as well as recoverable.

It is recommended that the completed drawings be used to build a prototype system and test it first in a remote section of the mine and then in the active longwall tail entry.

17. Originator's Key Words Roof Support Temporary Roof Support Longwall Entry Support Entry Support		18. Availability Statement	
19. U. S. Security Classif. of the Report None	20. U. S. Security Classif. of This Page None	21. No. of Pages	22. Price

FOREWORD

This report was prepared by Foster-Miller Associates, Inc. (FMA) of Waltham, Massachusetts under USBM Contract Number H0252020. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of SMRC with Mr. Eric Zahl acting as the Technical Project Officer. Mr. Monte Camp was the contract administrator for the Bureau of Mines.

This report is a summary of work recently completed as part of this contract during the period 5 November 1976 to 3 June 1977. This report was submitted by the authors on 1 June 1977.

TABLE OF CONTENTS

Section		Page
1.	INTRODUCTION	8
1.1	Objectives	8
1.2	Background	8
1.3	Summary	10
2.	REVIEW AND REFINEMENT OF CONCEPT	14
2.1	Review of Phase IA Concepts	14
2.2	Site Selection	15
3.	DETAILED DESIGN OF THE SYSTEM	17
3.1	Support System	17
3.1.1	The Support Assembly	18
3.1.2	Beams	18
3.1.3	Cylindrical Socket Bearing Plates	21
3.1.4	Props	22
3.1.5	Load Distributing Devices	25
3.2	Transporter	29
3.2.1	Chassis Design	31
3.2.2	Crane Design	35
3.2.3	Hydraulic Circuit	43
3.3	Gate Support	47
3.3.1	Design and Selection	48
3.3.2	Operation	48
3.4	Installation and Operating Procedure	50
3.4.1	Installation	50
3.4.2	Operation	53
4.	DESCRIPTION OF TEST SITE AND TEST PLAN	56
4.1	Test Site	56
4.2	Field Test Plan	57
4.2.1	Availability	57

TABLE OF CONTENTS (continued)

Section		Page
4.2.2	Off Site Test	57
4.2.3	Installation	58
5.	ECONOMIC ANALYSIS	62
5.1	Cost of FMA Support System	62
5.2	Comparison with Conventional Entry Supports	64
6.	CONCLUSIONS AND RECOMMENDATIONS	67
6.1	Conclusions	67
6.2	Recommendations	68
Appendix		
A	LIST OF DRAWINGS	69
B	PARTS LISTS	71
C	SUMMARY OF QUOTATIONS	76
D	SYSTEM SPECIFICATIONS	77
D.1	Entry Support (Drawing No. C-7522-11000)	77
D.2	Gate Support (Drawing No. C-7522-15000)	78
D.3	Transporter (Drawing No. D-7522-12000)	79
E	BENCH TEST PLAN	80
E.1	Functional Test	80
E.1.1	Objective	80
E.1.2	Transporter	80
E.1.3	Support Frames	81
E.1.4	Gate Supports	81

TABLE OF CONTENTS (continued)

Section		Page
E.1.5	Equipment	82
E.2	Operational Test	82
E.2.1	Objective	82
E.2.2	Support Installation	82
E.2.3	Transporter Operation	83
E.2.4	Adverse Conditions	83
E.2.5	Equipment	84
F	ASSEMBLY DRAWINGS	85

LIST OF ILLUSTRATIONS

Figure		Page
1.	FMA Entry Support System	11
2.	Plan and Elevation View of FMA Support System	12
3.	Support Assembly	19
4.	Honeycomb Load Distributor	27
5.	Hydraulic Pillow	28
6.	Crane Capabilities	36
7.	Hydraulic Prop Gripper	40
8.	Hydraulic Winch	41
9.	Fork Lift	41
10.	Hydraulic Chain Saw	42
11.	Hydraulic Circuit	45
12.	Dowty's "Drivehead/Anchor Support" - A face Support Adaptable as a Gate Support	49
13.	Beam Advancement Sequence	54
14.	Elevation View of Test Installation	60

LIST OF TABLES

Table		Page
1.	Specifications for Rotary Actuators and Cylinders Employed in the Crane Subassembly	44
2.	Cost Per Panel of the FMA Entry Support System	63
3.	Cost Per Panel of a Crib Supported Entry	65

1. INTRODUCTION

This report reviews the conceptual design and summarizes the results of the detail design required by the USBM Contract No. HO252020, a research and development contract for the Design, Fabrication and Testing of a Remotely Operated Longwall Head and Tail Support System.

1.1 Objectives

The overall objectives of this program are to conceive, design, construct and test a remotely operated support system for use in the head or tail entry of a longwall mine. The specific objectives of Phase IB have been the detailed design of a concept which was developed and recommended during the Phase IA activity. This concept was that of a series of steel beams and hydraulic prop sets which would be individually advanced by an electrically powered transporter that would remove the beam when its service was completed at the face end of the entry and carry it to an outby position 100 or more feet away to be reinstalled in a stable zone of the roof. This inverse "leap-frog" procedure of advancing the supports gave rise to the informal name of Leap-Frog for this system. An ancillary component of this system is a modified chock with an extended canopy to be used in the gate region which would support the face/entry intersection zone between the last beam set and the gob.

1.2 Background

The entries to the longwall face are the main avenues for ventilation and coal removal without which all activity ceases. Their condition and quality have a direct bearing on the consistency and success of the face operation. The entries are subjected to abutment pressures which are particularly severe in the tail entry adjacent to the face where the collapsing gob encompasses three quadrants around the work area.

The head entry is awkward to support with a mechanized system because of the congestion of equipment and activity. But, fortunately, it is usually located on the side of the panel next to another solid panel and therefore experiences less abutment pressure than the tail.

The tail entry is relatively easy to support, often with numerous posts or cribs since it is typically used for little else than ventilation and escapeway. This method, however, is quite expensive because of the enormous amount of wood abandoned in the gob as the face retreats. Also, to a large extent, wood cribs are ineffective in preventing the roof from breaking up and serve only to keep the broken roof from falling out. Wherever this is the case, the problem of removing the supports to clear the passing face equipment becomes hazardous and causes delays in advancement.

For these reasons, FMA has designed a system which is installed ahead of the appearance of severe abutment pressures, can be preloaded against the roof with stiff but yieldable hydraulic props to minimize roof breakage, and is readily advanced by equipment which protects the operator from exposure as the support is being removed from service. This system has been tailored primarily for the tail entry where its need is greater, although it can be used in head entries where the arrangement of existing equipment is not too congested.

The background which led to the development of the Leap-Frog concept over the other candidate systems has been fully explored in the Phase IA report and will not be repeated here. A primary reason for its choice was its flexibility and adaptability to a wide range of mine designs and varying conditions.

1.3 Summary

The detailed design of the Leap-Frog Entry Support system was completed during this phase. It is best illustrated in Figures 1 and 2. These figures show the three main components:

a. The beam and prop set

b. The transporter

c. The gate support chock for protecting the entry/face intersection.

In a typical application, the beam and prop set are installed in the entry at a point about 200 feet outby the face. This position is well ahead of the increasing abutment pressures and, if the beam is properly installed with a preload against the roof, it will forestall the usual breaking of the roof as the face approaches. The support set is removed when the face has become coincident with the beam.

The transporter has been designed for dual service. Its primary purpose is to leap-frog the beams from their terminal position at the face end of the entry to their new installation point approximately 200 feet away. But, it has also been designed as a universal beam handler which can pick a beam up from the floor for initial installation, maneuver it about, or put it back on the floor for storage or removal from the mine.

The Gate Supports are actually extensions of the chock line. Only two or three are required because they are only used in the intersection region of face and entry. They are chocks outfitted with extended canopies which extend across the tail drive of the face conveyor to a point approximately in line with the coal face. The tip is supported with hydraulic props for additional capacity and stability. In operation, these Gate Supports are brought as close as possible to the beam support set which is

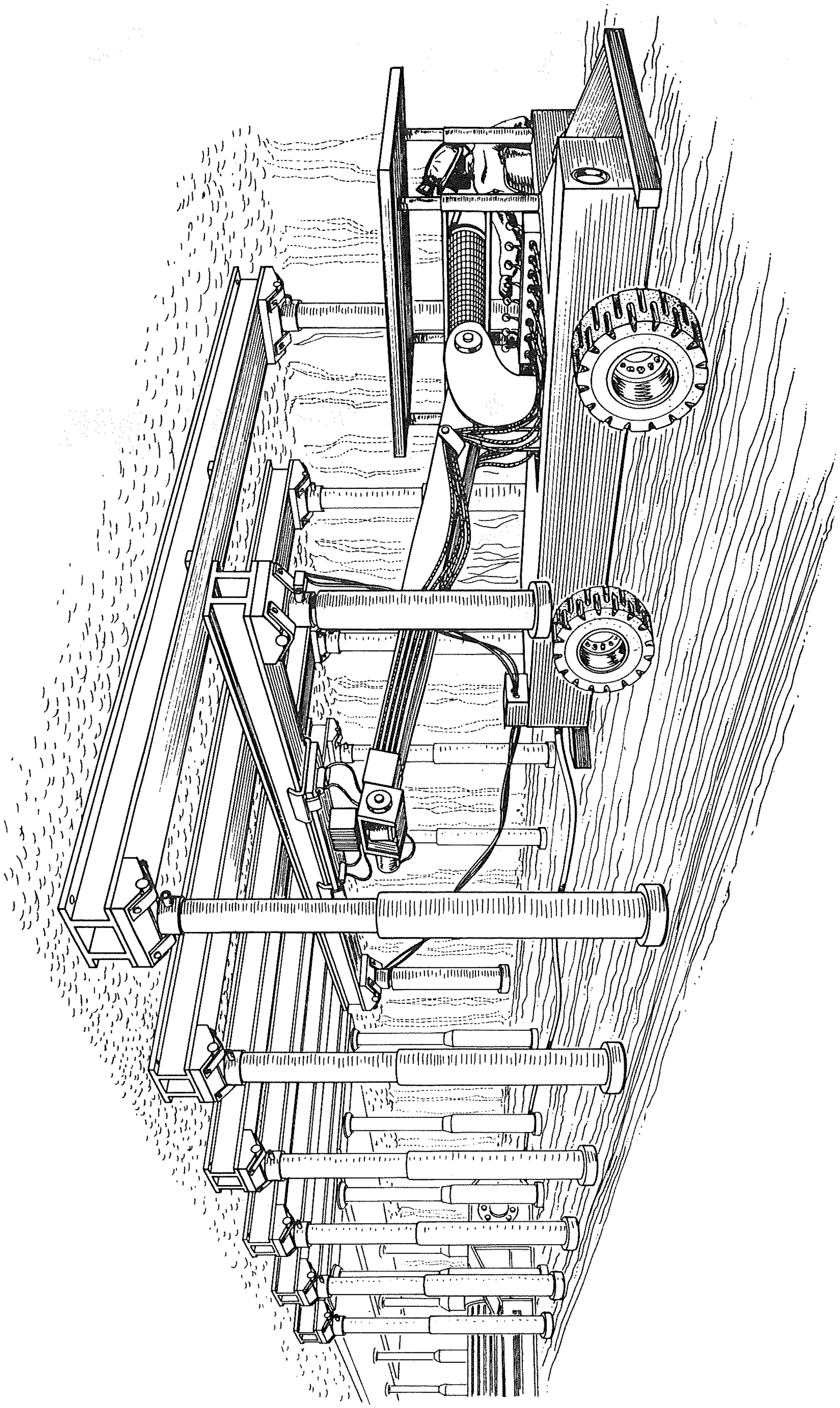


Figure 1. FMA Entry Support System

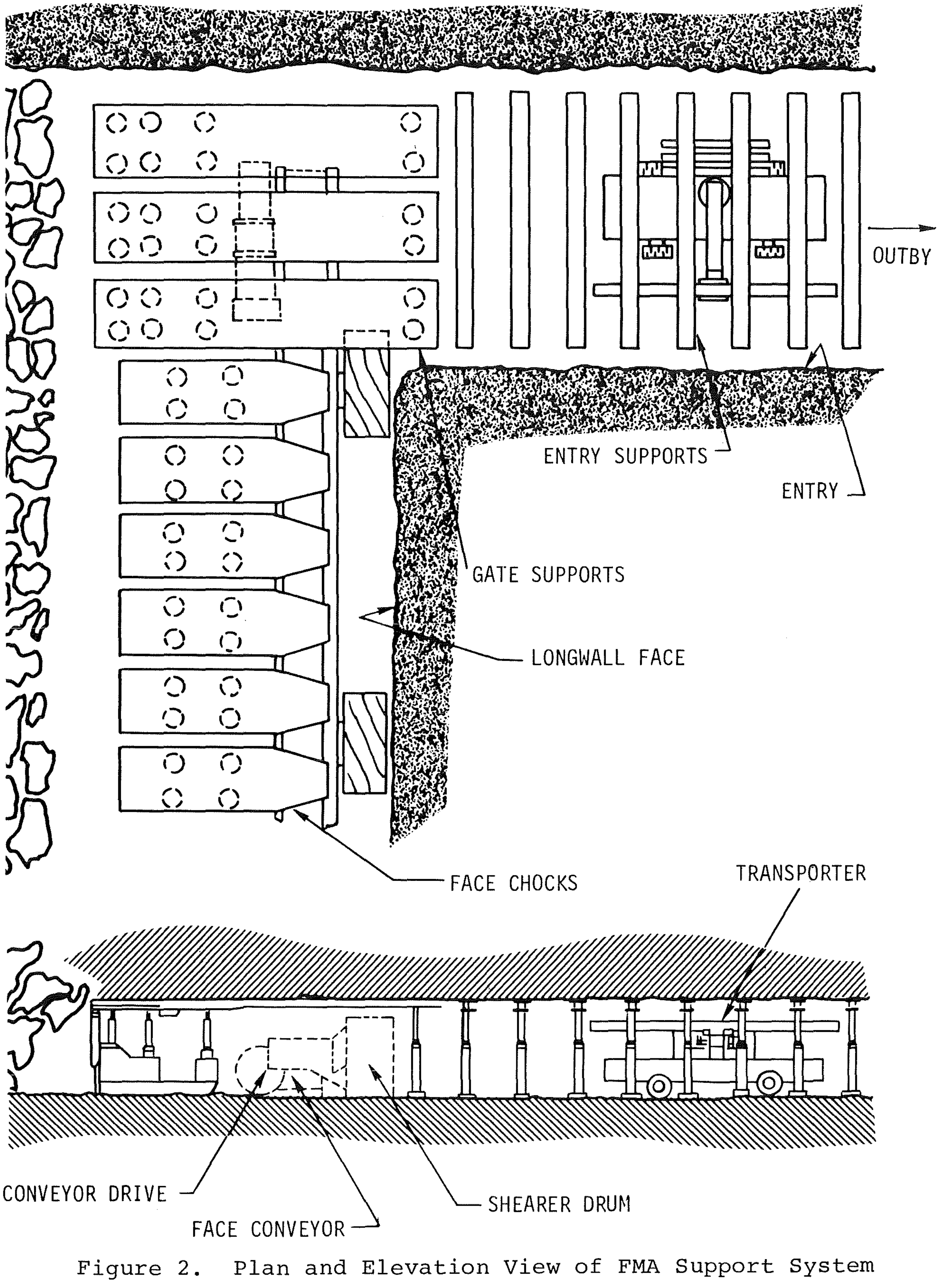


Figure 2. Plan and Elevation View of FMA Support System

to be removed before the transporter actually removes the beam. In this manner, a minimum of support interruption is experienced by the roof.

The advantages of this entry support system are as follows:

a. It maintains a wide corridor for ventilation and escapeway.

b. It applies a preload to the roof for optimal preservation of roof integrity.

c. It can be operated semi-remotely from a position under supported roof.

d. It is adaptable to a wide range of entry sizes and roof support requirements.

e. It protects the difficult intersection of face and entry.

We recommend that this program proceed to fabrication and testing of a sample system to affirm its support qualities and determine its efficacy toward improved production.

2. REVIEW AND REFINEMENT OF CONCEPT

2.1 Review of Phase IA Concepts

The research performed during Phase IA of this contract was roughly divided into three categories:

a. Research the problem, investigate related literature and experience, and develop several concepts which may satisfy the requirements.

b. Choose the best concept and complete a layout design of it.

c. Explore radically different approaches to solving the longwall entry problem such as different panel layouts, very narrow entries, variations on face equipments, etc.

The results of this work are extensively described in the Phase IA report, "Remotely Operated Longwall Head/Tail Supports". Briefly, three major concepts were developed:

- A walking support similar to face chocks linked up in two rows along the entry

- A crawling support with caterpillar-like tracks in continuous uninterrupted contact with both the roof and the floor

- A beam and prop support which is leap-frogged outby as the face retreats.

The last concept was chosen for final development.

It was determined that the best approach was to keep the support assembly as simple as possible and to confine any necessary complication to the transporting device. A number of concepts for transport were developed, such as monorails, bi-rails, individual roof hangers, cranes which moved along conventional rails, and a rubber wheeled vehicle with an articulated crane. The rubber tired transporter was chosen for further development, and a layout design was completed which employed a small Wilcox roof bolter as a base vehicle upon which was mounted a variation of a commercially available crane for handling the beams.

Several devices were considered for supporting the face/entry intersection region, the simplest of which was a modified chock with an extended canopy to reach over the face equipment. Hydraulic legs at the tip of the canopy would provide much greater support capacity than the cantilevered canopy alone. Subsequent to publishing the Phase IA report we have learned that Dowty is now making a "drive head anchor support" which is very similar to our concept.

In the present phase, these components have evolved somewhat for both technical improvement and better adaptability to the anticipated mine site. The test site will be discussed in the following section, and details of the current design will be fully described in Section 3.

2.2 Site Selection

During the early part of this phase, a survey was conducted on potential test sites. Contacts made previously were reestablished, and new ones were sought. Several satisfactory sites emerged which had seam heights in the range of 6 to 7 feet. Although the system design is relatively insensitive to seam height, the final choice of prop length and some of the transporter and crane details are dependent on height. Therefore, at this point in the program a seam range of 5 to 8 feet was set forth as a basis for the prototype design. The accompanying figures and drawings reflect this criteria.

The mining company most interested in FMA's Leap-Frog support system was the CF&I Steel Company. They wish to use it in their Allen Mine in Weston, Colorado, where the bad roof conditions are presently being controlled with steel beams which are abandoned as the longwall retreats.

Although other potential sites are being considered, CF&I is the strongest candidate, and a cooperative agreement covering the test program is currently being processed. A description of this mine and the application of this support system is covered in Section 4.

3. DETAILED DESIGN OF THE SYSTEM

This section will provide an explanation of the design and specification of the entire Leap-Frog system which is ready to be built as a prototype.

It should be noted that an important objective of the detail design was to use proven components and "coal mine" oriented design procedures to insure acceptability to industry.

Ease of modulation into the typical cycle requires standardization of such items as fittings, hoses, lubricants, and hardware. Operation must be straightforward and controlled similar to other vehicle operations. Selection of the above was accomplished by working with machine and cylinder manufacturers for the mining industry. This cooperative effort has resulted in a transport vehicle and support system composed mainly of off-the-shelf items.

3.1 Support System

The entry support system has been designed to incorporate a yieldable replacement for wooden cribs and posts and provide a safe access area for men and ventilation. This area is subjected to strata movements and induced abutment pressures caused by the advancing longwall. These loadings are not necessarily constant and may vary greatly from mine to mine depending on such constraints as geological conditions, entry size, panel size, etc. As concluded in the Phase IA report, the support capacity required would have to be tailored for a specific mine site but need not be limited to that. For purposes of the first prototype system, in a survey of probable mine test sites, attention was directed to particular support techniques used in tail entries and associated problems. Beams supported by wooden posts (Allen Mine), 8 inch 31 pound wide flange (W8 x 31) spaced from 30 to 60 inches on center, were found to be the larger end of beam sizes used. It was concluded that beams of at least comparable bending strength on yieldable props of adjustable capacity would provide the safest opportunity to test the system.

3.1.1 The Support Assembly

The basic support assembly, which will cover the entry, is shown pictorially in Figure 3 and is composed of:

- A welded pair of wide flange beams
- Cast socket bearing plate
- Cylinder prop end fitting
- Two yieldable single-acting support cylinders and associated setting and releasing valves.

As part of the site test, load distributing methods will be tested to ascertain their effectiveness in aiding roof maintenance. Three devices have been detailed for fabrication and will be discussed at the end of this section.

3.1.2 Beams

During the Phase IA study, the double wide flange beam section was found to possess many desirable support characteristics for the underground mining environment. This style of beam has:

- A high bending strength to weight ratio
- More stability under torsion, lateral bending and crushing loads than typical beam sections used underground such as rails, channels and I-beams

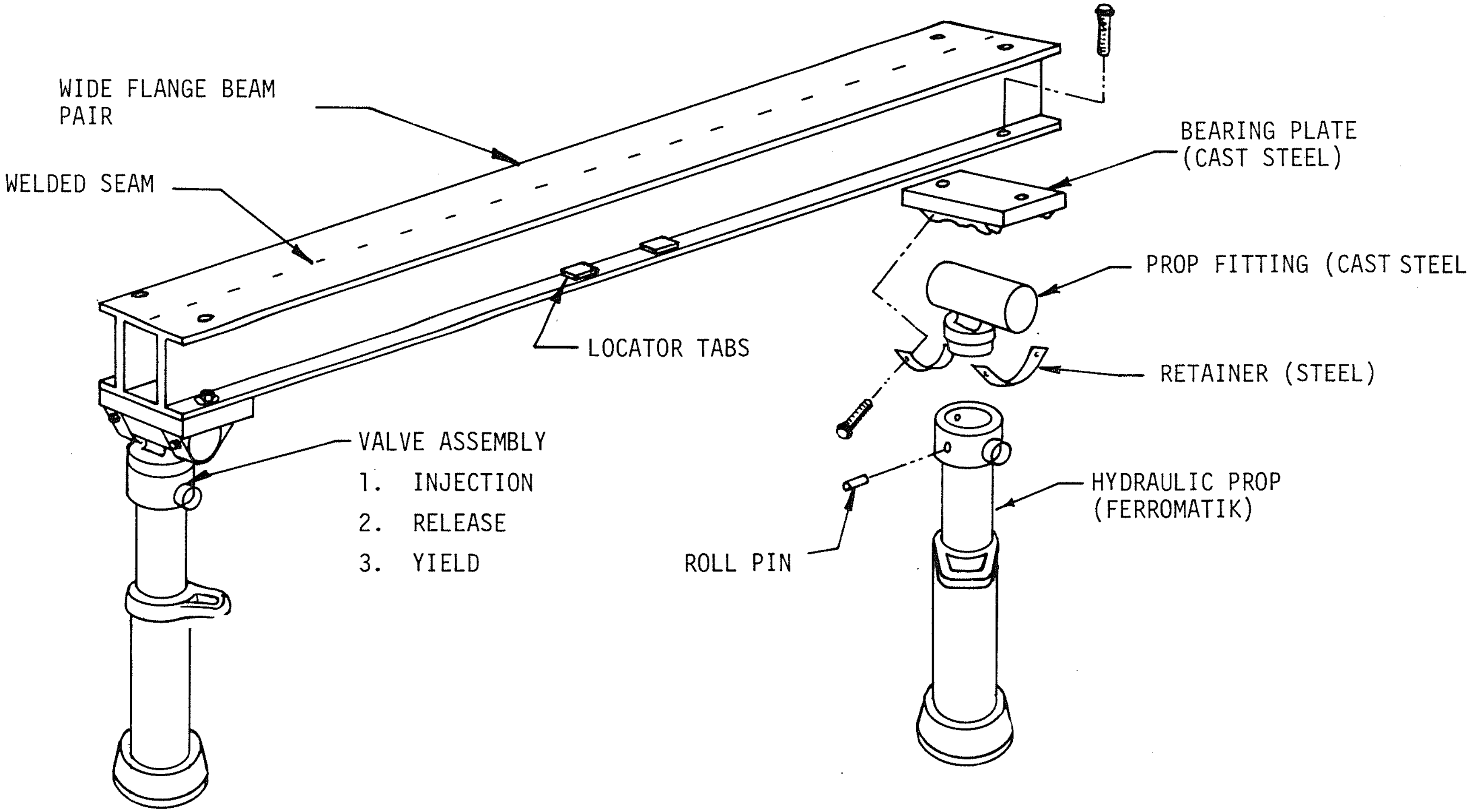


Figure 3. Support Assembly

- A ductile mode of failure when made of steel.
- A readily fabricated structure.

The strength required for purposes of the first prototype system was defined by considering past utilization of I-beams which had adequate strength to maintain open entries during operation. In most cases, the size found (in entries requiring steel beams) was the W8 x 31 beam. This beam has a section modulus of 27.4 cubic inches. To replace this single beam with two smaller beams welded together requires that the combined section modulus of the two smaller beams total or exceed 27.4 cubic inches. Two W8 x 17 beams, each having a section modulus of 14.1 cubic inches, satisfy this criterion. When the two beams are welded together the double web provides not only additional torsional rigidity and lateral bending strength to the beam but also increased crushing strength. The latter offers a practical advantage for mining use. It allows the placement of additional individual props, when required, with less concern for local failure.

The maximum load carrying capacity of this beam section is dependent on: type of loading distribution, span covered, and material of the beam. Based on entry width data collected during the Phase IA study, a beam length of 14 feet was determined to be applicable for most longwall tail entries. It satisfies the criterion of minimum distance of support from the rib of no more than 5 feet in face areas for entry widths up to 24 feet and still leaves a protected access envelope of approximately 12 feet in width.

The form of loading could vary from concentrated near the center (worst condition) to fairly uniform. To accommodate the highest range of loads a high strength steel has been specified. EXTEN-60 is a high yield stress steel which is commercially available in structural sections. It will not begin to plastically deform until the stress exceeds 60,000 psi. Considering these specifications (14 feet, EXTEN-60) the beam is capable of elastically carrying loads ranging from 20 to 40 tons depending on whether the load is concentrated or uniformly distributed. Note that setting the beam against the strata such that it accepts the load in a distributed manner significantly increases its potential. (For a more detailed discussion, refer to Phase IA report, 21 May 1976, pp. 4-18 to 4-30.)

Summary of critical specifications are:

- Overall dimensions - 8 by 10.5 inches by 14 feet
- Weight - 476 pounds
- Yield strength - 60,000 psi
- Elongation - 18 percent

The beam sets will have mounting holes on both the top and bottom flanges such that they could be inverted if necessary. As depicted in the drawing, the beam sets will be delivered to the mine site with a set of tabs welded near the center. These will optimize ease of handling for the crane operator by serving as indicators for pick-up and handling locations. The crane is capable of controlling the beam even when grasping 4 feet off center when deemed necessary by adverse entry obstacles. However, this is not recommended as a standard procedure. See Appendix D for specifications.

3.1.3 Cylindrical Socket Bearing Plates

The socket bearing plates have three functions:

a. To safely transfer the beam load centrally to the prop without crushing the flange or the web (30 tons per plate)

b. To provide angular articulation up to 60 degrees for aid in transporting the beam/prop assembly

c. To allow setting of prop legs at a slight inward angle and thereby improving stability of support when required.

The bearing socket plate bolts directly onto the outside of the beam flange and, for most operations, will remain attached. The mating part is firmly secured to the prop by roll pins. The prop is held to the beam by two strap retaining bands that bolt readily in place. These are strong enough to allow the crane to lift the props out of the mud but can be quickly unbolted to release the prop for replacement, removal or general maintenance.

3.1.4 Props

The purpose of the beam assemblies is to support the area of roof between the pillar and the panel. Ideally, the beam/props should keep the roof from sagging by providing support that is greater than the immediate load. But there will be occasions when the abutment loadings exceed the support density of the pillars. Under these conditions, the coal pillars compress. The Leap-Frog support system must also be capable of "compressing" when excessive loads are experienced while keeping the immediate roof up. This will prevent punching through the roof or shearing at the ribs. Even during floor heave the yielding capability of props will help to minimize fracturing of the roof-strata-beam.

Keeping the roof intact requires that a constant support load be maintained during all conditions. To satisfy these criteria, the FMA design specifies two 45 ton, single stage, single acting, open hydraulic, yielding pit props.* These props have been used since 1955 and proved their reliable service in mines both in Europe and the United States. They are particularly suited for this application for five reasons:

*Equipment being used and found to meet all criteria for this program is Kloeckner-Ferromatik.

a. They use a 1 percent oil-in-water emulsion as a hydraulic fluid (same as face chock system) and will not require any modifications to operate with our system.

b. They can be set against the beam at a predetermined load which is not affected by the man placing the prop. It is controlled independently by the pressure in the line supplied to the prop.

c. They have a gas-controlled yield valve which operates with minimal internal friction. It provides a constant supporting resistance against the beam.

d. They are designed in such a way that all components are readily accessible and can, to a large extent, be replaced underground.

e. They are available in many height ranges (for example, 50 to 79 inches for the prototype).

In addition to these pertinent technical characteristics, the manufacturer also provides a number of accessories to complement the versatility of this prop. A load measuring pressure gage can be fitted to any prop under load at any time. This feature will permit a constant surveillance of the load distribution down the entry, a factor which can enhance safety during testing by indicating high loads as they approach each zone. The props also have a protective outer steel shield which encases the working cylinder and takes the abuse. The internal valves of each prop are easily activated by a setting pistol. This enables the entire system of props to be set by one or two hoses which need not remain attached to the prop after setting. The props come equipped with an extra-strength return spring. This will close the cylinder (when held at the top) to within 4 inches of its collapsed height if the release valve is open and the cylinder is not under load. The manufacturer has supplied shop drawings of the prop and some of the associated accessories with their price quote and can easily supply them in the quantities and load-height range required. (Refer to drawing B-7522-11003-X).

It should be noted that more than half a million of these props have been put into service underground to date. Their functions have been refined over the years to a high degree of reliability. The ease of operation allows a miner to control the setting or release of the prop manually. Since the Leap-Frog system requires the props to be pressurized and depressurized remotely to insure safety of the man, FMA has designed a separate hydro-mechanical device to externally replace the hand functions. By doing this, the integrity of the props' support capabilities, which have already been proven, are preserved.

Basically, the prop's setting valve is three valves in one. The first valve section has a spring-loaded check valve for setting. This will open and permit fluid to enter when pressurized from the emulsion line. Typically, this is accomplished by using a setting pistol. The pistol is inserted in the prop valve and contains a hand operated flow control over the pressurized emulsion.

The second valve section is a yield valve. It senses internal pressure and will bleed to atmosphere when the pressure exceeds the yield setting.

The third valve is mechanically operated by a hand-held cam-lever. It allows fluid to be released from the prop for lowering. The cam is manually inserted into the cylindrical receptical on the prop collar. When rotated 90 degrees the check spring is compressed and the valve is opened. This allows fluid in the cylinder to flow out of the system until the cam is rotated back to the free position.

FMA's design replaces the two manual operations of pulling the setting pistol trigger and that of rotating the release cam as follows:

The setting pistol is still used to mate with the prop fitting but a pilot operated check valve is put in-line with the emulsion supply hose to supply pressure to the prop. The pilot line is remotely operated by the main valve bank at the canopy station on the transporter. It will open or close the check valve in the emulsion hose. With this flow control implemented, the trigger on the setting pistol can be adjusted to "open" and the need for a manual operation eliminated.

The hand-held rotating cam-lever is replaced by a mechanical lever actuated by a small single-acting hydraulic cylinder. This cylinder is also controlled from the main valve bank. Once the hydro-mechanical device is inserted into the prop release receptical and the setting pistol secured to the collar, the man can return to the operator's station and activate or depressurize the prop remotely. See Appendix D - System Specifications.

3.1.5 Load Distributing Devices

As pointed out in the Phase IA report, one of the advantages of this system, unlike most conventional systems, is the preloading force that is applied to the roof where the support is installed. This will help prevent initial sag and cracking of the immediate roof strata prior to the abutment loading. Unfortunately, the roof contour is usually irregular. How much this will diminish the effective support of the system is at this time unknown and will have to be determined by testing. By using a load distributing device on the top surface of the beam assembly to approach ideal contact conditions between the beam member and the applied load a comparison can be made. Three such techniques were presented in the Phase IA report:

a. Camber

b. Paper honeycomb

c. Hydraulic pillow

These have been detailed for the first underground test as follows:

Camber

A few beam assemblies will be precurved in an upward arch which, when measured in the center of the 14 foot beam pair, will be approximately 1-1/4 inches higher than the ends. This is a common commercial procedure and is frequently applied to structural beams. (Refer to drawing C-7522-11001-2). If the roof was initially flat, this device will tend to support the roof from the center outward up to 43,000 pounds before the beam is flat against the roof from end to end.

Paper Honeycomb

Paper honeycomb is available in the strength range required for this task and can be impregnated with a fire retardant. Based on observations of mine roofs shortly after a cut, a 4 inch thickness of honeycomb was determined adequate to encompass cutting teeth variation across the entry and local irregularities. A support density of 45 psi has been specified before crushing. This will be low enough to allow local protrusions to sink down into the honeycomb and still be high enough to support a load of 30 tons when about two-thirds of the area of the upper flange covered by the honeycomb has made contact with the roof. Note that for excessive loads the honeycomb will begin to crush down onto the beam until the load valve reaches the yield setting of the props and, at this point, the entire assembly will yield. See Figure 4 for details (also drawing B-7522-11008).

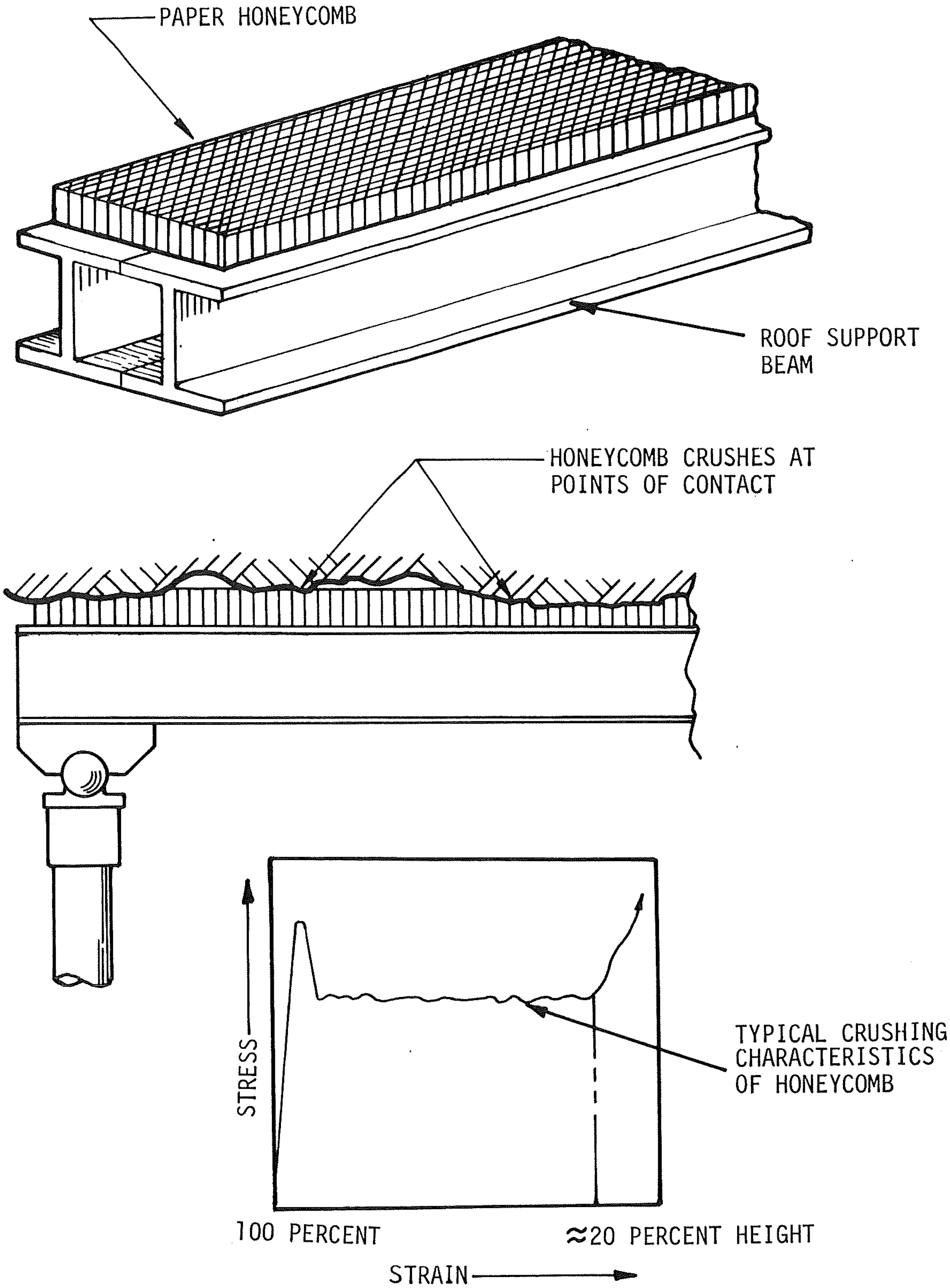


Figure 4. Honeycomb Load Distributor

Hydraulic Pillow

Another method to provide more uniform loading to an irregular surface is by using a pressurized flexible cushion. This imparts equalized pressure over all points of contact. This method also has the advantage of being reusable. For purposes of testing the prototype system, a double jacket, high abrasion resistant hose, rated in excess of 200 psi, has been specified. A ready source of this material is 6-inch diameter "soft-suction" fire hose. It measures approximately 10 inches when flattened and would support 120 tons for the 14 foot length when inflated with fluid to a 2 inch height. As shown in Figure 5 it is held in place on the beam by end clamps which also serve the purpose of sealing the fluid in the cushion (also drawing A-7522-11007). Angle irons along the length of the flange edge will provide a trough to maintain the pressure over the center of the beam. Proper operation to assure stability of the support would require the following steps:

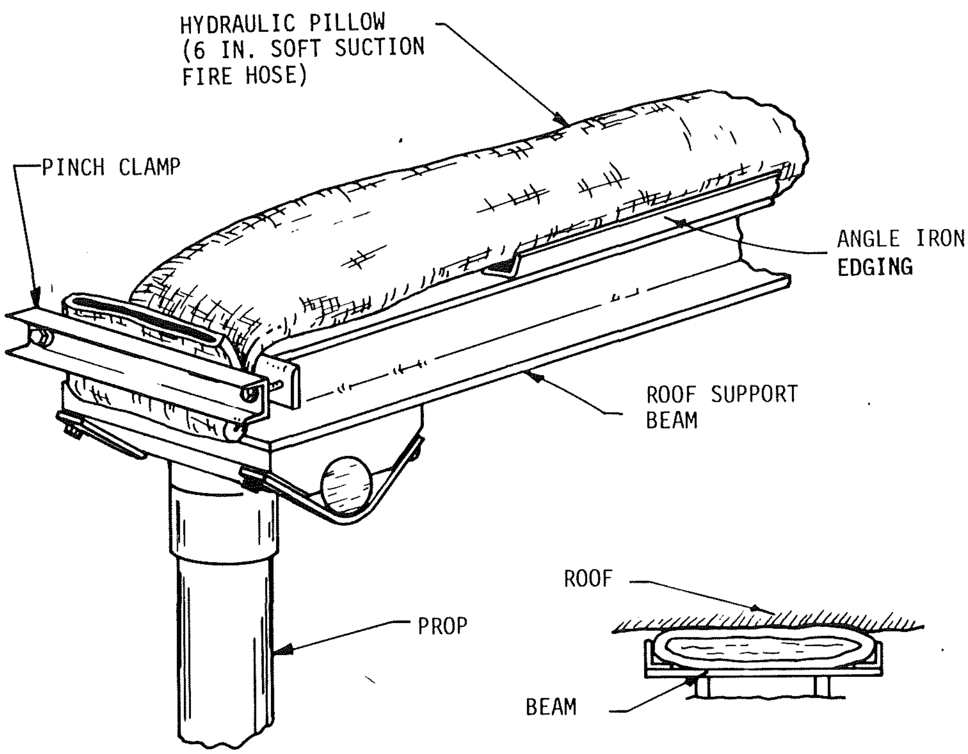


Figure 5. Hydraulic Pillow

a. Depressurize hose

b. Set beam against roof with props

c. Inflate hose with emulsion at 20 psi until all voids have been filled.

3.2 Transporter

Inherent to the Leap-Frog support system is the necessity to physically move a beam-prop assembly, which is in position adjacent to the advancing face, to its new position 200 feet outby. This function must be performed safely, as frequently as every 30 minutes on occasion, and without interference to the remaining portion of the support system. In addition to this basic operation, the versatility to include initial installation and transfer to another section of mine will be an attractive attribute of the system. The need for a mechanical apparatus to handle the individual supports evolves from the following requirements:

a. Remote operation of the system is required to protect an operator from injury, either from the beam structure itself or the occasional occurrence of rock fall while removing installed or existing supports.

b. The weight of the beam alone will exceed 476 pounds. When the props and end fittings are added to this, the total weight of the assembly increases to 823 pounds.

The key to the Leap-Frog concept is providing the safe support required to satisfy industry by a method which operates smoothly in conjunction with existing equipment. The functions required by a transport vehicle were defined during the Phase IA study as:

a. Move readily within the confines of the supported entry

b. Articulate the crane to the beam assemblies' center of gravity

c. Carry hydraulic lines which will be used to pressurize and depressurize support cylinders

d. Remotely control setting and retractions of props

e. Be capable of not only supporting the entire weight of the beam prop assembly but also be capable of lifting the assembly out of a soft floor

f. Clamp the beam securely for safe transport

g. Raise and lower beam assembly during transport to negotiate obstacles

h. Rotate beam assemblies a minimum of 35 degrees to permit passage between emplaced beam assemblies

i. Retreat with beam-assemblies a minimum of 200 feet outby of the face

j. Install beam assembly at the outby position.

In addition to these entry specific requirements, FMA has concluded that in order for the unit to be used optimistically by miners and industry it must:

a. Make the job of entry support easier and safer than conventional methods so that the job is desirable

b. Not only provide the specific job of Leap-Frog units but be capable of removing or installing existing wooden or steel beams

c. Be capable of "picking" a beam from the floor and then carrying on typical handling procedures.

These features would aid in other parts of the mine such as building false roofs or unloading beams or timber from railed vehicles or adding additional support to road heads.

FMA has designed a rubber-tired vehicle with a mounted turret crane to accomplish all of the above. The machine will operate from electric power tapped off the tail drive of the face conveyor or other suitable high voltage line. It will allow an operator to remotely handle the beam completely by the articulated crane from a canopy station. This will include such operations as "picking" a beam up off the floor, raising a beam to the roof, rotating a beam in a yawing manner, pitching or roll, and repositioning the beams from one end of the vehicle to the side or other end for transportation. An adapter clamp can be provided as an accessory to handle other size steel beams or timber. The transporter chassis is structurally similar to the Fletcher LTDO single arm roof bolter with the exception of the location of internal equipment and hydraulic reservoirs. In fact, the overall design is simpler for manufacture than most bolter chassis and still provides more than adequate mobility to cover the typical mine terrain.

3.2.1 Chassis Design

The parameters defining the chassis constraints were: the envelope of work space under the support system, power source available, and the total power required to operate the crane. Of these, the envelope of work space presented the most difficulties to the mechanical design. This was the result of keeping the vehicle small enough to provide adequate mobility and at the same time large enough to manipulate a 1000 pound beam through its various positions. The latter also required that the operator be under supported roof and in a remote safe location at all times.

The Phase IA study has shown that a small roof bolter could be modified to carry a crane at a mid-chassis location and an operator's canopy station at one end. Its overall dimensions would be 4 feet wide, 9 feet long and 3 feet high. This design was presented to operate in head entries as well as tail entries, that is, alongside the stage loader conveyor, and only transport beams from one support position inby to another support position outby. As mentioned at the onset of this section, for purposes of a prototype, a more versatile machine would enhance its acceptance during testing. A machine with a longer and wider wheelbase improves stability during beam handling. It allows the use of many size support beams (heavy or light) and removal of heavy beams currently in place. This system has ample counterbalance to permit extension of a crane beyond the end of the vehicle enabling the operator to pick and lift a beam up off the floor.

Survey revealed a machine which had been manufactured by Joy and some maintenance shops called a timber setter. Its purpose was that of lifting timbers to the roof and holding them there while posts were cut and wedged in place. These machines were usually quite large and did not effectively satisfy the transporter requirements because their booms were mounted at the extreme end of the vehicles preventing the required 180 degree swing to the opposite end for reinstallation.

Analysis of virtually all small roof bolters showed the following desirable and some undesirable characteristics:

Desirable

- Tram drive and steering
- Basic power components, cable reel, pump, filter, lights, starter box, etc.
- U-shaped chassis adaptable for housing the crane turret mount
- Proven durability and mobility in mine entries

Undesirable

- Short wheelbase
- Oil reservoirs occupying central location of chassis
- Unbalance of weight after removing forward drill and boom assembly
- Limited room for a mid-position operator's canopy station due to short wheelbase.

It was found that J.H. Fletcher and Company had manufactured one of their LTDO's with an extended wheelbase of 69 inches for the U.S. Steel Gypsum Mine. Further conversations with Jim Fletcher confirmed which modifications could be made to essentially "open" the mid-chassis area to accept the crane. This would involve relocating the 40 hp electric motor, the hydraulic pump, the cable reel, dividing the oil reservoir into two separate tanks, and removing the boom and drill assembly. Other manufacturers were not willing to supply us with these modifications to their machines.

The detail design and specifications of the transporter chassis were based on developing a new chassis which maintained as many features of the modified Fletcher LTDO as possible. Attention was directed toward utilizing all available space in a cost effective approach starting with the initial U-shaped frame and tram wheel mounted suspension system. The cable reel was mounted within the "U" frame, eliminating the extra support bracketry usually incurred when mounted off to one side. The motor and pump were located diametrically opposed at the far end, again within the U-frame to balance the weight. To provide adequate cooling for the hydraulic fluid a large reservoir was necessary. This was accomplished by using two reservoirs. One was located adjacent to the cable reel in an L-shape and the other next to the motor. The tank near the motor was designed in a wedge shape with its slender portion tapering down to the end of the vehicle. This was done to provide space for the boom to lower to the ground. With the utilities in these locations the mid-chassis is open to house the turret crane. Two cross plates spanning from one side of the U-frame to the other were detailed to be welded and braced with perpendicular gussets forming a rigid box section to mount the crane. This completed the interior design of the U-frame. As shown in drawing R-7522-12001, the canopy-control-station is mounted between the wheels on the side of the vehicle. Its location permits the crane to swing in excess of 210 degrees such that beams can be handled to either end and from a safe position. The canopy protected platform for operations of setting and removing beams in a tail entry is an essential aspect of the machine and, as such, the canopy has been designed to prevent debris larger than 3 inches from falling through the top and to maintain the structural integrity required by MESA regulations. All of the hydraulic controls are positioned along the inboard side of the platform. This will enable the operator to drive and completely articulate the crane without leaving the canopy station, thereby inherently insuring that he will be under the canopy during beam manipulations. Fletcher and Company has reviewed and approved the transporter chassis just described and shown in drawing R-7522-12001.

3.2.2 Crane Design

The transporter vehicle was designed to operate in entries ranging in height from 56 to 96 inches with a width of approximately 16 feet. The design parameters were based on the evaluation of the following criteria:

a. Operational requirements
b. Environmental considerations
c. Safety
d. Versatility
e. Maintenance and repairs
f. Cost.

The following paragraphs are a definition of each of the above criteria.

3.2.2.1 Operational Requirements

The transporter crane assembly is far from being an ordinary lifting crane. Due to the limited space in which it will work it will always have to maintain a positive grip on the roof beam assembly that it will transport. The operator is required to have positive control of the position and attitude of the roof beam assembly so that it can be maneuvered between and around obstacles in the entry. As a consequence, the crane assembly has to meet the following criteria (Figure 6).

Rotation of the Entire Crane Assembly Around Turret

The fact that the transporter does not normally turn around in the entry makes it mandatory that the crane swing the support

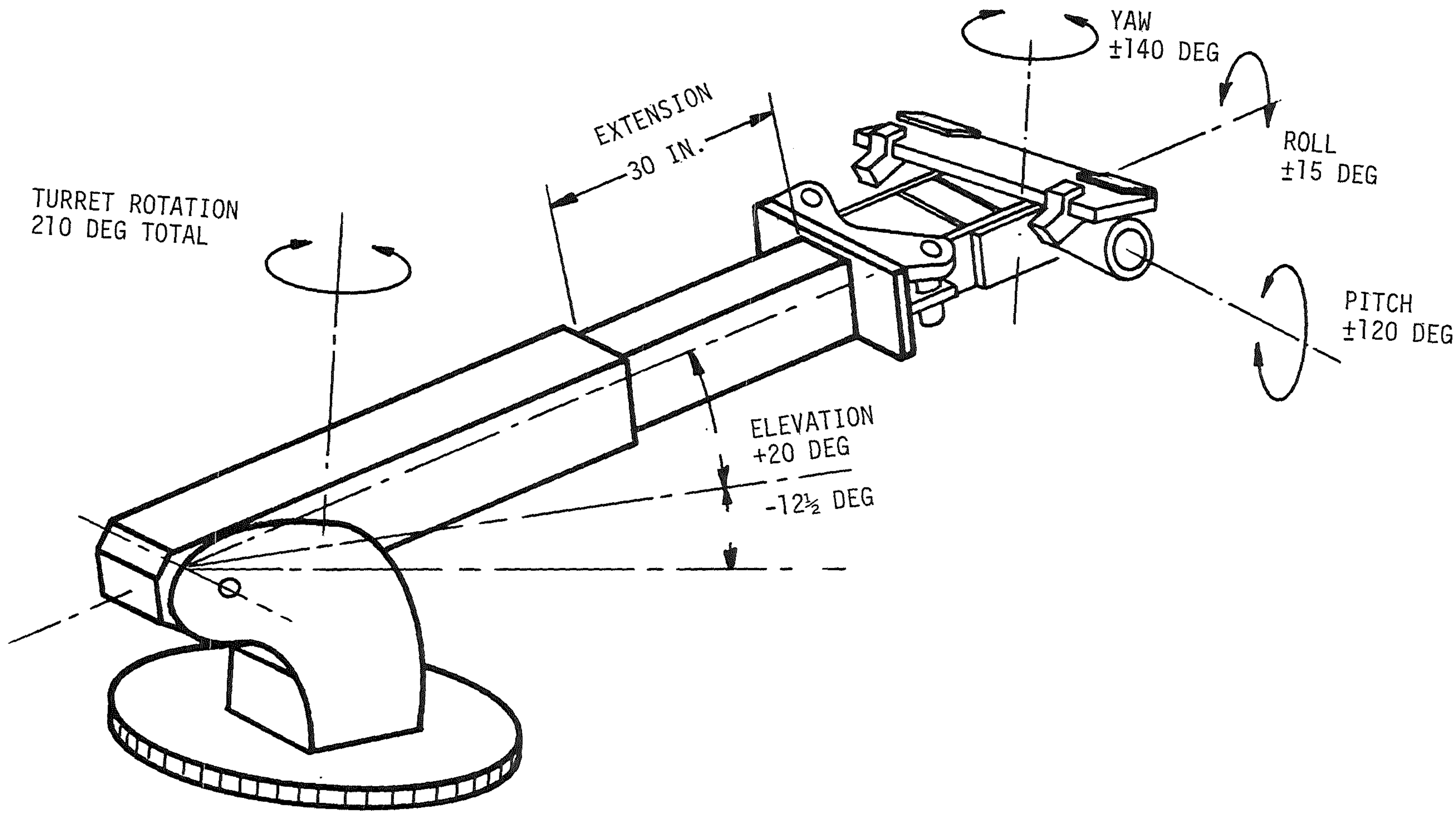


Figure 6. Crane Capabilities

beam assembly from the front of the vehicle (removal) via the side (transport) to the rear (installation). In addition, a revolving crane makes positioning of the beam saddle under the roof beam considerably easier. Rotation is limited by the operator canopy to approximately 210 degrees.

Elevation of the Boom

The boom can be elevated +20 degrees to install 8 inch beams against an entry roof with a maximum height of 96 inches. It can be lowered to -12.5 degrees to pick up a beam lying on the entry floor.

Extension and Retraction of the Boom

The upper boom assembly has a 30 inch stroke. There are a number of reasons for this feature. In the extended position, the roof beam assembly can be held beyond the transporter frame; this will reduce damage to the vehicle by falling rocks as beams are removed. Additionally, the saddle clamp has to reach beyond the vehicle to pick up beams from the floor.

When travelling with the boom swung to the side of the vehicle it is desirable to keep the boom as short as possible. This will give the vehicle more room to maneuver and will also give the transporter greater stability because of the reduced overturning moment. Finally, an extendable/retractable boom will greatly assist the operator to properly position the saddle clamp under the roof beam.

Rotation of the Roof Beam Around a Vertical Axis (Yaw)

Rotation of the saddle clamp is required in order to comply with the geometric constraints of the system within the entry. For example, each time a beam-prop assembly is removed from the inby face position it must be rotated a minimum of 35 degrees to provide end clearance before it can be transported. Furthermore, the approach position between the transporter and the beam will always be slightly different. To compensate for this difference, to allow for manipulation around obstacles, and to provide the necessary articulation for final beam placement, a 280 degree rotational capability has been designed into the head of the boom. This flexibility will aid the operator in positioning a support beam within a very confining work envelope.

Rotation of the Roof Beam Around the Crane Boom Axis (Roll)

The roof beam cannot always be installed in a perfectly horizontal plane. Neither will the vehicle always be level. To meet these conditions, a ± 15 degree roll mechanism is an essential part of the upper boom assembly. This roll is sufficient to handle a beam assembly with one prop fully extended and the other fully retracted.

Rotation of the Roof Beam Around a Transverse Boom Axis (Pitch)

The roof beam assembly cannot always be positioned in a vertical plane. Besides, keeping the beam-prop assembly vertical while the boom is raised or lowered requires a pitch control mechanism. A rotary actuator with 280 degrees of rotation also allows the head to rotate 180 degrees for picking up beams from the floor.

Beam Clamping Mechanism

Two cylinders, each rated at twice that of any of the other components, will activate clamps that hold the roof beam on the beam saddle. The reason for the extra safety factor is that the beam should be held by the boom at all times and should not be allowed to drop from the saddle.

3.2.2.2 Environmental Considerations

Because this crane will work in a coal mining operation, particular attention was paid to explosion hazards and coal dust. The crane assembly is, therefore, entirely hydraulically operated. All bearings are sealed and major components are enclosed and sealed as much as possible. Lube fittings are installed at those points where it is necessary to force out dust from mating surfaces.

3.2.2.3 Safety

Realizing that the transporter will operate under adverse conditions, a safety factor of three was used for the structural part of the crane assembly. From an operational point of view, several other safety features have been incorporated. The boom swing mechanism is driven by a worm gear reducer in order to provide a positive lock should the drive motor lose hydraulic power. The lift cylinder has an automatically actuated check valve that is activated when there is a sudden loss in hydraulic pressure. In addition, each actuator and cylinder has, at its ports, a flow control valve which limits the rate of rotation or retraction to one that poses no danger to the operator. As mentioned before, the clamping cylinders have a rating twice that of the other hydraulic components so that under all circumstances the roof beam will remain clamped in the saddle.

Routing and installation of the hydraulic hoses has been given particular attention to ensure that they do not accidentally get cut or bent beyond their minimum bending radii during any of the operational movements.

3.2.2.4 Versatility

By expanding the operating requirements of the transporter just slightly a more versatile unit was designed. Increasing the pitch rotational capability from about 45 degrees (as required for roof beam handling) to 280 degrees, allows the crane to pick up beams, without props, from the floor. Assembly of the support set can then be accomplished by lifting the beam and manually installing props at both ends.

The roof beam saddle is sized in such a way that adapter blocks can be bolted on it so that beams of various widths can be transported. The saddle plate, with the clamping cylinders, is bolted to the saddle shaft and can be easily removed to accommodate a variety of attachments that may have up to two hydraulic circuits (see Figures 7,8,9,10).

3.2.2.5 Maintenance and Repairs

Realizing that maintenance and repair conditions are far from ideal, we have standardized as many components as possible. Rotary actuators are identical, bearing sets are identical, and

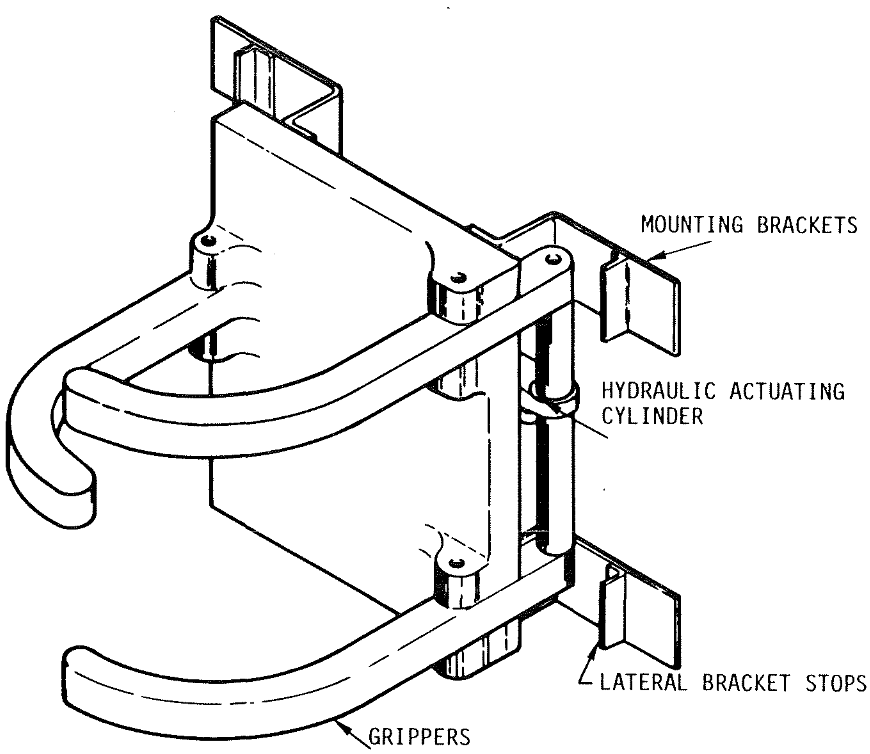


Figure 7. Hydraulic Prop Gripper

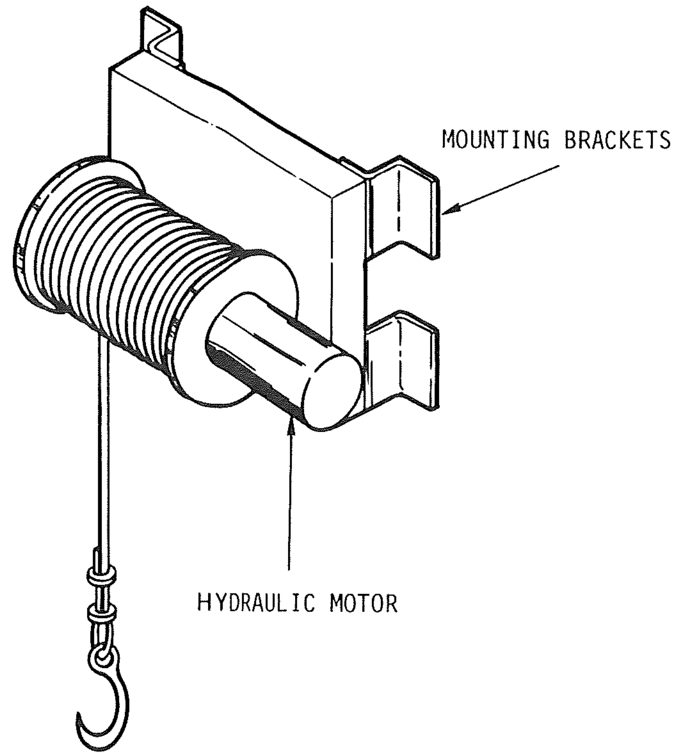


Figure 8. Hydraulic Winch

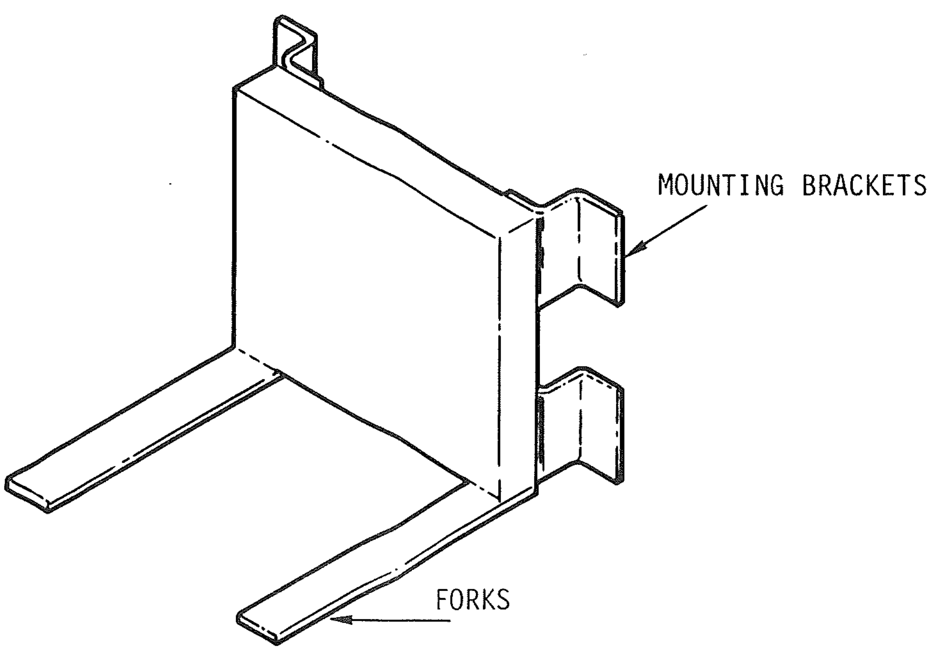


Figure 9. Fork Lift

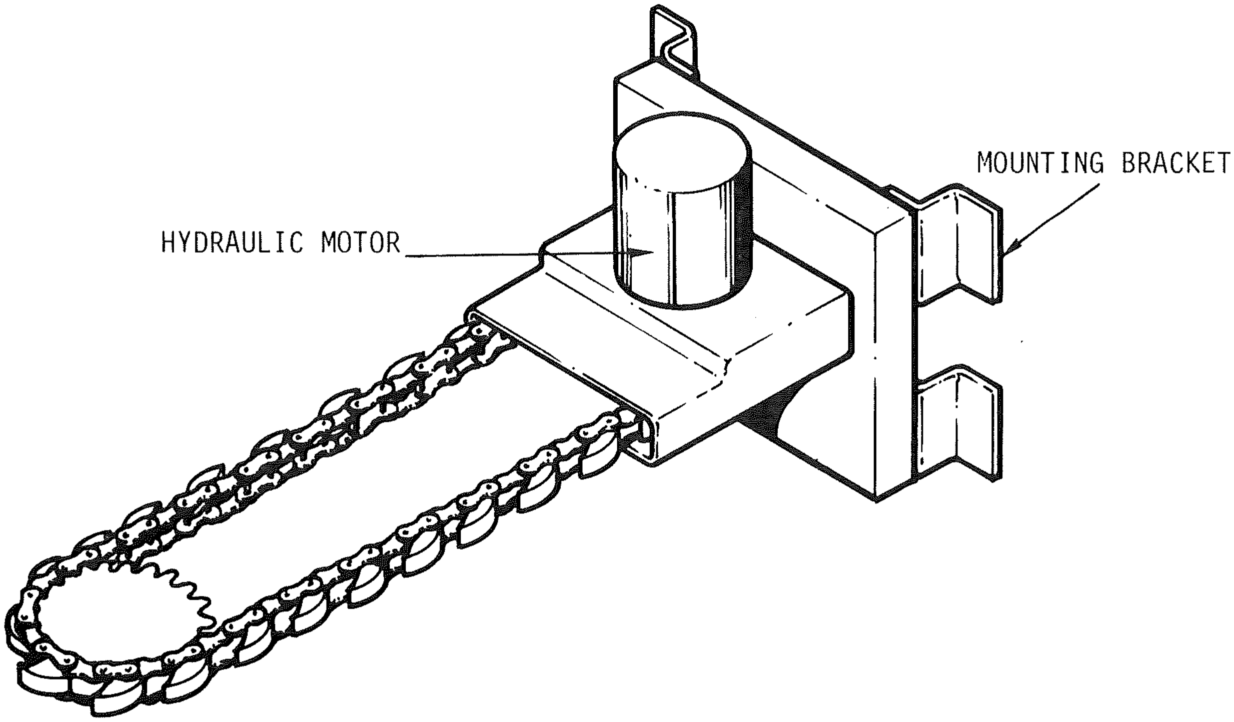


Figure 10. Hydraulic Chain Saw

95 percent of all hydraulic hoses are 1/4 inch ID with corresponding fittings.

The extension cylinder, mounted inside the boom, can be removed without removal of the entire boom.

3.2.2.6 Analysis of Anticipated Loads

Previous work in Phase IA and additional research in this phase indicates that the roof beams most likely to be used are either a pair of W8 x 17 beams or a single W8 x 31 beam, each 14 feet long. It was assumed that each prop will have a maximum weight of 159 pounds (79 inch extended length). Furthermore, an allowance of up to 500 punds may be required to break out those props that are embedded in the entry floor. Thus, the maximum lift requirement is: [14 x (2 x 17) + (2 x 159) + 500 = 1294 pounds.] The worst loading condition is reached when the roof beam assembly is carried off center with its center of gravity rotated away from the vehicle. The maximum values for off center pick up and rotation are established by the maximum resisting moments at which the rotary actuators and cylinders start to relieve hydraulic pressure (see Table 1).

The worst loading condition is that where the 823 pound beam assembly is picked up 48 inches away from its center of gravity and at the same time is rotated 45 degrees away from the vehicle.

The maximum resisting moments of the roll and yaw mechanism and weight of the roof beam assembly plus the crane weight formed the basis for the structural calculations and the selection of the purchased components.

3.2.3 Hydraulic Circuit

The complete hydraulic circuit schematic for the transporter with crane assembly is shown in Figure 11 (which is drawing D-7522-12 HYD). The system will be supplied by a commercial shearing two section pump, series 2500 and will have an operating line pressure of 2000 psi. The schematic shows one large valve bank; it governs the tramming as well as all crane functions. The first pump section copy out supplies the left tram control and all crane control valves. These spool control valves are parallel circuited and can operate independently of one another. The lift valve controls the raising and lowering of the boom. The return port is supplied with a flow restrictor to prevent the double-acting cylinder from unloading too fast during lowering under load. The extend valve also controls a double acting cylinder and must have restricted flow on both ports to insure safe operation of the boom above and below horizontal.

The turret, pitch, yaw, and roll control valves all have similar functions. They must have safe restricted flow in both directions and must inherently protect the structural system from

Table 1. Specifications for Rotary Actuators and Cylinders Employed in the Crane Subassembly

Movement	Actuator Mechanism	Actuation Range*	Relief Setting (psi)	Resisting Moment (ft/lb)	Linear Force Push/Pull (lb)	Velocity	
						Angular Rad/Min	Linear In./Min
Rotation	Gear Motor	±105 deg	1,300	652**	-	12.56	-
Elevation	Cylinder	+20 to -12.5 deg	1,500	-	12,450/3,530	-	60
Extension	Cylinder	0 - 30 in.	2,000	-	9,800/6,850	-	120
Yaw	Rotary	±140 deg	2,000	27,000	-	25	-
Roll	Cylinder (2)	±15 deg	670	38,600	-	-	60
Pitch	Rotary	±120 deg	2,000	27,000	-	25	-
Clamping	Cylinder	-	2,000	-	3,530/2,920	-	120

*Values with respect to "mid-travel" positions.

**Pinion rating to acquire resisting moment of 4500 ft/lb for boom.

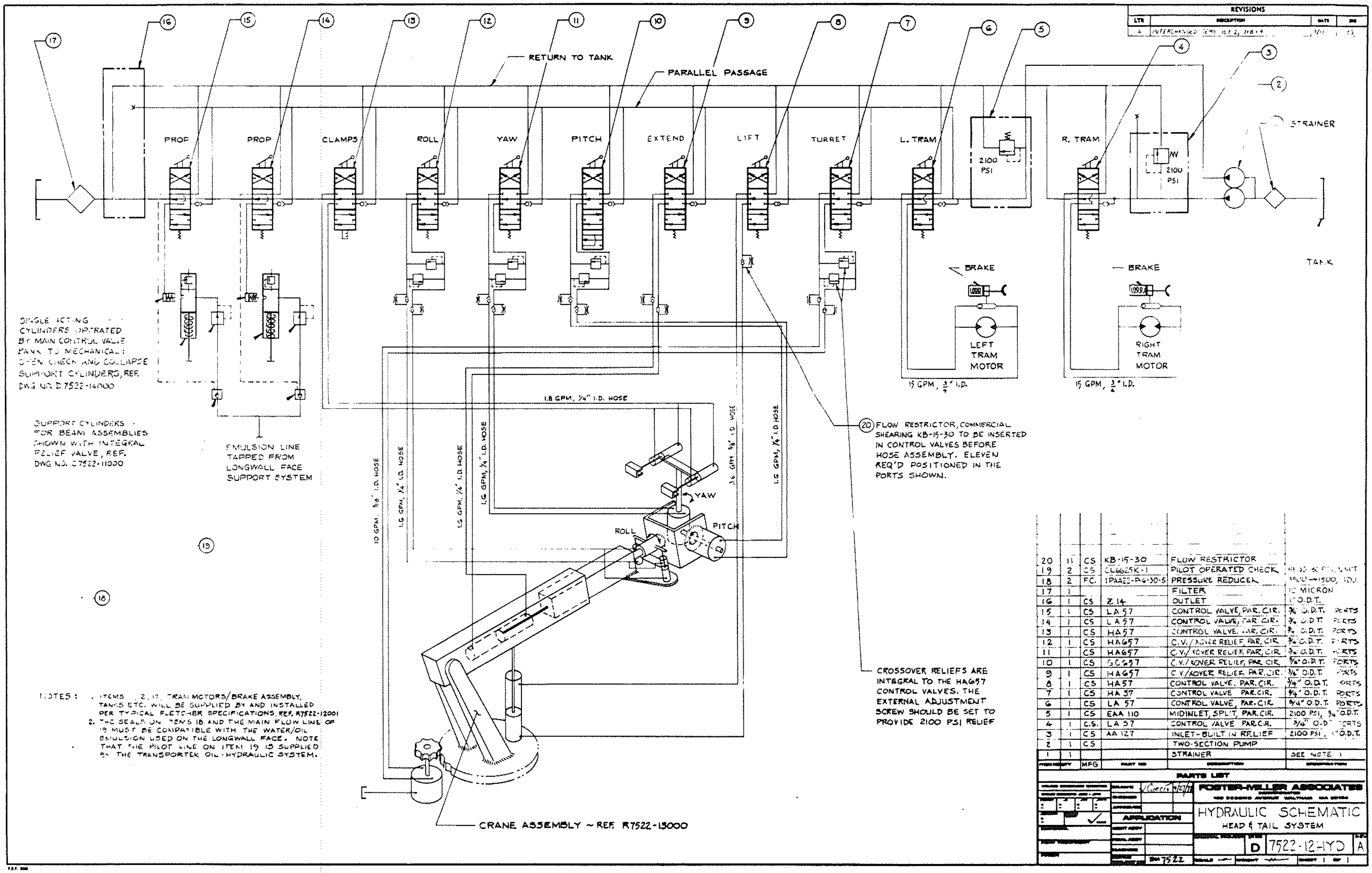


Figure 11. Hydraulic Circuit

unforeseen obstacles. For example, when carrying a beam down the entry accidental collisions between the beam and the roof or support can occur. This will not only cause excessively high internal line pressures but subject the crane assembly to the forces balanced by the vehicle momentum. Each of these valves will be equipped with cross-over reliefs which will allow any high pressure build-up on one side of the circuit to bleed to the other side; in effect, a slipping clutch for the control motors. In addition, the pitch valve will be a four-way, four-position valve where the fourth position is a "float" mode. This feature will allow the beam-prop assembly to hang freely in a vertical equilibrium position from the crane saddle during raising. This is accomplished by having the pitch pivot bearings above the center of gravity of the support assembly. When the beam-prop assembly is removed from the roof the "float" mode will be a safety device for the saddle, that is, if the feet of the props are stuck in the floor the crane head is free to pitch and thereby accommodate the changing angular alignment between the closing prop cylinders and the lowering boom.

The beam clamp is activated by two small double acting cylinders. They are parallel circuited and controlled by one spool valve. This valve will have detent sets in all positions and will maintain an open or clamp position until changed by the operator.

There are two prop control valves: one for each end of the beam support assembly. Since the beam support assemblies operate on a different hydraulic system (emulsion from the face), these valves activate pilot type controls to direct the emulsion to and from the prop. The valves both have a free float in the neutral position, which serves two purposes:

a. It allows the pilot operated check valve which controls the emulsion line to depressurize and hence stop the emulsion flow.

b. It allows the hydraulic fluid in the single-acting remote prop actuator (drawing D-7522-14000) to return to tank, thus closing the prop release valve.

The remaining components in the field of the drawing are standard on all rubber-tired vehicles, that is, filter, strainer, tank, tram motors, and brakes and will not be discussed here since they are being used in the conventional manner.

3.3 Gate Support

In most longwalls, it will be necessary to remove the support assembly before the face approaches so that the face conveyor and shearer drum can extend freely into the entry. This leaves the relatively large face/entry intersection unsupported which is not only hazardous but threatens the entire face operation if any collapse does occur. It further implies that the removal of the Leap-Frog support beam is a particularly dangerous operation since sudden removal of such a large area support frequently promotes failure of the roof.

For these reasons, the third component, a gate support, was designed. This unit, in its simplest form, is merely another face support, chock or shield, with an extra long canopy extension supported at its tip by hydraulic props. Because of the additional tip support provided, the canopy can not only be made quite thin for minimum obstruction, but it can also support considerable weight. Two or three are used together and are oriented so that they extend the chock line. The canopy tip is brought up close to a support beam before the beam is removed. In this manner, the load carried by the support beam is transferred to the gate support to minimize the risks of fracturing the roof upon release of the support.

3.3.1 Design and Selection

The gate support can be provided easily by outfitting any chock with an extension to its canopy and adding hydraulic props. Most chocks have articulated forward canopies with some form of hydraulic control of the hinge. Any welding shop can cut into the tip of the present canopy, weld in new extender ribs, and enclose the structure with plates. This extension should be light enough so that the unit does not tip forward under its own weight if the hydraulic legs are lifted.

In some applications it may be desirable to fabricate a gate support as above for the express purpose of maintaining similarity between the gate support and all the other face supports. However, since a similar structure is directly available from at least one manufacturer, Dowty Mining Equipment, Ltd., of England, we have not provided any design details for a fabricated version. This design is shown in Figure 12. While this unit is available with a variety of features; legs, valves, etc., the specification for this application is provided in drawing C-7522-15000 and in Appendix D. This specification may require revision to better suit a particular mine site.

3.3.2 Operation

The rear portion of the gate support operates just as any other face support by lowering the canopy and walking forward under the power of the ram attached to the face conveyor. In this case, an artificial extension of the clevis rail will be required in the region behind the conveyor drive and out beyond the tailpiece.

The elevation of the canopy extension is controlled with hydraulic legs at the tip and the two foremost legs at the rear end of the unit. During advancement, the tip legs can be picked

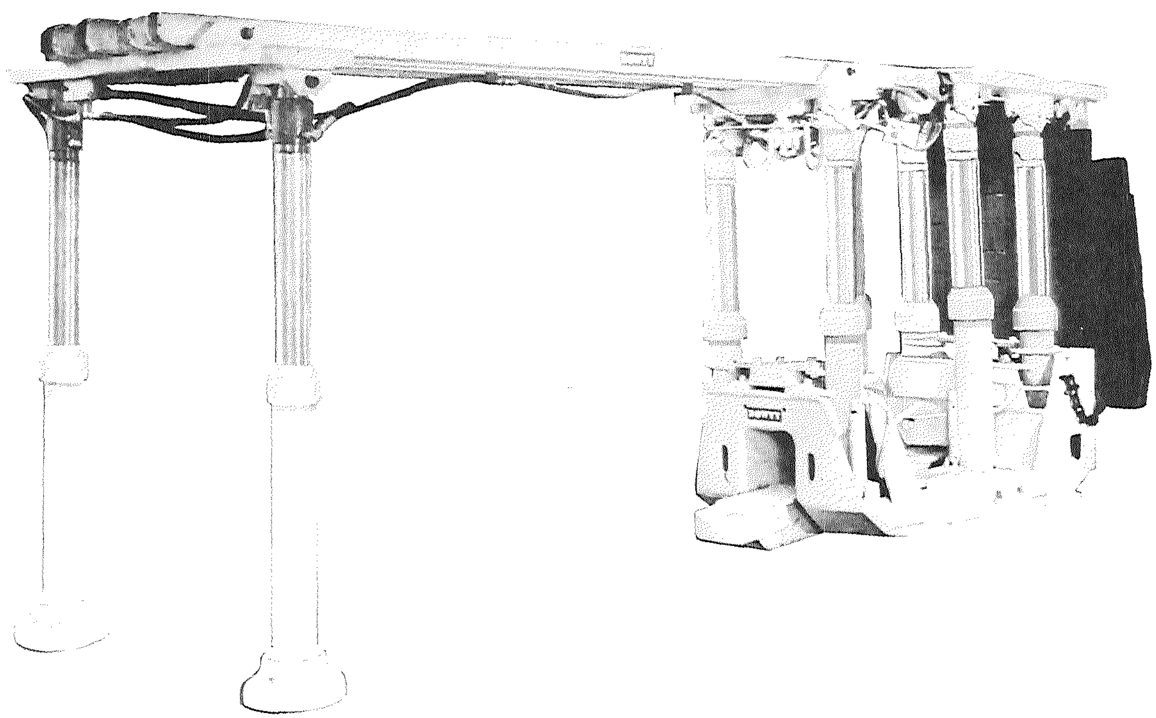


Figure 12. Dowty's "Drivehead/Anchor Support" - A Face Support Adaptable as a Gate Support

fix up from the floor and the foremost legs can keep the canopy extension up.

In a situation where a large piece of loose rock is sitting on the canopy extension the weight may be too great for the foremost legs at the rear to support in cantilever fashion. This situation will be obvious when the operator attempts to pick up the tip legs and observes the canopy coming down instead. In such a case the canopy is handled by picking up one tip leg only and then advancing the unit partially. The leg that is still down will be inclined since its top end moved forward while the bottom end remained on the floor. The next procedure is to put the other leg down and raise the inclined leg. At this point, the support is ready to be advanced again. In all but very low seams, the gate support can be advanced in two 15-inch increments under such a large load.

3.4 Installation and Operating Procedure

The following sections describe a generalized procedure for setting up an entry support system in a new longwall mine and a typical procedure of advancing the system along the entry as the face retreats.

3.4.1 Installation

3.4.1.1 Gate Supports

The gate supports can be installed like conventional chocks at the same time as the face supports. Depending on the procedure and the conditions at the mine, it may be necessary to remove the elongated canopy and/or the hydraulic legs at the tip of the canopy. Location of the gate supports may have to be adjusted to avoid interference with configurational details of the conveyor tail drive. The push rams of the gate supports should be attached to the clevis rail on the face conveyor or to an artificial extension of the clevis rail located behind the drive unit and extending far enough into the entry to accommodate the outermost support. Hydraulic supply and return lines should be appropriately attached. A 250 foot hydraulic hose terminating with a self sealing, quick disconnect fitting should be attached to the pressurized emulsion line for use in the tail entry.

3.4.1.2 Transporter

If the tail entry has been fully cribbed upon development,* the transporter must be brought in across the face prior to installation of face supports. Alternatively, it can be brought through one of the bleeder entries just behind the face entry.

If the tail entry is not cribbed or if there is room between cribs for the transporter, it can be driven up the entry to the test site. This choice may depend on the source of electric power. If the cable extends from the head entry across the face and into the tail only enough to reach the 200 foot long test zone, then the former mode of introduction may be preferable. If the supply cable is installed in the tail entry, the latter would be preferred.

Once in place, the transporter can be hooked up to the pressurized emulsion hose from the face line and used to install the support beams. The emulsion is used solely for actuating the hydraulic legs of the support sets. It may be preferable to use the setting pistol manually during the initial installation of the props.

---

*Except for the most severe applications, this system should obviate the requirement for cribbed entries. However, it is recognized that there may be requirements for using cribs, particularly during the early test installations of this system.

3.4.1.3 Support Sets

The support beams will be supplied separately from the hydraulic jacks. If the bearing plate has not been installed above ground, it should be so installed before lifting the beam into place. One plate is to be installed at each end using two screws each (drawing C-7522-11000).

Similarly, the jacks require a cast prop fitting to be installed at the top end. This should have been completed above ground but, if not, it should be done so now. Final assembly requires two retainer straps and four screws for each prop connection. These should be available before installing beams.

To install a beam, it must first be oriented on the floor in an upside down position; that is, the bearing plates should be on the upper side of the beam. The transporter crane can then be maneuvered to grasp the flanges of the beam and pick it up. The multiple degrees of freedom of the crane now permit the operator to turn the beam over and lift it into its proper place against the roof. The first beam should be installed close to the tips of the gate support canopy. Subsequent beams are to be installed on approximately 30-inch centers. While the beam is held in place by the transporter, the props can be put in place manually and jacked up with emulsion.

After the two props are in place the transporter can begin the job of readying the next beam for installation. However, the retainer straps should be put in place for permanent assembly of the jack to the support beam. This is necessary not only for later advancement of the support set but for increased stability, and thus increased safety of the assembled support set.

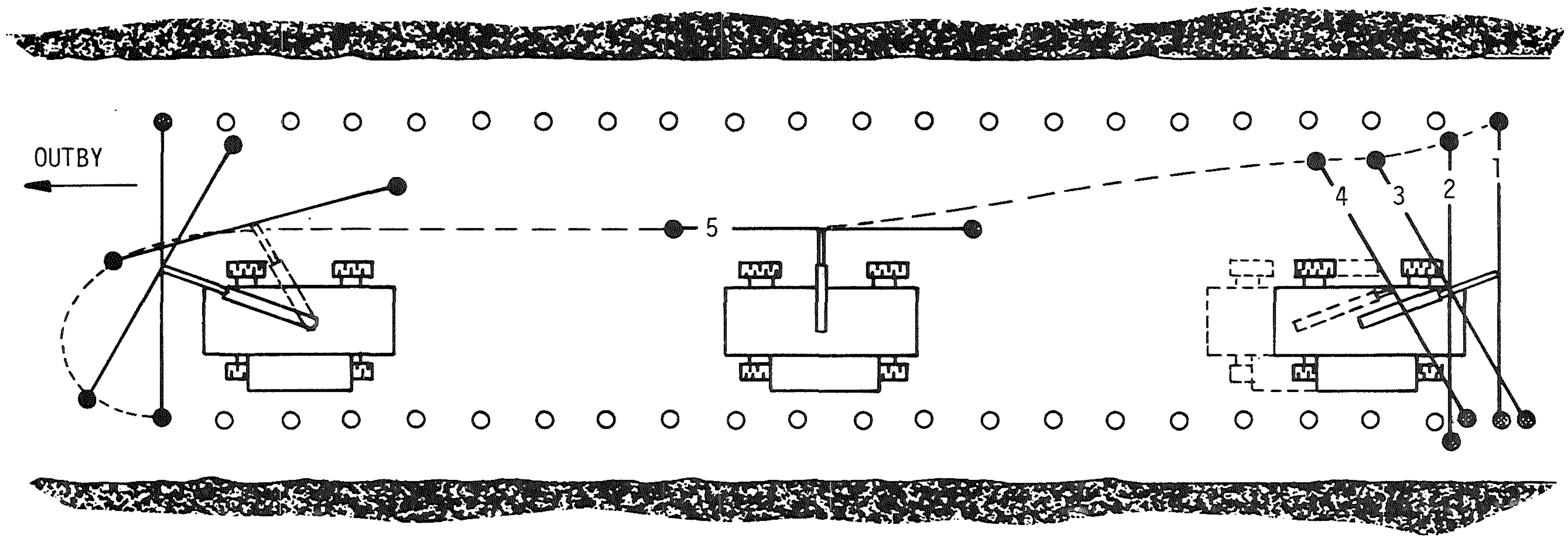
3.4.2 Operation

Once the system has been installed and the longwall operation is in process, the advancement of the support system will be as follows:

The precise positioning of the gate supports will be dependent on the position of the face conveyor rather than on the first beam set. It will be advanced much like a conventional face chock except for the operation of the two front legs (see details in Section 3.3.2). Assume for this description that it is set forward ready for the next pass of the shearer, and that the front tip is approximately 15 inches from the first beam set. This latter dimension will range from 0 to about 30 inches since the advancement of each shearer pass cannot be expected to be precisely in step with the entry support beams.

When the shearer reaches the tail entry, the drum can pass under the gate support canopy because of its length. Once the shearer has moved away and the face conveyor has been snaked forward, the gate support can be advanced. In this example, it will be advanced only about 12 inches until the tip is within a few inches of the support beam. The beam can now be removed safely because the gate support is in position to take the roof load. Once the beam is removed, the gate supports can be advanced the remaining 18 or so inches in preparation for the next shearer pass.

The beam removal process can best be understood by referring to Figure 13. The transporter approaches the roof beam along one side of the entry. With the transporter sufficiently close to the beam to be removed, the operator leaves the vehicle to install the remote prop supply line and release actuator. Back on the transporter the operator then positions the saddle under the beam, as close to the center as possible, using the welded locators as an



REMOVAL PROCEDURE:

1. LOWER BEAM FROM ROOF, PICK UP PROP LEGS
2. RETRACT BOOM (MOVES BEAM FROM POSITION 1 TO 2)
3. YAW (ROTATE) HEAD (MOVES BEAM FROM 2 TO 3)
4. BACK UP VEHICLE (MOVES BEAM FROM 3 to 4)
5. ROTATE TURRET AND BACK UP VEHICLE (MOVES BEAM FROM 4 TO 5)

INSTALLATION PROCEDURE:

1. REVERSE ABOVE - SIMPLER THAN REMOVAL DUE TO LESS CONGESTION

Figure 13. Beam Advancement Sequence

aid. This may require the manipulation of controls for yaw, pitch, roll, extension or lift. Once the saddle is properly positioned, the beam clamps are engaged and remain engaged until the beam has been reinstalled at the outby position. With the roof beam held firmly in the saddle, the remote actuator releases the internal pressure. If the props are solidly embedded in the floor, the boom can be lowered after placing the pitch control in the "float" position. A rocking motion can be used to dislodge the props. Once the props are lowered and the emulsion released, the remote actuator can close the release valve. The props can now be lifted by raising the beam with the crane, and the beam assembly can be rotated and swung to the side of the transporter in a manner detailed in Figure 13.

The beam is carried alongside the transporter with the boom fully retracted. This increases the stability of the vehicle and, at the same time, reduces the absolute vertical movement of the beam due to irregularities of the entry floor.

There are two variations for reinstalling the beam at the outby end. If the entry is open, the transporter can move beyond the last beam and reverse the process described above. If the entry is cribbed to a point close to the last beam, the beam can be swung to the rear of the transporter and installed while the transporter is still under previously installed beams. (This latter variation is illustrated in Figure 13.) With either variation, the beam is raised to the roof with the crane and the props extended to the floor. Both the supply line and the release actuator remain attached to the props for full control during the transport and reinstallation procedure. On completion, the remote prop actuators and prop guns are removed, the clamps disengaged, the boom lowered, and the operator can pick up the next beam assembly.

4. DESCRIPTION OF TEST SITE AND TEST PLAN

4.1 Test Site

The CF&I Steel Corporation has offered us a test site in the tail entry of their Allen Mine in Weston, Colorado. This typically 6.5 foot high entry has difficult roof conditions which they presently control with steel beams. The FMA support system would provide them with a more effective support because of the hydraulic props and torsionally stable beam section. It would also be recoverable, unlike the present support.

They apply steel beams throughout the mine because of the friable roof. Most of the beams are 8 inch deep, wide-flange beams weighing 31 pounds per foot. They are installed 4 feet apart and are separated with wood lagging which rests on the lower beam flange. Wedges are sometimes placed between the lagging and the roof to give additional support between the beams. The beams are supported with wooden posts at each end and are additionally secured with steel straps bolted to the roof.

As the longwall face retreats, large cribs, roughly 4 by 6 feet, are built along the pillar side of the entry. Each crib is oriented to support the end of two beams. These are installed 150 to 200 feet outby the face. Hydraulic jacks are installed near the opposite (panel) end of the beam as the face approaches. These jacks support the beam as the shearer drum knocks out the wood post which originally supported that end. The last two face chocks which are located in the entry advance under the beams, supporting them as well as the roof. This action usually crushes the beams somewhat. In any event, the beams eventually fall off the back of the chock and are abandoned in the gob.

The current plan for a demonstration test is to remove the wood lagging from between the beams and immediately install one or two of the FMA supports between each of the presently installed beams. The original beam would then be removed, leaving only the FMA support. This would be the sole support in the 200 foot test zone, providing a valid basis for evaluating the support system. No change in their approved roof control plan is required.

Prior to installation in the active longwall mine, the system must be tested in an off section area of the mine. During this test the methods for and viability of removing the lagging and replacing it with hydraulic support sets will be determined. Tentative procedures for performing these tests are described below.

4.2 Field Test Plan

4.2.1 Availability

As the equipment is delivered to the mine, the mine representative shall keep FMA up to date on the status of inventory received so that missing material can be expedited and installation can be scheduled. The mine shall maintain proper storage of the components.

4.2.2 Off Site Test

The purpose of this test is to instruct the mine operators and personnel in the details of operation, to establish a procedure for installing the equipment and to provide assurance in the proper functioning of the equipment. This test will be performed underground in a remote area of the mine to be designated by the CF&I Steel Corporation.

The components should be set up as specified (see more details in Section 4.2.3), power provided, and the components advanced through their standard operation. Notes and procedures established during the "Bench Test" should be available at this time and used for instruction.

This test should continue as long as necessary to establish confidence among operating personnel but in no event shall it exceed 1 month. Records should be logged during this task which include notes on installation time and procedure, preferred operational sequences and procedure, and any problems or difficulties encountered.

4.2.3 Installation

Since the Allen Mine does not anticipate beginning a new longwall in the spring of 1978 when the equipment will become available, it will be necessary to make the installation in the active tail entry at a point several hundred feet from the face, ahead of the abutment pressure zone. In this way, the equipment can be installed without hindering the face operation, and only waiting time will be required to bring it into effect. Furthermore, a region with good roof can be selected for minimal installation problems, and the equipment can readily be brought in through the tail heading as it has no obstructing cribs.

4.2.3.1 Transporter

The electric cable to power the transporter will be installed along the entry, but the emulsion line for the hydraulic legs will have to come from the face line of chocks. Although the emulsion line is normally connected to the transporter through a remotely operable "relay" valve the initial installation may be easier if the setting pistol is used manually.

4.2.3.2 Support Sets

Since the Allen Mine has steel beams already installed, it requires special procedures to accommodate the FMA support system. The first step is to remove the steel straps which secure each end of the beam to the roof. This is done manually with a wrench and levering the strap down if necessary. Remember that the primary support is accomplished with a post at each end so there is little risk in removing these straps. Next, the wood lagging must be removed from between adjacent beams. This is done by using the crane mounted chain saw illustrated in Figure 10. With this unit, each piece of lagging can be remotely cut through so that the two halves fall free.

Once the lagging is clear, the saw is removed from the crane and the crane used to install one or two beams between each pair of original beams. Since the original beams are 16 feet long while the FMA beams are 14 feet, there should be little problem with working the beams into place. The general procedure for installing the beam and prop is fully described in Section 3.4.1.3 and will not be repeated here.

The spacing of the original beams is 4 feet center-to-center. FMA proposes to install two new beams between every other pair of original beams and one new beam between the intermediate pair. This results in an average spacing of 32 inches center-to-center and leaves exposed sections of roof less than 22 inches wide (Figure 14).

4.2.3.3 Gate Supports

This component will be the most difficult to install. It cannot be put in place ahead of time to await the progression of the face since the conveyor tail drive would not be able to

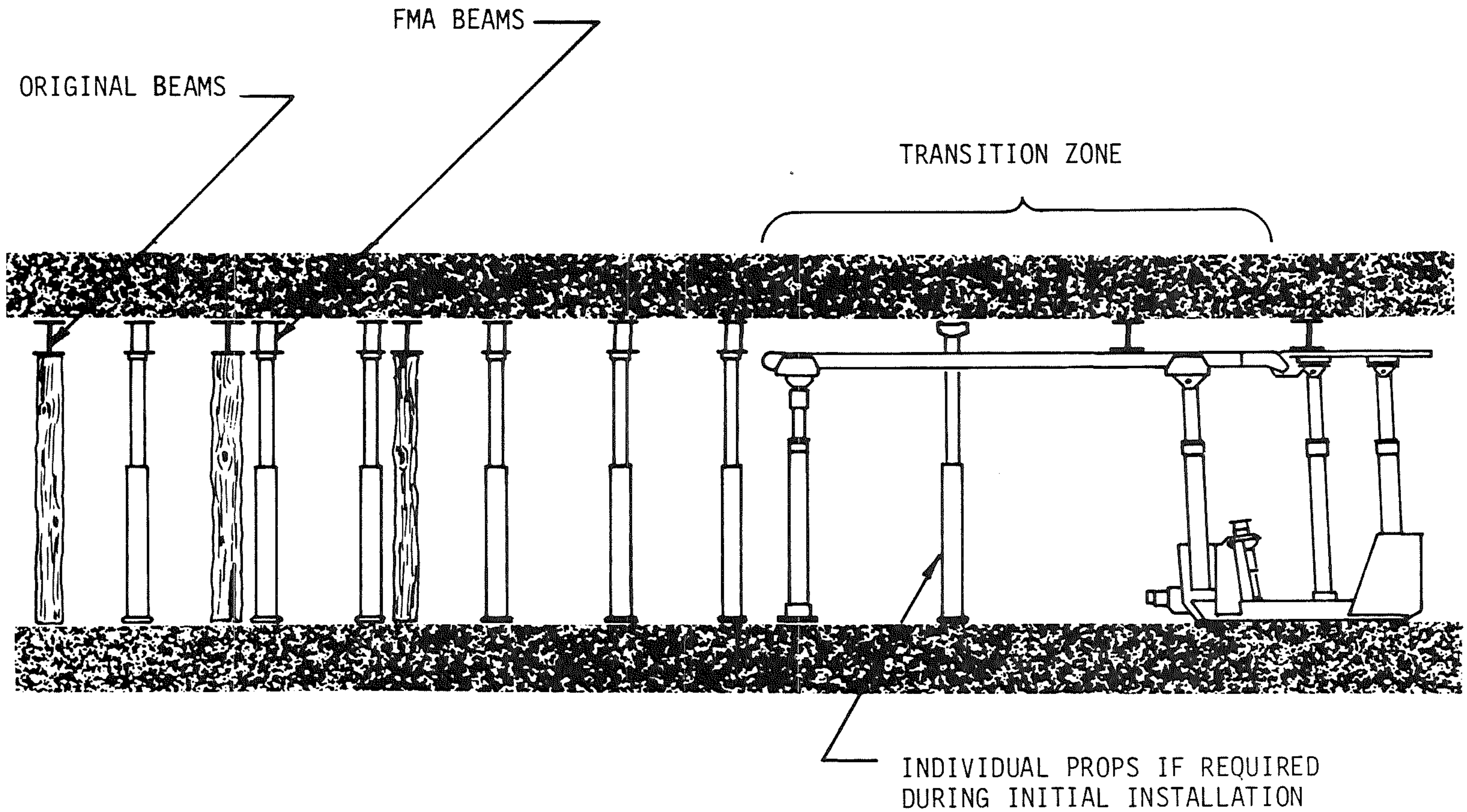


DIAGRAM SHOWS INSTALLED RELATIONSHIP BETWEEN ORIGINAL BEAMS
ON 48 INCH CENTERS AND FMA BEAMS ON 32 INCH CENTERS.

Figure 14. Elevation View of Test Installation

pass by the rear of the support. Furthermore, such a sequence would entail abandoning the two face chocks which are in line with the gate supports.

The best method is to bring the gate supports into the FMA entry supported zone and leave them lined up along one side. When the face has retreated until it is in line with the most inby FMA support, further retreat is halted until the gate supports are installed. This operation begins be removing the conventional chocks either one at a time or both together. This choice is dependent on how much the tail drive extends into the entry. Use of individual hydraulic props will be necessary during this process to ensure that the original beams remain in place while the chocks are removed. Once the chocks are gone, the gate supports can be installed in their place.

As retreat commences, there will be a 12 to 15 foot long transition zone in which the gate support moves from the region where there are roof beams above the support to the region where the support bears directly against the roof. During this transition, it may be necessary to use some wooden headers and hydraulic supports set between the gate support canopies. Once this transition zone is passed, however, the support system begins to operate normally as described in Section 3.4.2.

5. ECONOMIC ANALYSIS

5.1 Cost of FMA Support System

Studying the economics of the FMA entry support system, the costs have been broken down into three elements: capital costs, initial installation labor and continued operational labor. A fourth element, the savings of costly downtime, is of great significance in some applications but will be dealt with later. It should also be remembered that this system not only provides a safer, remotely operated tail support but provides a complete coverage of the face/entry intersection which is usually unprotected against hazardous and time consuming falls.

The entire FMA support system has an initial capital cost of $240,000. This money could also buy enough crib blocks for supporting four tail entries, but since the FMA equipment, unlike crib blocks, is reusable for a number of panels the outlay must be amortized to give an accurate evaluation. For the analysis herein, the equipment is amortized over five panels which, for average longwalling today, implies a lifetime of about 3 to 4 years. This is in line with the history of face chocks. Usually roof bolters, which the transporter resembles, have lives far in excess of 4 years. It is assumed that there will be some attrition of beams and props, so an extra 30 sets have been provided for to cover losses. These and other costs are summarized in Table 2.

Installation time is minimal. The gate supports are installed in the same manner as the other face supports. The transporter will be delivered by rail and driven under power from the rail terminus to the entry site with little time required. The beams and props can be brought in on large skids and assembled in place

Table 2. Cost Per Panel of the FMA Entry Support System

Item	Total	Cost/Panel
Capital Costs		
Beams, 70 at $627 each	$ 43,890	$ 8,778
Beams, (extras), 30 at $627 each	18,810	3,762
Props, 140 at $414	57,960	11,592
Props (extras), 60 at $414	24,840	4,968
Fittings (200 sets) at $78.90	15,780	3,156
Transporter	51,896	10,379
Chassis 19,800		
Dump Valve 707		
Lights 5,496		
Crane 15,000		
Hydraulics 1,500		
Assembly Labor 1,500		
Miscellaneous 5,000		
Gate Support	28,500	5,700
Subtotal	$241,676	$48,335
Installation Costs		
	Man-shifts	
Delivery of Beams (2 shifts x 4 men)	8	
Delivery of Transporter (1 shift x 2 men)	2	
Delivery of Gate Supports (1 shift x 5 men)	5	
Installation of Beams (1 hr x 2 men x 70)	23	
Subtotal	38 x $100	$ 3,800
Operational Costs		
Advancing of Beams (2 shifts x 2 men x 150 days x 1/2 time)	300 x $100	$30,000
TOTAL		$82,135

using the transporter to do much of the work. The analysis in Table 2 provides conservation labor allowances for these operations.

The normal operation of advancing a beam to the outby end of the support system 200 feet from the inby end requires an operator and a helper. The job can be done in less than half an hour. Since average longwall advance rates will require the advancement of only two to four supports per shift, and since the dust levels typically found in tail entries (if return air) dictate only a few hours exposure per day, it has been assumed that this job is a half time assignment.

The summary shown in Table 2 shows the cost of the FMA entry support system to be about $82,000 per panel. The following section compares this cost with that of conventionally cribbed entries.

5.2 Comparison with Conventional Entry Supports

The majority of longwall tail entries today are supported with cribs. The entries with problems where our system would be most useful, are supported with many cribs, frequently three rows.

Wood is no longer cheap, and the price is rising rapidly. Further, there is no recovery value of wood used in entry cribs since they are usually abandoned in the gob. Because of wood's bulk, installation labor is significant, and more labor is required to set temporary supports and pull at least one row of cribs to make clearance for the face equipment to retreat.

Costs for materials and labor for this operation in a 3000 foot entry appear in Table 3. The total of over $97,000 when compared with the total of $82,000 for the FMA system indicates

Table 3. Cost Per Panel of a Crib Supported Entry

Item	Total	Cost/Panel
Capital Costs		
Cribs, 30 in. x 6 ft ($1.50/crib block) $36.00 x 375 cribs	—	$13,500
Cribs, 4 x 6 ft ($2.45/crib block) $58.80 x 750 cribs	—	44,110
Subtotal		$57,610
Installation Costs		
Operation	Man-shifts	
Delivery of 27,000 blocks (50 sec)	62	
Crib erection (30 men x 2 men)	188	
Subtotal	250 x $100	$25,000
Operational Costs		
Setting props, removing cribs, etc. (2 shifts x 1 man x 150 days x 1/2 time)	150 x $100	15,000
Subtotal		$15,000
TOTAL		$97,610

a significant cost savings when using the FMA system. (Costs common to both support systems, such as bolts, have been excluded from the figures in Tables 2 and 3).

The cost element associated with savings in downtime can be quite significant. For example, if downtime in a longwall mine is presently running at 25 percent (better than most mines are experiencing), and if improved entry and gate support reduces that downtime by 20 percent (both through fewer falls and shorter delays in advancement of equipment), then a savings of about 15 shifts will be realized in the production of a complete panel.

With operating costs of about $7,500 per shift, such a production improvement would potentially save about $112,000. In actual practice, only about half of the operating costs are fixed with respect to time so the real savings would be about $56,000. This is substantial, particularly in view of the modest improvements indicated in this example. At some sites, an effective support system could effect savings of several times this value.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The major conclusions reached as a result of this effort are summarized as follows:

- Detail design of the Leap-Frog support system consisting of gate support chocks, beam-prop assemblies, and a transporter has been completed and sized for a 5 to 8 foot seam height.

- The system will provide an effective means of controlling the gate intersection of longwall entries and is remotely operated hydraulically.

- The yielding beam-prop support assemblies have been designed to conservatively maintain immediate roof strata while yielding under abutment pressures when required. This will minimize stress cycling and fracturing of the roof.

- The transporter canopy station has been designed to provide the operator with protection and all the controls necessary to raise or lower a beam assembly remotely.

- When amortized over five panels, the Leap-Frog system is cost competitive with wooden crib support.

- The entire system is recoverable by its mode of operation and reuseable for subsequent longwall panels.

6.2 Recommendations

The long-term recommendations for completing the objectives of this contract are as follows:

- Establish a finalized agreement with Allen Mine as a test site.
- Build the prototype system per the detail drawings for this site.
- Procure several Dowty gate support chocks and load distributing devices.
- Bench test the entire Leap-Frog support system.
- Install the Leap-Frog system in a remote section of a mine for final qualification prior to testing it at a longwall site.
- Install the Leap-Frog system in an operating longwall tail entry for testing.
- Evaluate the effectiveness of the system from the test site data.

APPENDIX A - LIST OF DRAWINGS

Support Assembly Drawings

C-7522-11000	Support Assembly
C-7522-11001-X	Support Beam
B-7522-11002	Support Beam with Clamps
B-7522-11003-X	Prop
C-7522-11004	Prop Fitting
C-7522-11005	Bearing Plate
B-7522-11006	Retainer
A-7522-11007	Fire Hose
B-7522-11008	Paper Honeycomb
A-7522-11009	Clamp Plate

Transporter Drawings

D-7522-12000	Transporter
R-7522-12001	Transporter Chassis
D-7522-12HYD	Hydraulic Schematic

Crane Subassembly Drawings

R-7522-13000	Crane Subassembly
C-7522-13001	Saddle Plate
C-7522-13002	Saddle Beam Clamp
A-7522-13003	Saddle Attachment for W8 x 31 Beam
B-7522-13004	Saddle Trunnion Block
C-7522-13005	Saddle Shaft
C-7522-13006	Housing Assembly Yaw Actuator
C-7522-13007	Housing Body Yaw Actuator
B-7522-13008	Housing Cover Yaw Actuator
B-7522-13009	Bearing Retainer - Large
B-7522-13010	Bearing Retainer - Small
D-7522-13011	Support Assembly - Pitch Actuator
D-7522-13012	Support Frame - Pitch Actuator
C-7522-13013	Side Frame - Pitch Actuator

Crane Subassembly Drawings (Continued)

B-7522-13014	Bushing - Pitch Actuator
A-7522-13015	Thrust Washer - Pitch Actuator
B-7522-13016	Plate - Thrust Washer Retainer
A-7522-13017	Bracket - Roll Cylinder
A-7522-13018	Nut - Roll Cylinder
C-7522-13019	Bracket - Roll Cylinder
B-7522-13020	Bearing - Retainer Roll Cylinder
D-7522-13021	Upper Boom Assembly
D-7522-13022	Guide Assembly Hydraulic Hoses
A-7522-13023	Bearing - Sliding Boom
A-7522-13024	Clevis - Extension Cylinder
A-7522-13025-1	Pin - External Cylinder Mounting
A-7522-13025-2	Pin - External Cylinder Mounting
D-7522-13026	Lower Boom Assembly
D-7522-13027	Rotating Base
B-7522-13028	Pivot Pin - Lower Boom Assembly
B-7522-13029	Trunnion Block - Lift Cylinder
B-7522-13030	Hydraulic Manifold - Upper Boom Assembly
C-7522-13031	Hose Assembly - Clamp Cylinder - Extend
C-7522-13032	Hose Assembly - Clamp Cylinder - Retract
C-7522-13033	Hose Assembly - Rotary Actuator - Yaw
C-7522-13034	Hose Assembly - Rotary Actuator - Pitch
C-7522-13035	Hose Assembly - Roll Cylinder - Right Roll
C-7522-13036	Hose Assembly - Roll Cylinder - Left Roll

Remote Prop Actuator Drawings

D-7522-14000	Remote Prop Actuator
D-7522-14001	Housing - Remote Actuator
D-7522-14002	Actuator - Remote Prop Actuator
B-7522-14003	Hydraulic Piston - Remote Prop Actuator
B-7522-14004	Flat Spring - Remote Prop Actuator

Gate Support Assembly Drawings

C-7522-15000	Gate Support Assembly

APPENDIX B

PARTS LISTS

FOSTER MILLER ASSOC.
WALTHAM, MASS.

ASSEMBLY PARTS LIST

SHEET 1 OF 4

MODEL:

ASSEMBLY: CRANE SUBASSEMBLY

ASSY DWG. NO.: R-7522-13000

PREPARED BY: PETER DE BAKKER

APPROVED BY:

DATE: APRIL 28, 1977

ITEM	PART NO.	DESCRIPTION	UNIT QTY.	ASSY. QTY.	VENDOR OR MANUFACTURER	DATE ORD.	QTY. ORDERED	P.O. NUMBER	DUE DATE	DATE REC'D	REMARKS	PRICE
1	C-7522-13001	SADDLE PLATE	1	1	FMA							
2	C-7522-13002	SADDLE BEAM CLAMP	1	2								
3	A-7522-13003	ATTACHMENT W8 x 31 BEAM	1	2								
4	B-7522-13004	SADDLE TRUNNION BLOCK	1	2								
5	C-7522-13005	SADDLE SHAFT	1	1								
6	C-7522-13006	HOUSING ASSY	1	1								
7	D-7522-13007	HOUSING BODY	1	1								
8	B-7522-13008	HOUSING COVER	1	1								
9	B-7522-13009	BEARING RETAINER - LARGE	1	1								
10		DELETED										
11	D-7522-13011	SUPPORT ASSY	1	1								
12	D-7522-13012	SUPPORT FRAME	1	1								
13	C-7522-13013	SIDE FRAME	1	1								
14	B-7522-13014	BUSHING	1	2								
15	A-7522-13015	THRUST WASHER	1	2								
16	B-7522-13016	PLATE-THRUST WASHER	1	1								
17	A-7522-13017	TRUNNION BLOCK-ROLL CYL	1	2								
18	A-7522-13018	NUT-ROLL CYL	1	2								
19	C-7522-13019	BRACKET ROLL CYL	1	1								
20	B-7522-13020	BEARING RETAINER	1	2								
21	D-7522-13021	UPPER BOOM ASSY	1	1								
22	D-7522-13022	GUIDE ASSY	1	2								
23	A-7522-13023	BEARING-SLIDING BOOM	1	12								
24	A-7522-13024	CLEVIS-EXTENSION CYL	1	1								
25	A-7522-13025-1	PIN-EXTERNAL CYL CLEVIS	1	1								
26	A-7522-13025-2	PIN-EXTERNAL CYL MOUNTING	1	1								
27	D-7522-13026	LOWER BOOM ASSY	1	1								
28	D-7522-13027	ROTATING BASE	1	1	FMA							

FOSTER MILLER ASSOC.
WALTHAM, MASS.

ASSEMBLY PARTS LIST

SHEET 2 OF 4

MODEL: ______ ASSEMBLY: CRANE SUBASSEMBLY ASSY DWG. NO.: R-7522-13000

PREPARED BY: PETER DE BAKKER APPROVED BY: ______ DATE: APRIL 28, 1977

ITEM	PART NO.	DESCRIPTION	UNIT QTY.	ASSY. QTY.	VENDOR OR MANUFACTURER	DATE ORD.	QTY. ORDERED	P.O. NUMBER	DUE DATE	DATE REC'D	REMARKS	PRICE
29	B-7522-13028	PIVOT PIN-LOWER BOOM ASSY	1	2	FMA							
30	B-7522-13029	TRUNNION BLOCK-LIFT CYL	1	2								
31	B-7522-13030	HYDRAULIC MANIFOLD-UPPER BOOM	1	2								
32	C-7522-13031	HOSE ASSY-CLAMP CYL EXTERNAL	1	1								
33	C-7522-13032	HOSE ASSY - CLAMP CYL RETRACT	1	1								
34	C-7522-13033	HOSE ASSY - ROTARY ACTUATED YAW	1	2								
35	C-7522-13034	HOSE ASSY - ROTARY ACTUATED PITCH	1	2								
36	C-7522-13035	HOSE ASSY - ROLL CYL RIGHT	1	1								
37	C-7522-13036	HOSE ASSY - ROLL CYL LEFT	1	1								
38	C-7522-13037	HOSE ASSY - EXTERNAL CYL	1	2								
39	C-7522-13038	HOSE ASSY - LEFT CYL EXTERNAL	1	1								
40	C-7522-13039	HOSE ASSY - LIFT CYL RETRACT	1	1								
41	C-7522-13040	HOSE ASSY - HYDRAULIC MOTOR DRIVE	1	2								
42	C-7522-13041	HOSE ASSY - HYDRAULIC MOTOR DRAIN	1	1								
43	C-7522-13042	FROM B-7522-13030 HOSE ASSY TO VALVE BANK	1	8								
44	B-7522-13043	MOUNTING EXTENSION CYL	1	1								
45	B-7522-13044	HOSE CLAMP	1	1	FMA							
46	HS-15-280	ROTARY ACTUATED-SPLINED SHAFT	1	2	BIRD JOHNSON						B.J. DRAWING 450305-1	
47	HP-341	HYDRAULIC CYL 2000 PSI	1	2	AIROYAL						2" BORE/2.75" STROKE (KK = 2.75")	
48	HP-341	HYDRAULIC CYL 2000 PSI	1	2	AIROYAL						1.5" BORE/3" STROKE (KK = 4.63")	
49	SD31MC-10 1/2	CYLINDER, DOUB.ACT,2000 PSI	1	1	COMMERCIAL SHEARER						DISTANCE FROM END OF CYL TO ℄ TRUNNION - 14-1/2"	
50	103-1026-007	HYDRAULIC MOTOR/S-SERIES 4.3 in.^{3}	1	1	CHAR-LYNN						OPERATE 7-9 GPM at 1300 PSI	
51	MODEL 460	WORM GEAR REDUCER	1	1	VON RUDEN						SAE TWO BOLT "A"/25:1 RATIO TYPE DR/OPTIONAL HOLES	
52	L7-22-E1Z	BALL BEARING EXTERNAL GEAR	1	1	ROTEK							
53	P4-3.5 D2	PINION FOR ITEM 52	1	1	ROTEK						D.P. = 4/P.D. = 3.5/N = 14/P.A.=20 DEG	
54	15SF24TT	SPHERICAL BEARING 1.500 BORE	1	1	TORRINGTON							
55	25SF40TT	SPHERICAL BEARING 2.500 BORE	1	3	TORRINGTON							
56	TN 12	BEARING LOCKNUT	1	1	TORRINGTON							

FOSTER MILLER ASSOC.
WALTHAM, MASS.

ASSEMBLY PARTS LIST

MODEL: ______ ASSEMBLY: CRANE SUBASSEMBLY ASSY DWG. NO.: R-7522-13000

PREPARED BY: PETER DE BAKKER APPROVED BY: ______ DATE: APRIL 28, 1977

ITEM	PART NO.	DESCRIPTION	UNIT QTY.	ASSY. QTY.	VENDOR OR MANUFACTURER	DATE ORD.	QTY. ORDERED	P.O. NUMBER	DUE DATE	DATE REC'D	REMARKS	PRICE
57	TW 12	BEARING LOCKWASHER	1	1	TORRINGTON							
58	3210	ROD END SWIVEL EYE	1	2	AIROYAL							
59	No. 5042	LUBE FITTING 1/4"-28 THD	1	12	LINCOLN							
60	5160-98	RETAINING RING, HEAVY DUTY	1	4	TRUE ARC							
61	900729-12	HOSE CLAMP	1	2	AEROQUIP							
62	23055-24	DUST PLUG	1	1	AEROQUIP							
63	COM-12	SPHERICAL BEARING 0.7495 BORE	1	2	SPHERCO							
64		CLEVIS PIN 5/8" DIA	1	2							PIN LENGTH = 3.50" HEAD TO HOLE = 3.45"/HOLE 9/64"	
65		CLEVIS PIN 5/8" DIA	1	2							PIN LENGTH = 1.88 HEAD TO HOLE = 1.63/HOLE 9/64"	
66		CLEVIS PIN 1-1/4" DIA	1	1							PIN LENGTH = 2.50" HEAD TO HOLE = 2.40"/HOLE .265"	
67		COTTER PIN 1/8" DIA x 1-1/2" LG	1	4								
68		COTTER PIN 1/4" DIA . 2" LG	1	1								
69		DOWEL $\frac{0.2503}{0.2501}$ x 3/4"	1	4								
70		DELETED										
71		DOWEL $\frac{0.3753}{0.3751}$ x 1.0"	1	2								
72	GRADE 8	SCREW - HEX HD 5/8-11 x 2"	1	15								
73		DELETED										
74		SCREW - HEX HD 1/2-13 x 2"	1	4								
75		SCREW - HEX HD 1/2-13 x 1-1/2"	1	12								
76		5/8 SHOULDER SCREW x 5/8 " LG	1	6								
77		SCREW - HEX HD 1/2-13 x 1"	1	8								
78		SCREW - HEX HD 1/2-13 x 7/8 "	1	4								
79		SCREW - HEX HD 3/8-16 x 2-1/4"	1	4								
80		SCREW - HEX HD 3/8-16 x 1.0"	1	6								
81		SCREW - HEX HD 3/8-16 x 1-1/8"	1	4								
82		SCREW - HEX HD 3/8-16 x 7/8"	1	4								
83		SCREW - HEX HD 5/16-18 x 2"	1	4								
84	GRADE 8	SCREW - HEX HD 3/8-24 x 2-1/4"	1	8								

FOSTER MILLER ASSOC.
WALTHAM, MASS.

ASSEMBLY PARTS LIST

SHEET 4 OF 4

MODEL:

ASSEMBLY: CRANE SUBASSEMBLY

ASSY DWG. NO.: R-7522-13000

PREPARED BY: PETER DE BAKKER

APPROVED BY:

DATE: APRIL 28, 1977

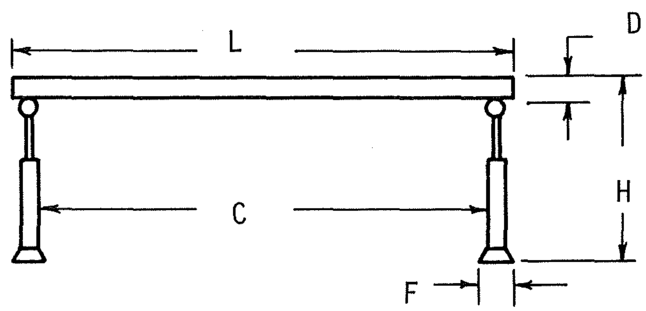
ITEM	PART NO.	DESCRIPTION	UNIT QTY.	ASSY. QTY.	VENDOR OR MANUFACTURER	DATE ORD.	QTY. ORDERED	P.O. NUMBER	DUE DATE	DATE REC'D	REMARKS	PRICE
85	GRADE 8	SCREW SOCKET HEAVY DUTY 1/4-20x3/4"	1	20								
86		SCREW-FLAT, HEAVY DUTY 10-32x7/16"	1	24								
87		NUT, H.D. - 5/8 - 11 UNC	1	15								
88		DELETED										
89	GRADE 8	NUT, H.D. - 3/8-16 UNC	1	4								
90		LOCK WASHER 5/8"	1	21								
91		LOCK WASHER 1/2"	1	28								
92		LOCK WASHER 3/8"	1	28								
93		LOCK WASHER 5/16"	1	4								
94		LOCK WASHER 1/4"	1	24								
95	SH 9B 2 1/2x30	CYLINDER 2-1/2" BORE-1-3/8" ROD	1	1	TOMKINS JOHNSON						1-3/8" ROD CLEVIS	
96	GRADE 8	NUT - 3/8-24 UNF		16								
97		SCREW-3/8-24 UNF SOCKET HD x 1-1/4 LG		4								
98		LOCK NUT 5/8-18 UNF		2								
99		SCREW 1/4-20 UNC x 1" LONG SOCKET HD		4								
100	A-7522-13045	SPACER-EXTENSION CYL		2								
101	10SF16TT	SPHERICAL BEARING 1.0 BORE		1	TORRINGTON							
102		SCREW 3/8-16 SOCKET HD x 1-1/4 LG		2								
103		WASHER, (HEAVY DUTY) - 3/8		4								
104		SCREW 3/8-16 SOCKET HD x 1-3/4 LG		2								

APPENDIX C - SUMMARY OF QUOTATIONS

Description (Drawing No.)	Manufacturer	Quantity	Quote ($ each)	Delivery (weeks)
Transporter Chassis (R-7522-12001)	J.H. Fletcher	1	19,800	10-16
Dry Chemical Fire Suppression and Solenoid Dump Valve	J.H. Fletcher	1	1,600	10-16
Crane Assembly (R-7522-13000)	Stetco	1 10	15,000 11,250	
Hydraulic Controls (D-7522-12HYD)	Commercial Shearing	1 set	753.53	12-14
Emulsion Pressure Reducers	Fluid Controls	2	84.25	4-6
Props per (B-7522-11003)	National Mine Service	150	413.83	18
Gate Support Chocks (C-7522-15000)	Dowty Corp.	3	9,500	
Bearing Plate (C-7522-11005)	Waltham Foundry	200	39.60	
Prop Fitting (C-7522-11004)	Waltham Foundry	200	36.45	
Retainer Strap (B-7522-11006)	Ryerson	300 4000	1.35 .95	
Support Beam (C-7522-11001-1)	Ryerson	75 1000	627 467	
Cambered Support Beam (C-7522-11001-2)	Ryerson	5 15 75	727 694 627	
Support Beam with Hose Clamps (B-7522-11002)	Ryerson	5 15 75	782 748 681	
Hose Clamp Plates (A-7522-11009)	Ryerson	10 30 150	5.35 7.55 2.75	
Soft Suction Hose (A-7522-11007)	Boston Coupling Co.	5 15 75	13.50 12.15 11.75	
Lighting System for Vehicle (Full Compliance)	General Energy Development Corp.	1 set	5,496	

APPENDIX D - SYSTEM SPECIFICATIONS

D.1 Entry Support (Drawing No. C-7522-11000)



Beam:

Length (L)	=	14 feet (4267 mm)
Depth (D)	=	8 inches (203 mm)
Width	=	10.5 inches (267 mm)
Clearance (C)	=	13 feet (3962 mm)
Section Modulus	=	28.2 $in.^3$

Maximum point load at center = 20 tons (18 tonnes)
Maximum uniformly distributed load = 40 tons (36.5 tonnes)
Maximum elastic deflection at center = 1.18 inches (30 mm)
Materials: Ex-Ten 60 steel
Weight with bearing plate = 520 pounds (236 kg)

Prop:

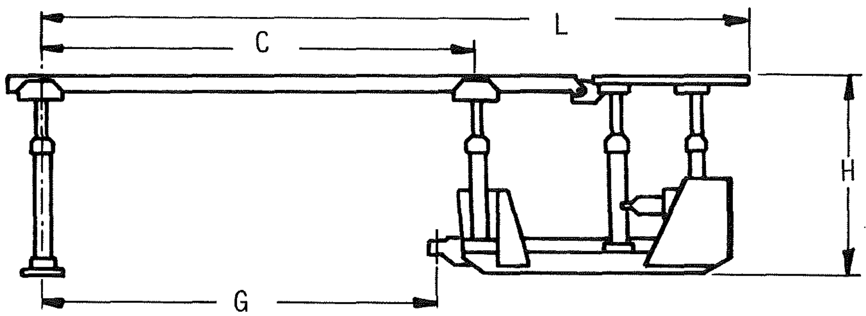
Make: Kloechner-Ferromatik
Yield Load: 10 tons (9.1 tonnes)*
Total height (H) = 61 to 90 inches (1549 to 2286 mm)
SS 41/200 prop
Other heights available:

66 to 99 inches (1676 to 2515 mm)	SS 41/224
55 to 82 inches (1397 to 2083 mm)	SS 41/180
51 to 74 inches (1295 to 1880 mm)	SS 41/160
47 to 66 inches (1194 to 1676 mm)	SS 41/140
43 to 60 inches (1092 to 1524 mm)	SS 41/125

Fluid: Emulsion
Setting: Conventional with Ferromatik pistol
Release: Manual or remote with FMA transporter
Foot Plate (F) = 7 inches (180 mm) diameter
Extensions available: 3.9 inches (100 mm), 11.8 inches (300 mm), 19.6 inches (500 mm), 27.5 inches (700 mm)
Weight with top fitting = 167 pounds (75.7 kg)

*Adjusted downward from nominal value of 45 tons

D.2 Gate Support (Drawing No. C-7522-15000)



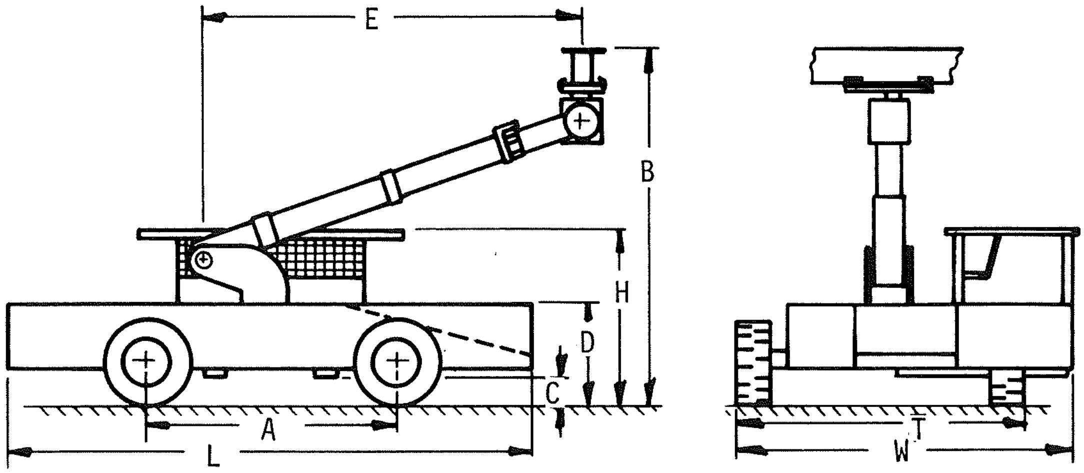
Overall length (L)	=	180.3 inches (4581 mm)
Canopy length (C)	=	111.1 inches (2821 mm)
Gate clearance (G)	=	100.2 inches (2544 mm)
Chock capacity (6 legs at rear)	=	272 tons (247 tonnes)
Canopy capacity (2 legs at front)	=	33 tons (30.5 tonnes)
Height range (H)	=	57.6 to 85.6 inches (1465 to 2175 mm)

Other heights available:

64.2 - 97.2 inches	(1630 - 2470 mm)	Single Extension
50.2 - 73.1 inches	(1275 - 1860 mm)	Single Extension
43.7 - 61.7 inches	(1110 - 1565 mm)	Single Extension
49.4 - 89.6 inches	(1255 - 2275 mm)	Double Extension
42.5 - 72.5 inches	(1075 - 1840 mm)	Double Extension

Manufacturer: Dowty Mining Equipment Ltd.

D.3 Transporter (Drawing No. D-7522-12000)



Chassis:

Length (L)	=	11 feet, 11 inches (3632 mm)
Width (W)	=	81 inches (2057 mm)
Body height (D)	=	27 inches (686 mm)
Width over tires (T)	=	70 inches (1778 mm)
Wheelbase (A)	=	69 inches (1753 mm)
Height over canopy (H)	=	47.5 to 56.5 inches (1206 to 1435 mm)
Ground clearance (C)	=	7 inches (178 mm)
Tram speed	=	0 to 125 ft/min
Steering	=	Differential
Hydraulic capacity	=	110 gallons (420 l)
Cable handling	=	Reel
Weight	=	9700 pounds (4400 kg)
Power:		
Electrical	=	40 kVA
Emulsion	=	1.5 gal/ft of face advance at 1370 psi

Crane:

Boom extension	=	30 inches (762 mm)
Boom radius (E)	=	88 inches (2235 mm) maximum
Beam height (B)	=	0 to 96 inches (0 to 2438 mm)
Rotation	=	210 degrees
Head roll	=	±15 degrees
Head Pitch	=	±120 degrees
Head yaw	=	±140 degrees
Maximum safe load at head	=	1500 pounds (680 kg)

APPENDIX E - BENCH TEST PLAN

E.1 Functional Test

E.1.1 Objective

The purpose of this section of tests is to determine that all the components of the system are properly operating, such as checking that hydraulic components are correct, that labels are corresponding, that flow rates are approximately balanced, etc.

E.1.2 Transporter

Check all hydraulic control handles that their operation conforms to that indicated on drawing D-7522-12HYD and to the labels affixed to the control console.

Note whether the direction of valve operation seems to be in a natural direction, for example, the crane should lift when the valve handle is "lifted" not when it is "depressed". If any operations seem unnatural, then they should be reversed, if possible.

Check that all motions have their full and correct stroke and that the transporter travels in a straight line when the tram controls are equally thrown.

Observe the maximum speed of the various motions and give consideration to installing or changing the flow restrictor port checks. These can only be installed in valve ports with straight (O-ring) thread fittings.

Check the electrical system to see that all switches are properly marked and functioning. The "panic" bar should turn off all motive power.

Check lighting system to assure that all lights are functioning and that they properly respond to control switches.

E.1.3 Support Frames

Check end connectors for fit with hydraulic supports. Check fit of beam and centering stops into clamping cradle of the transporter crane.

Install a sample of each load distributor onto the corresponding beam to qualify fit and assembly technique.

Test hydraulic props using remote controlled setting pistol and release wrench.

Verify yield setting by placing prop into a rigid test frame and applying emulsion pressure. Increase the pressure slowly and observe the pressure gage at the time when the yield valve begins to bleed. Calculate yield load as follows:

$$Y \text{ (tons)} = 0.0073 \, P \text{ (lb/in.}^2\text{)}$$

Compare this value against specification on drawing B-7522-11003.

E.1.4 Gate Supports

Connect up pressurized emulsion to gate support valves. Operate all controls to determine that jacks, canopy jack and advancing ram operate properly.

E.1.5 Equipment

Power Supply - 480 Vac, 40 kVA
Emulsion Pump - 1 gal/min minimum capacity at 2000 psi.
Pressure Gage - 0 to 2000 psi
Tank for emulsion mixing and storage
Emulsion
Hydraulic oil
Test frame for prop
Prop accessories - setting pistol, release handle, etc.
Miscellaneous pipes, hoses, fittings, tools, etc.

E.2 Operational Test

E.2.1 Objective

The purpose of this portion of tests is to assure that the system is operable in a simulated mining environment, that the transporter will perform its beam handling function, that the supports are movable as designed, and that the system can operate under adverse conditions.

E.2.2 Support Installation

Uncrate a beam as required and locate it on the floor upside down. Pick up the beam with the transporter, turn it over, and lift to an elevated position. Attach props with the proper fitting, adjusting the beam with the transporter as required to make contact with the props.

Install the supports into position in the mock entry. Actuate the emulsion supply to set the props. (The support setting operation should be done carefully to avoid damage or upset to the mock entry. It is not as solid as a real entry.) Secure the beam in place with the cleats provided. (This operation is for bench test only.) When the support is secure, release the crane and withdraw the transporter.

Reapproach the beam with the transporter. Maneuver the crane into position at the center of the beam and clamp it to the beam. Release the prop pressure. Lower the beam. Close the prop valves. Lift the beam and prop assembly.

Withdraw the support assembly from the support position into the entry. This operation may require a series of events. Repeat, trying different sequences to determine the simplest procedure. Make notes of this preferred procedure.

Carry the beam to the far end of the entry. During this operation stop the machine and pace the crane through its various degrees of freedom. Make notes of any noteworthy features.

When the far end of the entry is reached, swing the support assembly around to the rear of the machine. Install the supports outby the last support approximately 3 feet. As before, this may require a series of operations. Make notes of the preferred procedure.

E.2.3 Transporter Operation

During the above operations much will be learned about the transporter. However, it may be useful to operate the transporter and crane controls repeatedly so as to become thoroughly familiar with their characteristics. This can be done both with a beam in the clamps of the crane and without a beam attached.

E.2.4 Adverse Conditions

When the operator has become thoroughly familiar with the basic operation of the system, the entry should be outfitted with various obstructions simulating adverse conditions in the mine. These include support posts at irregular locations, an exceptionally low-hanging beam, and floor irregularities such as rocks and bricks strewn about. The system should then be advanced through these obstacles and notes made on the best procedures for doing so.

Construct a low barrier around one or both prop bases to simulate a floor that has heaved up around the prop. Then extricate the support by inclining the prop to drag it up and over the barrier.

Test the total lift capacity of the crane and prop by strapping weights onto the prop leg. Open the prop release valves and lower the beam. Close the valves and lift. Add more weight and repeat until capacity limit is reached. This may be determined either by the ability to maintain beam attitude with the crane or by the cavitation of prop fluid. If the former, reattach the crane head to the beam at a point closer to the prop and proceed as above until the condition of cavitation is reached. Make notes on the results and the amount of weight which was attached.

E.2.5 Equipment

The following materials are required to construct a mock entry:

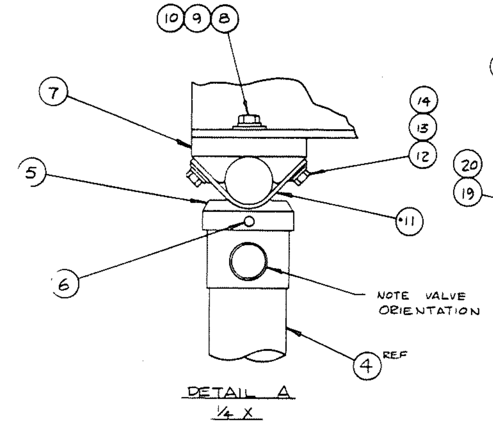
- Plywood Entry - to include a series of simulated beams, a location at each end to install a real beam, and attachment cleats for same

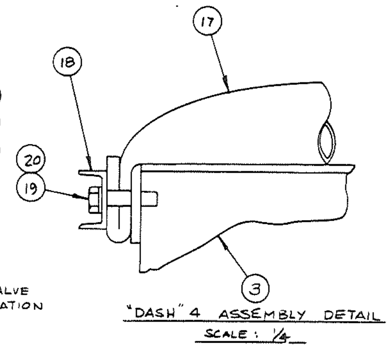
- Prop barricade obstacles such as posts, low "beam", rocks, gravel, etc.

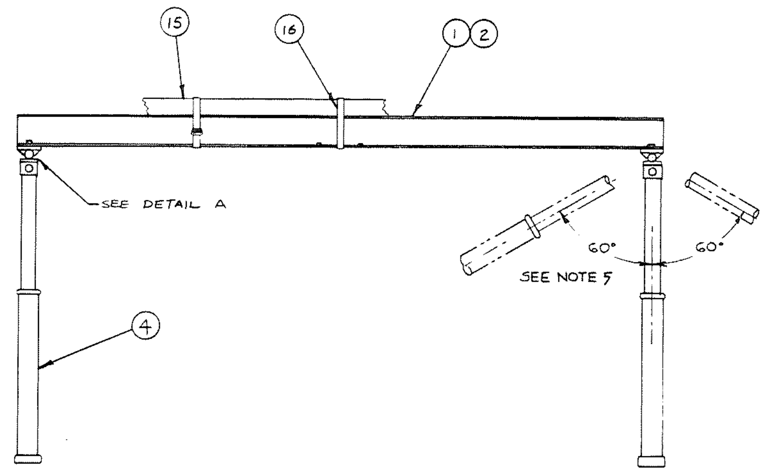
APPENDIX F - ASSEMBLY DRAWINGS

C-7522-11000	Support Assembly
D-7522-12000	Transporter
R-7522-12001	Transporter Chassis
R-7522-13000	Crane Subassembly
D-7522-14000	Remote Prop Actuator
C-7522-15000	Gate Support

REVISIONS			
LTR	DESCRIPTION	DATE	SIG







NOTES:

1. CAMBERED SUPPORT BEAM TO BE ASSEMBLED WITH CONVEX ARCH UPWARD.
2. ROLL PINS, ITEM 6, ARE SUPPLIED WITH PROP, ITEM 4.
3. OBSERVE ORIENTATION OF VALVE RELATIVE TO PROP FITTING, ITEM 5, AT ASSEMBLY TO PROP, ITEM 4.
4. HOSE, ITEM 17, TO BE PARTIALLY FILLED WITH APPROX GAL. WATER OR EMULSION DURING ASSEMBLY.
5. SOCKET BEARING PLATE WILL PERMIT A ± 60° ARTICULATION OF PROPS FROM THE VERTICAL POSITION SHOWN, TYPICAL.

-4	-3	-2	-1	ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
4	-	-	-	20		LOCKWASHER, 3/4	
4	-	-	-	19		SCREW, 3/4-10UNC × 3 LG, HEX HD	
2	-	-	-	18	A7522-11009	CLAMP PLATE	
1	-	-	-	17	A7522-11007	HOSE	
-	5	-	-	16		STRAPS	
-	1	-	-	15	B7522-11008	PAPER HONEYCOMB	
8	8	8	8	14		LOCK WASHER, 1/2	
8	8	8	8	13		PLAIN WASHER, 1/2 HEAVY	
8	8	8	8	12		SCR, 1/2-13 × 1 LG, HEX	
4	4	4	4	11	B7522-11006	RETAINER	
4	4	4	4	10		LOCK WASHER, 5/8	
4	4	4	4	9		PLAIN WASHER, 5/8 HEAVY	
4	4	4	4	8		SCR, 5/8-11 × 1 1/2 LG, HEX HD	
2	2	2	2	7	C7522-11005	BEARING PLATE	
6	6	6	6	6	B7522-11003-2	ROLL PINS	
2	2	2	2	5	C7522-11004	PROP FITTING	
2	2	2	2	4	B7522-11003-1	PROP	
1	-	-	-	3	B7522-11002	SUPPORT BEAM, CLAMPS	
-	1	1	-	2	C7522-11001-2	SUPPORT BEAM, CAMBERED	
-	-	-	1	1	C7522-11001-1	SUPPORT BEAM, STRAIGHT	

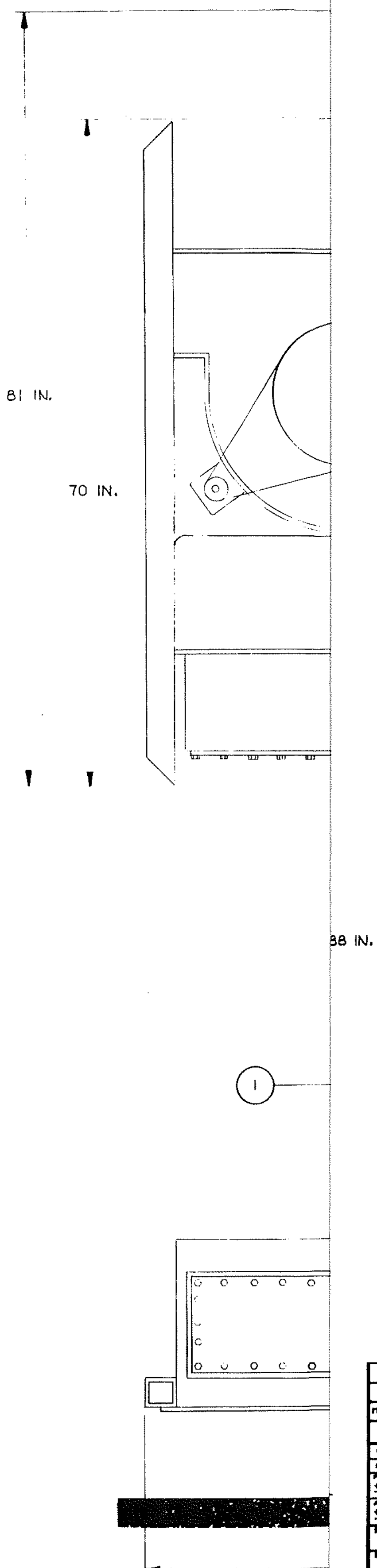
PARTS LIST

DRAWN	[signature]	FOSTER-MILLER ASSOCIATES INCORPORATED 135 SECOND AVENUE WALTHAM MA 02154
CHECKED	J. Quick 3/31/77	
APPROVED		SUPPORT ASSY HEAD / TAIL SYSTEM
APPLICATION		
NEXT ASSY		
FINAL ASSY		ORIGINAL PROJECT BM7522 · SIZE C · 11000 · REV 5/25
MACHINE		
ACTIVE PROJECT NO	BM7522	SCALE 1/20 · WEIGHT · SHEET OF

MATERIAL —//—
HEAT TREATMENT —//—
FINISH —//—

P.S.P. 3555

REVISIONS			
LTR	DESCRIPTION	DATE	SIG



NOTES:

1. BOLT CRANE ASSEMBLY TO CHASSIS PER DRAWING NO. R 7522-13000
2. INSTALL HYDRAULIC COMPONENTS PER HYDRAULIC SCHEMATIC D7522-HYD. ROUTE CRANE CONNECTING HOSES AROUND TURRET TO PERMIT SPECIFIED ROTATION OF CRANE WITHOUT TWISTING OR KINKING.
3. INSTALL FULL COMPLIANCE LIGHTING SYSTEM PER SPECIFICATIONS PROVIDED BY GENERAL ENERGY DEVELOPMENT CORPORATION (SUPPLIERS TO NMS). COMPONENTS REQUIRED:
   - POWER CONDITIONER
   - 6 FLUORESCENT LUMINAIRES
   - 2 PAIR SWITCHABLE HEADLAMPS
   - CONTROL SWITCHES

ITEM NO	QTY		PART NO	DESCRIPTION	SPECIFICATION
2	1		R7522-13000	CRANE	
1	1		R7522-12001	CHASSIS	

PARTS LIST

UNLESS OTHERWISE SPECIFIED	DRAWN	P.d.B.	5-15-77
BREAK CORNERS .005 - .010	CHECKED	Circle	
FRACT ± .X ± .XX ± .XXX ±	APPROVED		
ANGLES ± MACH SURF √ MAX	APPLICATION		
MATERIAL	NEXT ASSY		
HEAT TREATMENT	FINAL ASSY		
FINISH	MACHINING		
	ACTIVE PROJECT NO	BM-7522	

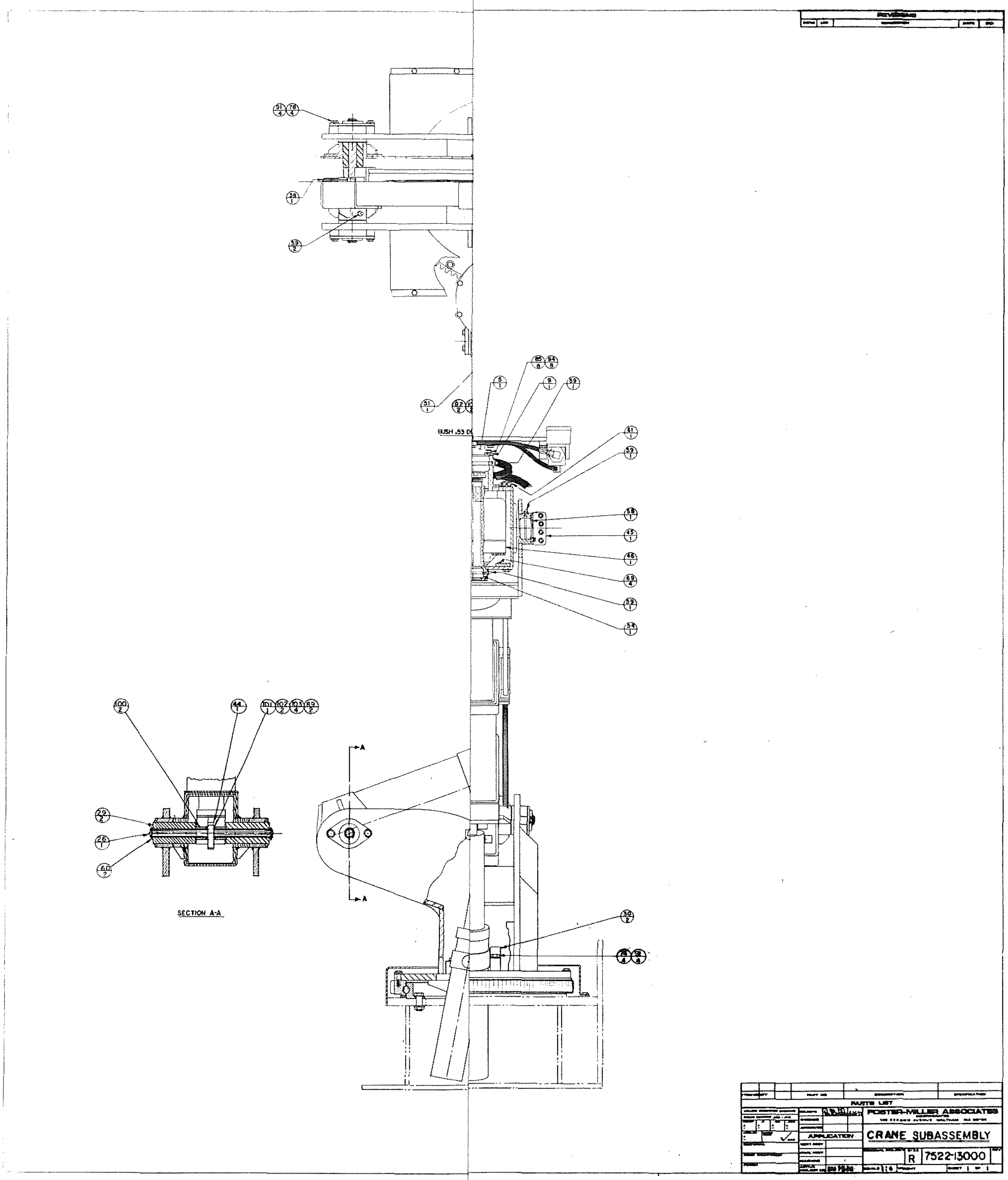
FOSTER-MILLER ASSOCIATES INCORPORATED
135 SECOND AVENUE WALTHAM MA 02154

TRANSPORTER
HEAD-TAIL SYSTEM

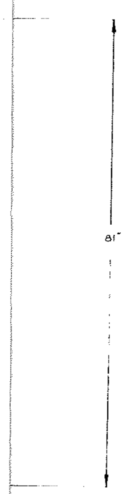
ORIGINAL PROJECT | SIZE D | 7522-12000 | REV 5/26

SCALE 1/8=1" | WEIGHT — | SHEET 1 OF 1

F.A.P. 3633


SECTION A-A
BUSH .53 DO
PARTS LIST
FOSTER-MILLER ASSOCIATES
APPLICATION
CRANE SUBASSEMBLY
R
7522-13000

REVISIONS			
LTR	DESCRIPTION	DATE	CG
A	ADDED NOTE 8, RELEASED FOR PILOT PROD	8/7/77	



…SH SCREEN

…TRONG STEEL PIPE WITH ASTM
…E B OR EQUIVALENT

…ED ROUND, AISI 1141 OR EQUIV.

…TRUCTURAL STEEL TUBING, ASTM 500
…YIELD = 46 000 PSI, OR EQUIV.

EXTRA STRONG STEEL PIPE
… A53 GRADE B OR EQUIV.
…300")

NOTES:

1. STARTER/CONTROLLER BOX (460/240 VOLT, 40 HP) TO BE SUPPLIED BY THE VENDOR
2. CHASSIS TO BE SUPPLIED WITHOUT LIGHTS
3. LOCATION OF START/STOP SWITCH AND PANIC BAR WILL BE DETERMINED AFTER CONFIRMATION ON DIRECTIONAL CONTROL VALVE BANK MOUNTING
4. SIZE AND ATTACHMENT OF INTERCONNECTING OIL RESEVOIR PIPE LINE TO BE DETERMINED BY VENDOR
5. CANOPY STRUCTURE TO BE WELDED USING PROCEDURES WHICH ASSURE MAXIMUM YIELD STRESS PROPERTIES THROUGHOUT THE STRUCTURE
6. SEE SCHEMATIC D7522-12HYD FOR HYDRAULIC CONNECTIONS. CONNECTIONS TO BE COMPLETED BY VENDOR WHEREVER POSSIBLE. OPEN PORTS TO BE CAPPED OR PLUGGED VALVES, ETC. WILL BE INSTALLED BY CUSTOMER.
7. TRAM MOTORS, DRIVE TRAIN, TIRES ETC. TO BE SUPPLIED BY VENDOR USING TYPICAL INSTALLATION PROCEDURES
8. CHASSIS TO BE SUPPLIED WITH FIRE SUPPRESSION SYSTEM. LOCATION OF TANK SUBJECT TO APPROVAL BY CUSTOMER.

PARTS LIST

DRAWN J.Conca 2-12-77

F…TER-MILLER ASSOCIATES

APPLICATION

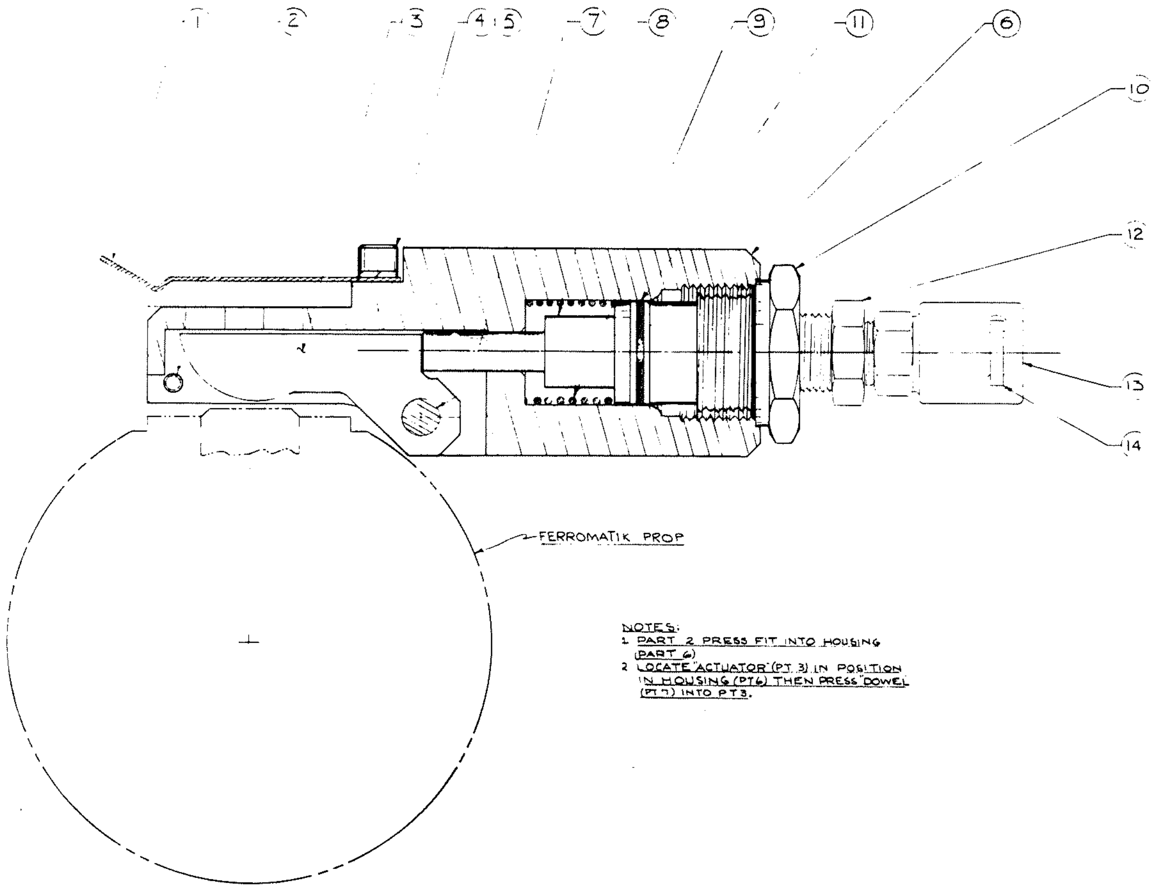
ACTIVE PROJECT NO. BM 7522

TRANSPORTER CHASSIS
HEAD/TAIL SUPPORT SYSTEM

R 7522-12001 A

SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	BY
B	WAS DOWEL PIN / IS ROLL PIN	5/12/77	
C	ADDED	5/12/77	
D	RELEASED FOR [illegible]	[illegible]	
E	ADDED	[illegible]	



NOTES:
1. PART 2 PRESS FIT INTO HOUSING (PART 6)
2. LOCATE ACTUATOR (PT. 3) IN POSITION IN HOUSING (PT 6) THEN PRESS DOWEL (PT 7) INTO PT 3.

ITEM	QTY		PART NO.	DESCRIPTION	SPECIFICATION
14	1		4410-4	CLIP	STRATOFLEX
13	1		18822-4-43	ADAPTER [illegible] PIPE	STRATOFLEX
12	1		C3109x8x4	[illegible] NPT x 1/4 NPT ADAPTER	WEATHERHEAD
11	1		TPO11	PISTON T SEAL BORE	[illegible]
10	1		C3269x16x8	[illegible] NPT ADAPTER	WEATHERHEAD
9	1		LC105L-0	MUSIC WIRE SPRING	LEE SPRING CO
8	1		14003	HYDRAULIC PISTON	
7	1		COMM	HARD & GROUND DOWEL	3/8 DIA x 2" LG
6	1		14001	HOUSING	
5	2		COMM	LOCKWASHER	1/4
4	2		COMM	SCREW, SOC. HD. C.S.	1/4 20 x 3/8 LG
3	1		14002	ACTUATOR	
2	1		COMM	ROLL PIN	3/16 DIA x 3/16 LG
1	1		14004	FLAT SPRING	

PARTS LIST

FOSTER-MILLER ASSOCIATES

REMOTE PROP ACTUATOR

D 7522-14000

BM 7522

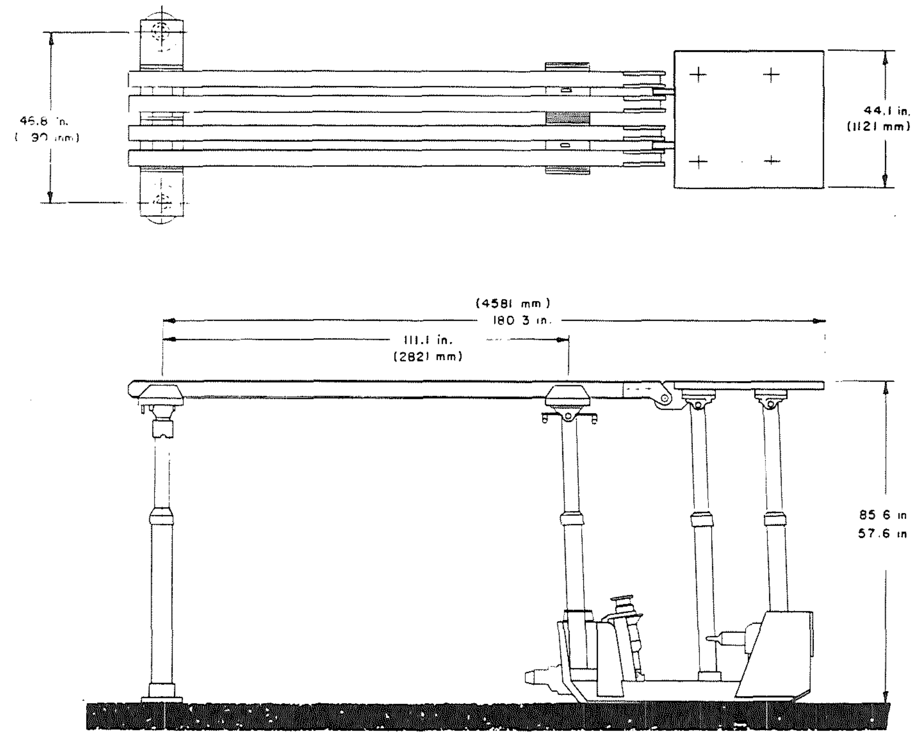
SCALE 2x

WEIGHT 3 lbs

SHEET 1 OF 1

REVISIONS

LTR	DESCRIPTION	DATE	BY



NOTES:

1. UNIT TO BE SUPPLIED BY DOWTY MINING EQUIPMENT, LTD. "RIGID BASE FACE ROADWAY ANCHOR POWERED SUPPORT" DRAWING NO. 100002-21-29 (REF. DWG. NO. 110002-01-28)

2. SUPPORT TO BE SUPPLIED AS CODED BELOW

1	ROOF BEAM	-	ACH (ARTICULATED CANOPY + FRONT FOREPOLE BARS)
2	BASE	-	HD (HEAVY DUTY BASE)
3	DA POWER SET LEGS	-	SE (SINGLE EXTENSION LEGS)
4	EXTENDED HEIGHT/TRAVEL	-	2175/710 (85.6 IN.EXTD., 57.6 IN. CLOSED)
5	SET/YIELD	-	18.7/40.6 (20.9 TON SET/45.4 TON YIELD.EACH LEG)
6	UNIT CENTERS	-	1200
	FLUSHING SHIELD	-	VNF (VENETIAN BLIND WITH FLAPS)
7	RAM	-	RF (510-760, REVERSE FORCE)
	CLEVIS	-	W (WIDE)
8	LEG POSITION	-	F (FORWARD)
9	HYDRAULIC CONTROL SYSTEM	-	OHC/DRV (ONE HANDLE CONTROL WITH DUMP VALVE & ISOLATION)

PARTS LIST

ITEM NO.	QTY		PART NO.	DESCRIPTION	SPECIFICATION

FOSTER-MILLER ASSOCIATES

DRAWN: P.d.B. 5-25-77

APPLICATION

GATE SUPPORT

HEAD TAIL SUPPORT SYSTEM

SIZE: C | 7522-15000

BM-7522

SCALE NONE | WEIGHT ——— | SHEET 1 OF 1