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DEVELOPMENT OF A CONVEYOR BELT SERVICE MACHINE

Contract No. J0333926
Tracor MBA

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U.S. Bureau of Mines
Minneapolis, Minn.

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16. Abstract (Limit 200 words) Tracor MBA under a contract to U.S. DOI Bureau of Mines designed, developed, fabricated and demonstrated a conveyor belt service machine. It is self-contained, battery powered, rubber tired and capable of handling, storing and transporting conveyor belting, wire rope and associated structures for sectional conveyor belts. While moving the tail section to its next position the machine discharges the belting, wire rope and belt structures. The belting is elevated and separated to provide for the insertion of the structures with minimum manual effort. A hydraulic system provides the power for steering, braking, winding or unwinding (under controlled tension) belting and wire rope, operate a load bed conveyor, connection hitches and power external hydraulic tools. Also, a pneumatic system is available to operate air impact tools. The service machine, in its present configuration can function in coal seams as narrow as 48 inches, double wind conveyor belting 42 inches wide 400 feet long, load or unload 3/4" wire rope on two separate reels and be controlled by two operators. A complete belt move using this machine requires only four persons. Successful underground demonstrations were conducted in coal mines located in west Virginia and Kentucky.			
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PREFACE

This report summarizes the work performed in the evaluation, design and fabrication phases of this contract and describes the underground proof-of-concept demonstration tests.

The underground proof-of-concept demonstration testing was made possible through the personal interest and cooperation of D. K. Flanagan, Bill Dulin, Tony Basco, John Hill and Richard Smith of Armco Material Resources and Dr. Richard A. Wolfe of United Coal Company.

ABSTRACT

Tracor MBA under a contract to U.S. DOI Bureau of Mines designed, developed, fabricated and demonstrated a conveyor belt service machine. It is self-contained, battery powered, rubber tired and capable of handling, storing and transporting conveyor belting, wire rope and associated structures for sectional conveyor belts. While moving the tail section to its next position the machine discharges the belting, wire rope and belt structures. The belting is elevated and separated to provide for the insertion of the structures with minimum expended effort.

A hydraulic system provides the power for steering, braking, winding or unwinding under controlled tension the belting and wire rope, operating a load-bed slat conveyor, raising, lowering and locking connection hitches and powering external hydraulic tools. Also, a pneumatic system is available to operate air impact tools.

The service machine, with its present components can function in coal seams as thin as 48 inches, double wind conveyor belting 42 inches wide, 400 feet long, load or unload 3/4" wire rope on two separate reels and is controlled by two operators. A complete belt move using this machine requires only four workers. Successful underground demonstrations were conducted in coal mines located in West Virginia and Kentucky.

EXECUTIVE SUMMARY

Tracor MBA (formerly MBAssociates) under contract with U.S. Department of the Interior Bureau of Mines #J0333296 (formerly H0357102 and DOE #ET-75C-01-8886 and DE-AC01-75ET-11083) designed, developed, fabricated and demonstration tested a conveyor belt service machine. The machine was to be used in the extensions and retractions of sectional conveyor belts performing the heavy arduous functions of a belt move and eliminating the need to use other mine vehicles such as the scoop. It was to be able to:

- o Operate in coal seams as low as 48 inches.
- o Wind and unwind conveyor belting and wire rope in controlled tension.
- o Handle belting from 20 to 42 inches wide, 1/4 to 1/2 inch thick and 200 to 300 ft. long.
- o Handle wire rope up to 3/4 inches in diameter and 120 ft. long in each of two reels.
- o Transport the support structures, associated equipment and tools along with the belting and wire rope.
- o Move readily between various sections of the mine.
- o Operate for a full shift on a single charge of its own batteries.
- o Supply auxiliary power (pneumatic) for hand-held air tools.
- o Take hold of and move the tail section of a sectional conveyor belt during the belt move.
- o Perform the critical tasks of a 100 ft belt move in 15 minutes.

A machine conforming to the above requirements was conceived, designed, fabricated and successfully demonstrated. The machine has a 64 cell storage battery of 650 amp/hr to power the four wheel drive using two 30HP 1200 rpm 128V series wound d.c. traction drive motors. Motor speed is controlled by an SCR solid

state d.c. to d.c. chopper system designed to provide smooth efficient speed control of series-wound d.c. motors.

All functioning components of the machine are powered by a hydraulic system. The belt reel component double winds conveyor belt 1/4 inch thick up to 42 inches wide and 400 ft. long. There are two wire rope reels (one on each side of the machine) capable of winding wire rope under controlled tension. The slat conveyor for the storage and transporting the belt's structural supports can be raised or lowered and rotated forward or reverse. There are two hitch hooks (one on either side) that can be individually lowered or raised and locked or unlocked hydraulically. Steering is also by hydraulic assist as are the brakes. A hydraulic motor drives the air compressor of the pneumatic system that supplies 80/100 psi air for the hand-held air tools.

In the first underground demonstration test the machine was used in a conveyor belt retraction of 160 feet. Three hundred and twenty feet of 1/4" x 36" conveyor belt was double wound on the machine's belt reel; the tail section was pushed out-by to its new location; thirty five support structures, two sail anchors and eight twenty-foot lengths of two inch pipe were loaded and transported along with the wire rope to another section in the mine and offloaded in a storage area. The machine was driven a total distance of about two to three miles in and out of the mine for this successful demonstration. The machine performed all its tasks efficiently with no malfunctions.

Additional proof-of-concept demonstration testing in two other coal mines extending both floor-mounted and roof suspended belts was successfully performed. The last demonstration mine requested and obtained permission to use the machine over an extended period of up to three years for further evaluation.

1.0 INTRODUCTION

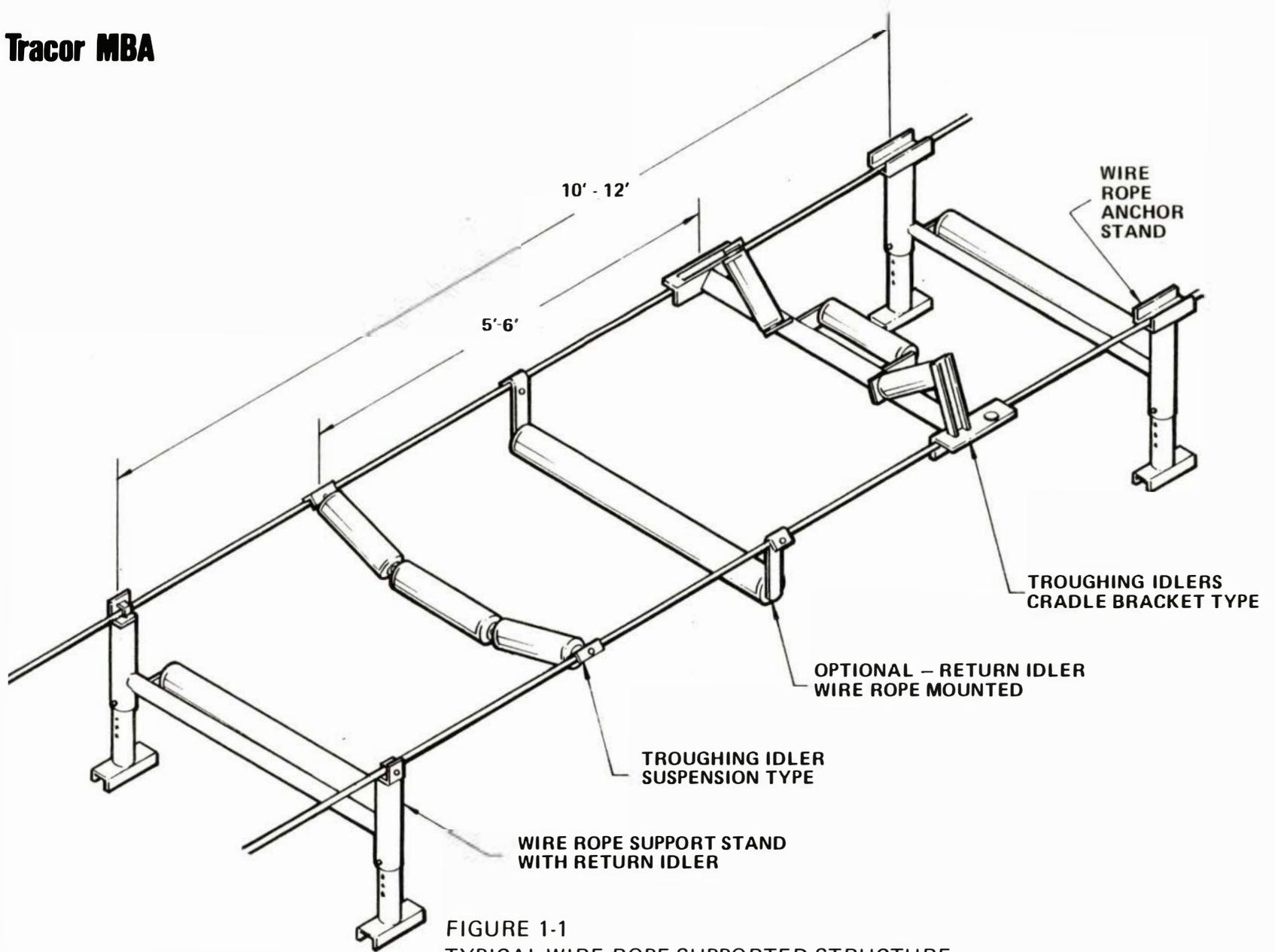
1.1 Background

A large number of underground coal mines use a combination of haulage units to move the coal from the working face to a rail car loading area. A belt haulage system usually consists of a main line belt conveyor which is fed by gathering belt conveyors or section belt conveyors. The gathering belt conveyors are usually fed by the section conveyors. The coal is moved from the continuous miners at the face by a shuttle car that unloads into a feeder breaker that breaks the large pieces of coal and feed it onto the tail piece of the section conveyor. The tail piece is skid mounted so it can be readily moved and the belt line lengthened or shortened by the addition or removal of belting, wire rope and support hardware. A typical section of a wire rope supported floor mounted sectional belt conveyor is shown in Figure 1-1.

The sectional conveyors are extended by adding sections to keep the conveyor end close to the face during mine development to shorten the haul distance for the shuttle cars. During retreat operations the sectional belt conveyors are shortened by removing sections to keep ahead of the extraction operations.

The normal belt move usually requires six to eight workers and takes three to eight hours. A 100 ft belt move requires handling up to 4000 lbs of material not including the tail section. The materials, in addition to the work tools are:

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Wire rope supported floor-mounted belt

Belting	200 ft.
Wire rope	200 ft.
Troughing rollers	16 (6 ft. spacing)
Stands	7
Anchor stands	2
Return idlers	7 (mounted on stands)
Wire rope anchors	2 jack pipes with hardware

Wire rope supported - roof suspended belt

Belting	200 ft.
Wire rope	200 ft.
Troughing rollers	16 (6 ft. spacing)
Chains	14 with clips
Return idlers	8 with brackets
Sail anchors	2 with hardware
Roof bolts	18 with brackets

Changing the length of a sectional conveyor can be a heavy, arduous labor consuming process. It can account for many of the personal injuries experienced such as strain, sprain, lacerations, etc. Thus, it is reasonable to expect that a machine designed to perform the heavy portion of the work task and provide power for hand tools could make the operation easier, safer and in less time.

This was the basis for a conveyor belt service machine or conveyor belt extender.

1.2 Objectives

The objectives of the contract were to design, fabricate, test and demonstrate a conveyor belt service machine capable of functioning in relatively low seam coal (42-48") and greatly reduce the time required to make belt extensions and retractions

The guideline goal was a conveyor belt move of 100 ft. in a 15 minute period for the critical tasks or those tasks that cannot be done while the conveyor belt is in operation. It was also deemed necessary that the machine should be designed to work with the conveyor belt equipment expected to be in use in 1980 i.e. it should not require specially designed conveyor belt hardware that will not be commercially available.

1.3 Approach

The approach used was first to study and evaluate the methods and techniques being used for extending and retraction of section belts. Time studies and operational analysis were made of belt moves in order to determine which functions and equipment would have the most effect on achieving the objectives. Concepts were then generated to meet the requirements and were evaluated on the basis of which would have the greatest effect on the critical functions. The most promising was selected for fabrication.

1.3.1 Belt Move Procedures

In the review of belt move procedures it was found that there could be as many different procedures as there are mines. Each belt crew adapts their procedures to the existing equipment and conditions.

There was a completely self propelled crawler mounted, self anchoring conveyor belt tail section which contained powered wire rope reels. This, however, had only the potential for short moves of 10 to 12 ft. and does not meet the 100 ft. moves unless large belt storage takeup sections are added.

There was also the rigid structure system which eliminates the stringing and tensioning of the support cables but the most used was the cable support system.

Time studies of existing manual systems (cable support) belt moves disclosed times of 62 minutes for 85 feet to 266 minutes for 120 feet. (See Table 1-1). Time will vary considerably from mine to mine depending on mine conditions, age of belting and structures and their condition and, of course, the experience of the crew. The best move time observed was by a well trained experienced dedicated crew that wanted to see how fast they could make the move. The conditions were also ideal. It was concluded that it is possible with the best equipment and ideal conditions for six to eight men to make a 100 foot belt move in one hour although it is believed that the greatest number of mines in the U.S. take longer than four hours for a belt move.

1.3.2 Evaluation of Promising Concepts

Six machine concepts were evaluated by estimating standard times for critical unit operations and comparing with actual observed and estimated times for manual moves. The comparisons included costs to determine if a machine design would be cost effective. The comparisons are shown in Table 1-2.

Cost per move analysis was done for conveyor belt service machine systems (CBSM), powered tail sections, existing manual systems, preassembled concepts and five of the observed moves from the Phase I Study report. The cost effectiveness comparison between any two of the move systems is done as follows. For example, the most rapid observed move (move No.2 advance) was 62 minutes at an estimated total cost per move of \$389. The most rapid

OBSERVED TIMES FOR 5 BELT MOVES

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Mine	Move Distance	MAN MINUTES						Clock Time Worked	Number of Men
		Total Worked	Releasing & Loading	Distance Related	Unloading & Anchoring	Available	Not Working		
2	85	436	101	188	146	558	122	62	9
2 (retreat)	85	374	74	158	142	576	202	72	8
5	120	621	115	290	216	1260	639	210	6
10	120	950	160	334	456	1596	646	266	6
11	160	1108	208	584	316	1820	712	260	7

TABLE 1-1
BELT MOVES TIME STUDIES

	MOVE SYSTEM	COST PER MOVE 4 SECTION MINE 200 MOVES/YEAR			CRITICAL TIME	NUMBER OF MEN AT 200 MOVES/ YEAR	8 SECTION MINE COST/MOVE 400/YEAR	12 SECTION MINE COST/MOVE 600/YEAR
		LABOR	OWNING	TOTAL				
SERVICE MACHINE SYSTEM MOVES	MOVE NO. 020	250	225	475	36:45	2	387	358
	MOVE NO. 022	375	214	589	20:00	3	506	478
	MOVE NO. 021	500	214	714	18:00	4	631	603
	MOVE NO. 018	500	218	718	14:15	4	633	604
	MOVE NO. 019	500	218	718	18:30	4	633	604
	MOVE NO. 023	375	214	589	23:45	3	506	478
ALTERNATIVES TO SERVICE MACHINE CONCEPTS	4-MAN MANUAL *	500	27	527	62:00	4	527	527
	8-MAN MANUAL *	1000	27	1027	35:00	8	1027	1027
	16-MAN MANUAL *	2000	27	2027	29:00	16	2027	2027
	SELF PROPELLED T.S. *	250	543	793	—	2	793	793
	COMBINATION F.B.T.S. *	250	740	990	—	2	990	990
BEST OBSERVED MANUAL MOVE	MINE NO. 2 ADVANCE *	359	30	389	62:00	9	389	389
	MINE NO. 2 RETREAT *	362	30	392	72:00	8	392	392
TYPICAL OBSERVED MANUAL MOVE	MINE NO. 5 ADVANCE *	375	23	388	210:00	6	388	388
	MINE NO. 10 ADVANCE *	450	23	473	266:00	6	473	473
	MINE NO. 11 ADVANCE *	525	23	548	260:00	7	548	548

*REQUIRES ONE COMPLETE UNIT PER SECTION

TABLE 1-2
CRITICAL MOVE TIME AND COST PER MOVE COMPARISON CHART

estimated move is 14.25 minutes with a total cost of \$589 per move and a time saving of 47.75 minutes. The coal production time lost during the extra 47.75 minutes of the observed move has a value. Its value is calculated by assuming a production rate of 2 tons per minute with a coal value of \$20/ton. The value of the coal production time lost is \$1,910 ($47.75 \times 2 \times \20). For comparison purposes the cost of the observed move must be increased by \$1,910 resulting in an adjusted cost per move of \$2,299 ($\$1,910 + \389). The service machine move would then be generating savings of the difference between the adjusted cost per move and its cost per move or a savings of \$1,710 ($\$2,299 - \589) per move. The difference between the estimated and the observed move yearly owning cost per move is \$188 ($\$218 - \30). When this yearly owning cost per move difference is multiplied by the 200 moves per year a total yearly owning cost difference results. In this case \$37,600 ($\188×200). If this yearly owning cost difference can be made up by the savings generated from the use of the CBSM, in a short time, the CBSM can be said to be more cost effective. Because the CBSM is generating a savings of \$1,710 each time it is used it has accrued an amount equal to the yearly owning cost difference after 22 moves ($22 \times 1710 = 37,620$). Since the machine is used 200 times per year it generates savings equal to its yearly owning cost difference in 40 days ($365 \times 22 : 200$). In this comparison the CBSM concept payback time is very short so it can be said to be more cost effective than the observed moves. In this analysis it is assumed that coal production shuts down for a belt move, i.e. coal is being mined on all three shifts.

2.0 SYSTEM DESIGN

2.1 Contract Requirements

The contract requirements included the system specifications within which the machine should be able to function such

as: move distance, seam thickness, belt size, and the various aspects of the machine that were considered desirable, such as components, auxiliary power systems and vehicle mobility.

2.1.1 Move Distance

In the mine surveys a variety of belt length moves were found. The moves depended upon the cross-cut spacing which is determined by the geology of the area dictating the pillar size. Generally the lower the seam thickness the smaller the pillars and shorter cross-cut spacing. It was decided that 80 foot moves would be adequate for more than 90 percent of the potential applications in a 42 inch seam and that 48 inch seams would require 100 foot moves. The 100 foot distance was chosen to provide greater flexibility for the service machine.

2.1.2 Seam Thickness

The seam thickness originally specified was 42 inches. However, with the double lapped winder concept this was limiting as to move distance depending upon belt thickness. Tracor MBA offered an alternative of designing to a 48 inch seam which would allow for the 100 ft. moves considering the same belt thickness. This 48 inch seam criteria was agreed to by the technical director.

2.1.3 Belt Size

A decision was made to design the double lapped winder to accommodate belts up to 3/8" thick and 42" wide. Most of the section belts are 1/4" thick and 36" wide.

The belt storage capacity was decided at a clarification meeting held after the submittal of the design concept report where it was agreed that the machine belt capacity would be that amount of belt that can be stored on one roll with a 12 inch core diameter plus the 30 feet that is stored in the machine under the conveyor. Figure 2-1 shows the service machine belt storage capacity in feet for belt thickness varying between .25 and .50 inches versus the belt roll outside diameter. The belt storage length capacity varies with both roll diameter and belt thickness. The size of belt roll that can be safely and conveniently transported through the mine is limited by floor and roof clearance. The maximum size roll would have its center midway between the mine floor and roof. That is, in a 42 inch seam the roll center should be 21 inches from the floor and in a 52 inch seam the roll center should be 26 inches from the floor. The service machine belt roll center height has been made adjustable for the purpose of maximizing the belt storage capacity. Assuming that 6 inches top and bottom clearance is adequate for transporting the belt roll (the belt roll has been located at the wheel centerline to minimize the deleterious effects of floor and roof undulations) a 30 inch outside diameter belt roll can then be transported in a 42 inch seam. Referring to Figure 2-1 it can be determined that 230 feet of .25" thick belt, 190 feet of .31" thick belt, 163 feet of .38" thick belt, 144 feet of .44" thick belt or 130 feet of .50" thick belt can be transported in a 42 inch seam. Those capacities are adequate to meet the move distance requirements found in the 42 inch seams. In seams over 52 inches the service machine belt storage capacity is established by the frame clearance limits. The limits allow a roll outside diameter of 40 inches. This diameter roll will contain 218 feet of .50" thick belt. With any thinner belt considerably more can be transported. This storage capacity should move any section conveyor belt 100 feet.

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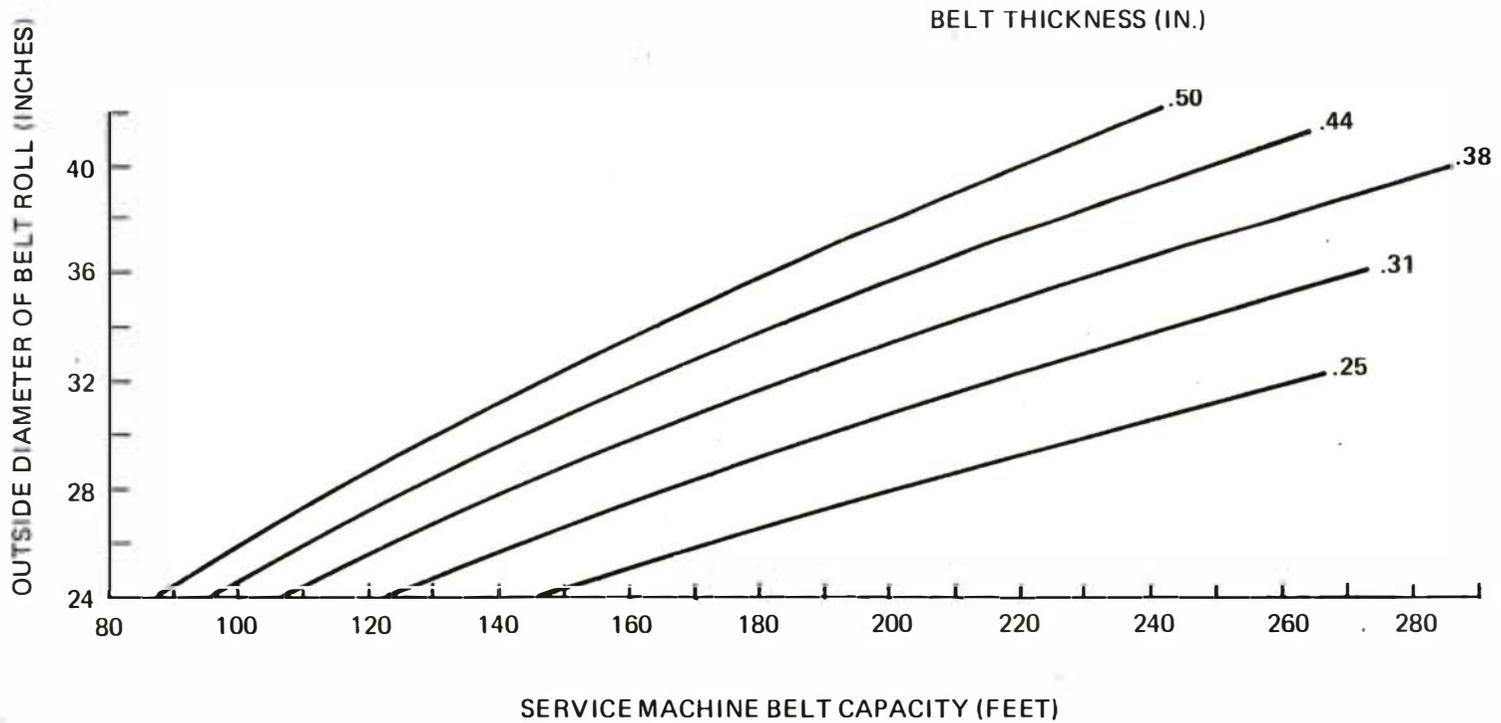


FIGURE 2-1
SERVICE MACHINE BELT STORAGE CAPACITY

2.1.4 Vehicle Components

The components specified to be on the vehicle were those deemed desirable and necessary to reach the objective goal.

These were:

- o Batteries for power
- o Traction motors
- o Hydraulic system for steering, braking and operation of vehicle components
- o Belt handling mechanism - reel or belt winder
- o Wire rope handling mechanisms one on each side
- o Large storage compartment for belt support structure
- o Compressed air supply - pneumatic system for powered hand tools
- o Powered clamp hooks or hitches to connect the tail section to the service machine.

2.1.5 Vehicle Mobility

It was decided that the machine should have complete mobility and be able to travel throughout the mine thus requiring four wheel steering similar to a shuttle car. It should be able to move slowly in either direction (creep) and up to 4-5 mph maximum speed. Draw bar capacity should be in the area of 15,000 to 20,000 lbs.

3.0 VEHICLE DESIGN

Having completed the requirements for the system in which the service machine was to operate it was possible to design the machine itself.

3.1 Structure

Since the service machine was to have the mobility of a shuttle car and travel within the same area, its basic structure was chosen to be similar. The overall height was set at 38" in order to be able to function in 42" seams. The ground clearance was also taken as similar to the shuttle car of 8 to 9 inches. The length and width were allowed to be 20-24 feet by 10 feet respectively and the vehicle would have four rubber tired wheels. The largest overall size believed feasible was chosen in order to provide space for the storage of the belt and its support structures. Figure 3-1 is a top and side view of the machine.

3.2 Tractive System

Using an estimated fully loaded vehicle weight of 32000 lbs and a 50% gradeability a drawbar pull of 16000 lbs was selected. At a 300% motor rating, an overall gear reduction of 28.98:1, and a traction drive gear box of 1.668:1, two 30HP 128V series motors were selected as the drive motors. A silicon controlled rectifier (SCR) controller for these motors was selected to provide the maximum in speed control, dynamic braking and battery efficiency.

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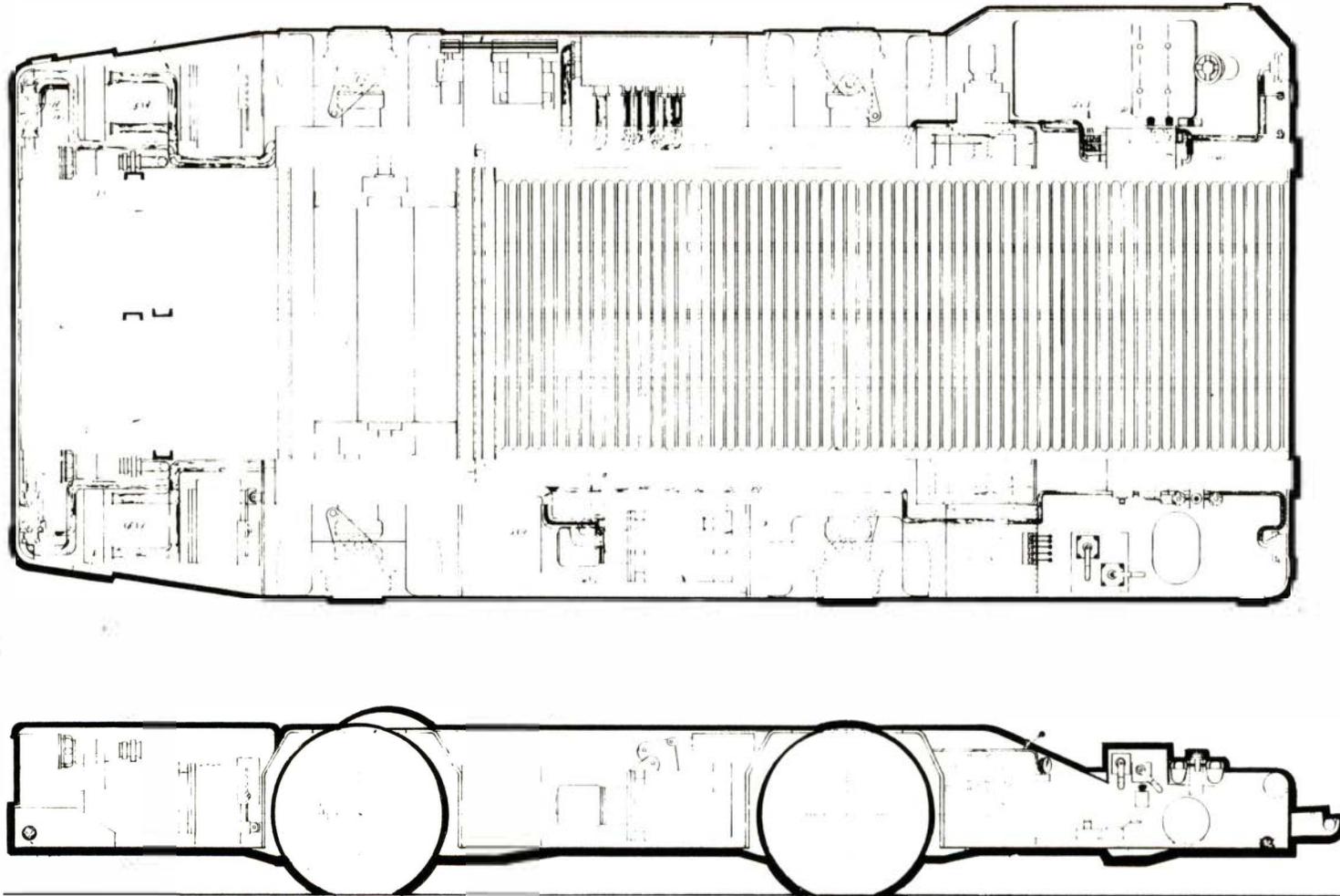


FIGURE 3-1
CONVEYOR BELT SERVICE MACHINE

3.3

Hydraulic System

The hydraulic system is second only to the propulsion or tractive system in complexity and importance. One hydraulic pump serves and powers all the machine's functions except the wheel drive. Even the air compressor is powered by a hydraulic motor in order to conserve space. Two hydraulic motors power the belt reel. Two hydraulic motors activate the rotation of the slat conveyor or storage rack. There is a hydraulic motor on each of the wire rope reels. The steering has hydraulic power assistance. Four hydraulic cylinders activate the up and down motion of both grab hooks and the forward and back motion (lock and unlock) of the locking pins (one on each side, front of the vehicle). Two hydraulic cylinders raise and lower the slat conveyor. Figure 3-2 is a photograph of the hydraulic controls station showing the control valves.

3.4

Belt Handling System

The capacity of the belt handling system was described in Section 2.1.3 under belt size. The belt winder or reel is somewhat complex since it double winds the belt starting from the center of the belt section and must have a lead-in cable (see Figures E and F, page 114), since the reel is located at the rear of the machine. Figure 3-3 shows the belt winder lead reel and the belt entering the reel. The lead reel is powered by a hydraulic motor of 300 in-lbs/100 psi (KPM/6.9 Bar) that pulls the belt through the machine into the center of the reel. Figure 3-4 is a sketch of the belt reel drive mechanism. When the belt is in place the torque is transferred to the rotation of the main reel. As the belt is wound on the reel and greater torque is required to continue winding the belt under tension the hydraulic motor on the other side of the belt reel is activated. It also is powered with the same size hydraulic motor providing adequate torque to wind the belt to maximum capacity.

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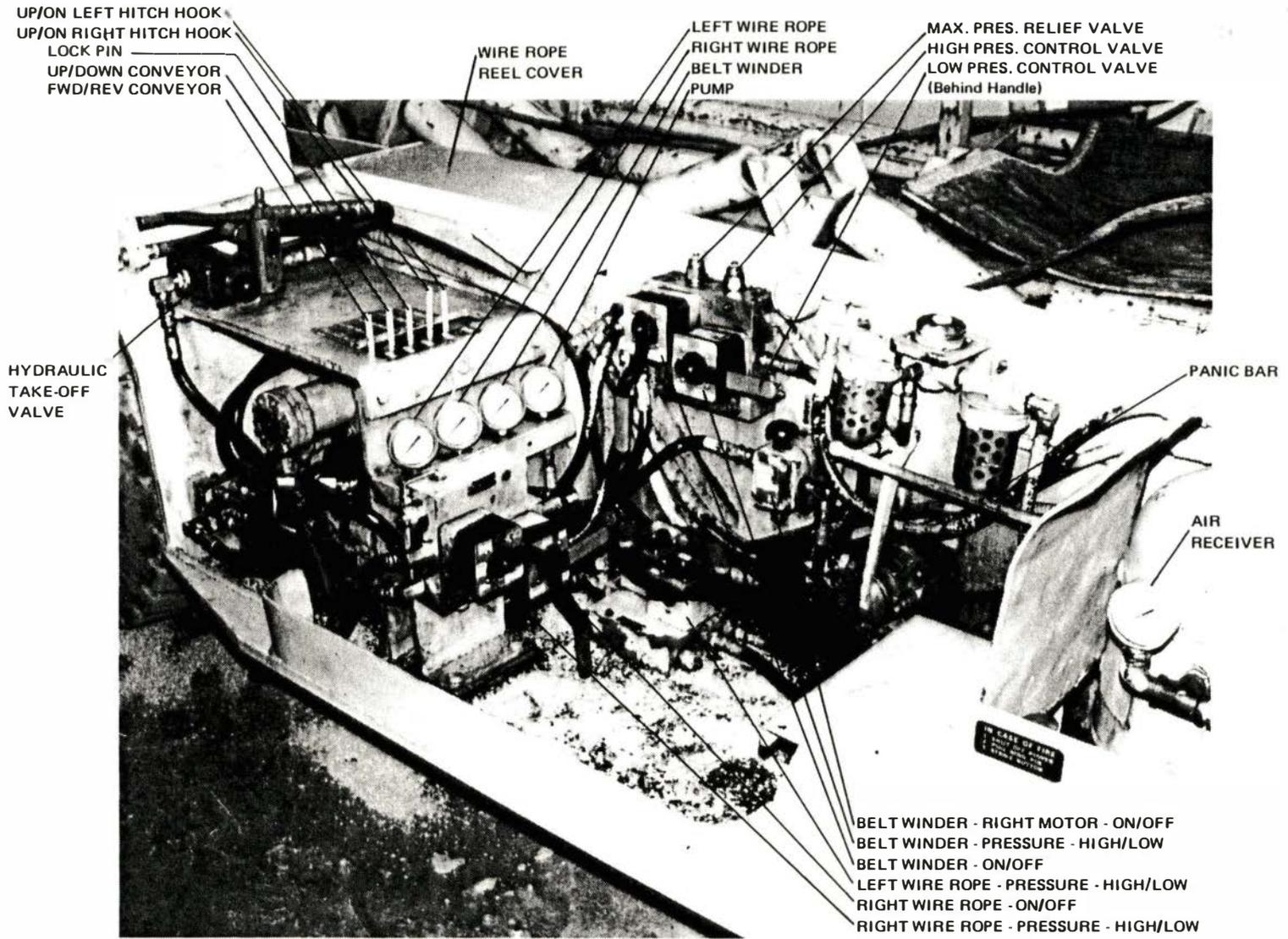


FIGURE 3-2
HYDRAULIC CONTROLS

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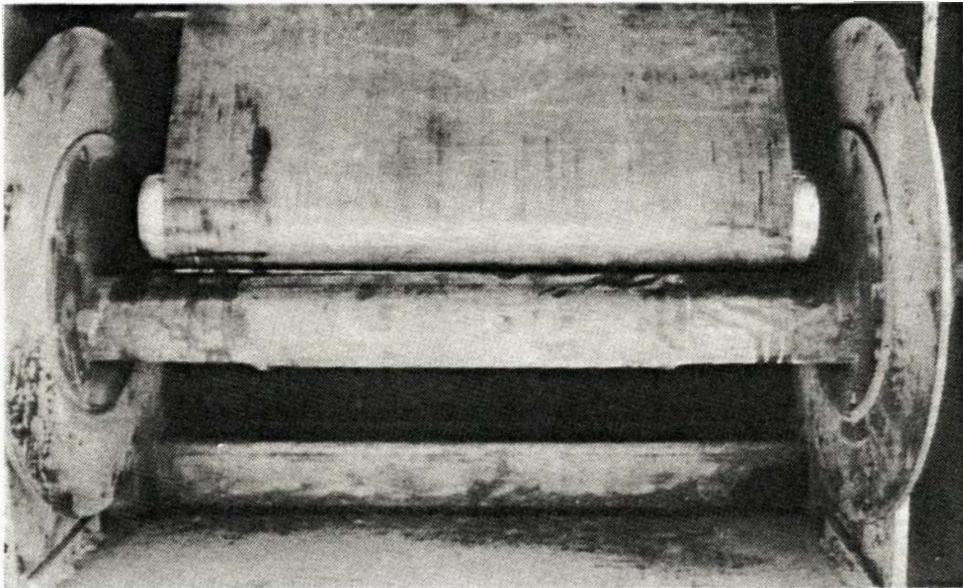
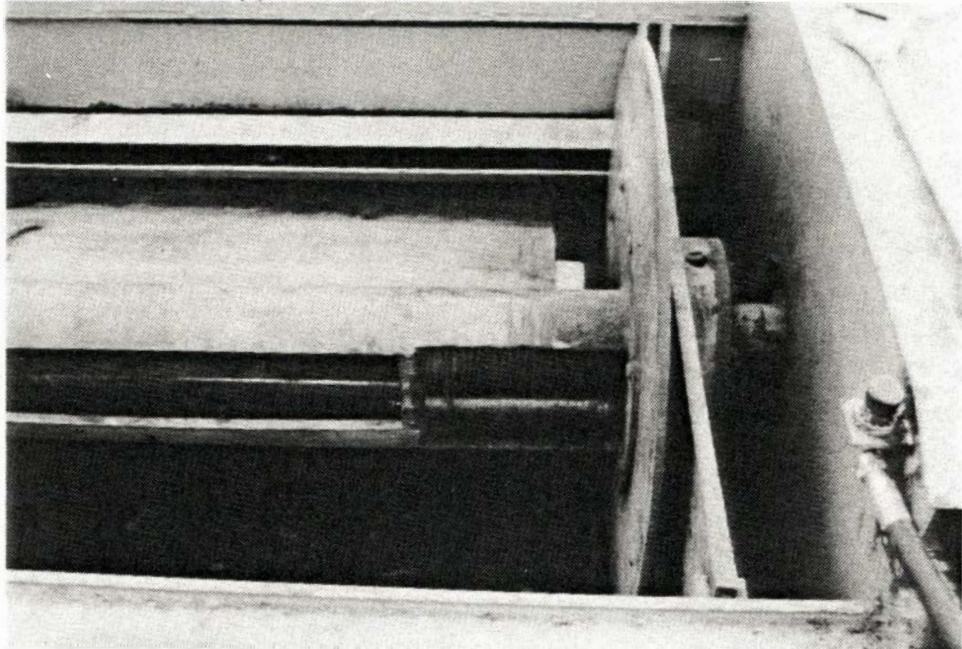


FIGURE 3-3
BELT ENTERING WINDER

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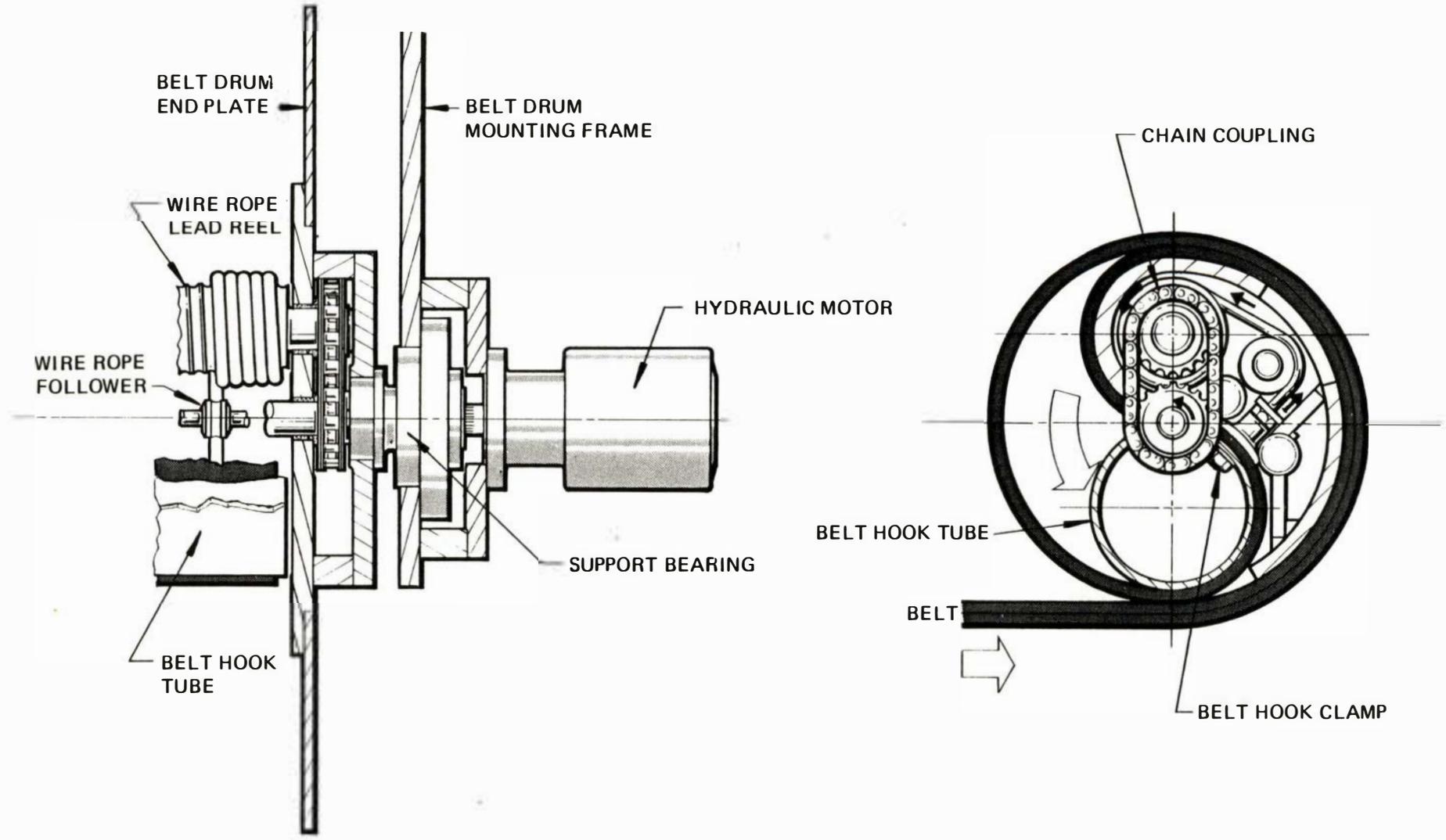


FIGURE 3-4
LEFT SIDE BELT REEL DRIVE MECHANISM

The motors are controlled by three valves. One pair of lever handle valves control the left side motor (lead cable reel). One of the valves is off or on, the other selects either a low or high preset pressure. The right side motor is fed the same pressure and is activated or deactivated by a push-pull valve.

3.5 Wire Rope Handling System

The wire rope handling system is composed of two reels, one on each side of the machine. Each is driven or powered by a hydraulic motor of 188 in-lbs/100 psi torque (KPM/6.9 Bar) through a gear reducer of 31:1. Thus there is more than sufficient torque available for tensioning the wire ropes. Each motor is separately controlled by a pair of lever handle valves. One is an on-off valve and the other is for the selection of either a high or low preselected pressure.

3.6 Pneumatic System

The pneumatic system supplies compressed air for hand-held air tools. It is composed of a hydraulic motor-drive air compressor and a receiver. The air pressure is maintained between 80-100 psi by the combination of an electric pressure switch and a normally open hydraulic on-off solenoid valve. There are female quick-coupled air connectors at each corner of the vehicle.

3.7 Tail Section

In order to be able to make demonstration tests above ground a tail piece was needed and was constructed with modifications deemed necessary to meet the requirement goal of a 100 ft. belt move in 15 minutes.

Each of the four legs of the tail section are individually adjustable for height by a ratchet mechanism (see Figure 3-6).

3.8 Work Platform

The work platform was welded to the outby end of the tail section (see Figure 3-6). For the belt move system to function as designed it is necessary to have a work platform or work table to hold the return belt off the ground and the feed belt apart from the return belt and above the work table's platform or shelf. This shelf provides a means of sliding the troughing rollers across under the belt. The wire rope support structure with the return idler is slid under the return belt. Figure 3-7 is a series of photographs showing the procedure of transferring the belt support structure to the work platform and how they are then installed by two workers. The last photograph shows the end result with work table top roller removed. The work table in this photograph was of later design for the underground testing and is detachable from the work piece.

4.0 FABRICATION

The fabrication of the machine was carried out by West Virginia Armature Company in Bluefield West Virginia. The company was chosen as subcontractor because of their experience in manufacturing underground vehicles of this type. They were also retained to act as engineering consultants during the design phase and participate in the design review meetings.

The machine's frame structure was designed and fabricated to its own individual design. It was not made using the frame of an existing machine. See Figure 4-1. Photographs of the completed vehicle are shown in Figures 4-2, -3, -4, -5, -6.

The machine as built by West Virginia Armature Company had the following specifications:

Tracor MBA

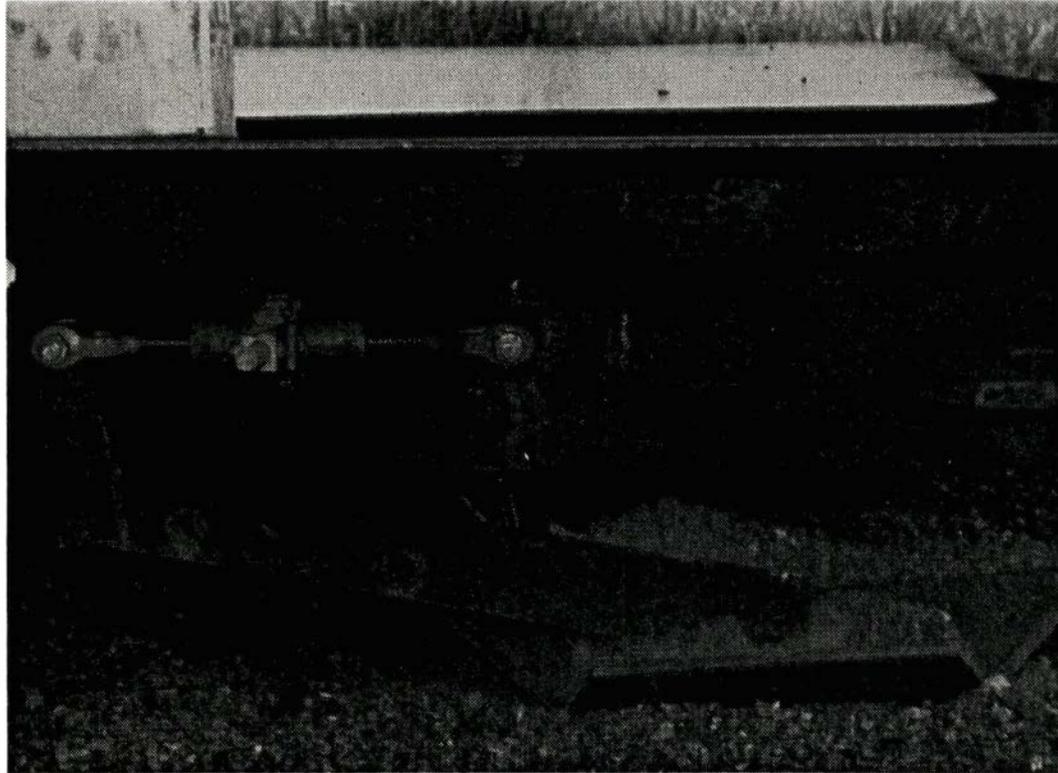


FIGURE 3-5
TAIL SECTION LEVELING SKID

Tracor MBA

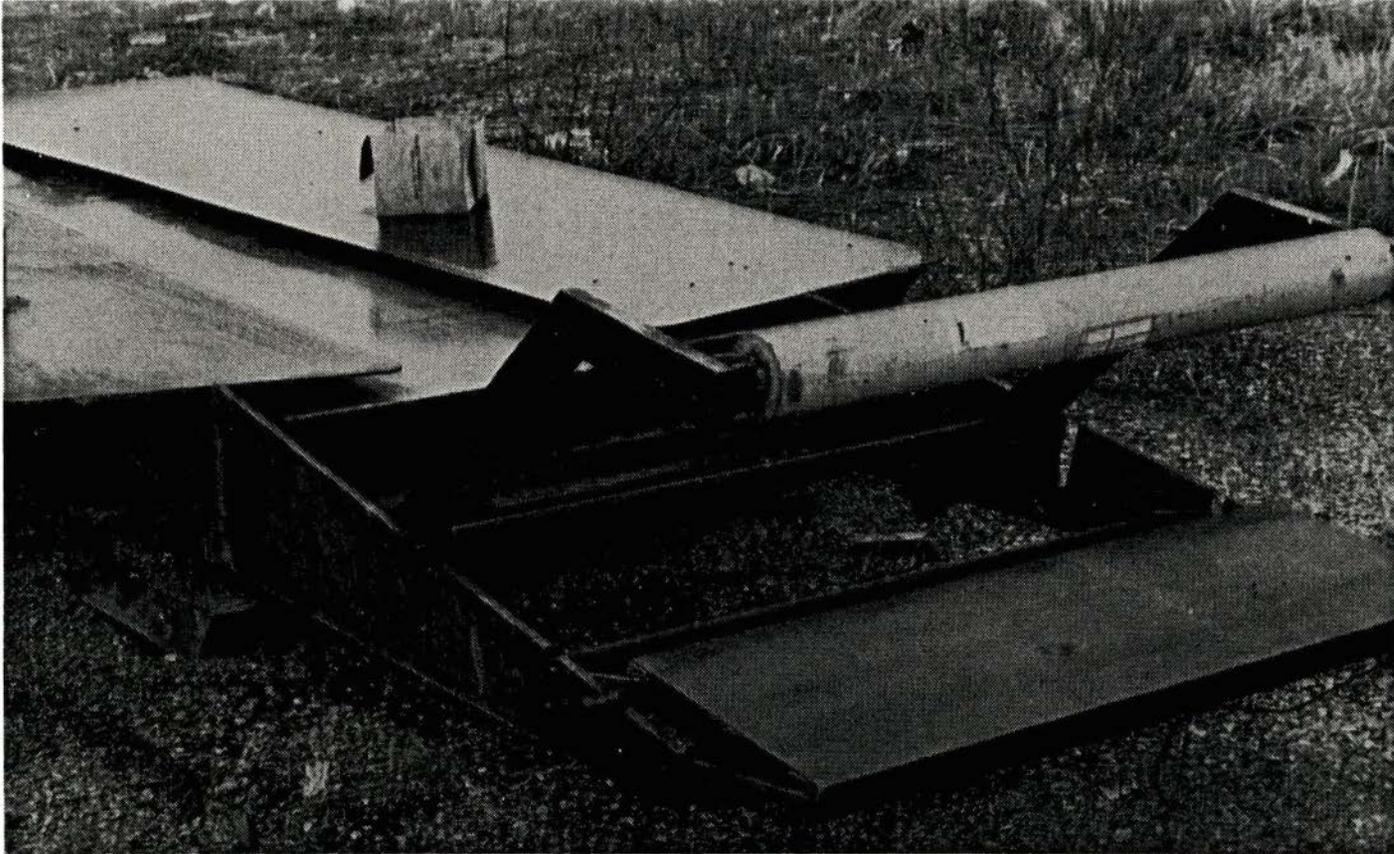


FIGURE 3-6
WORK PLATFORM

Tracor MPA

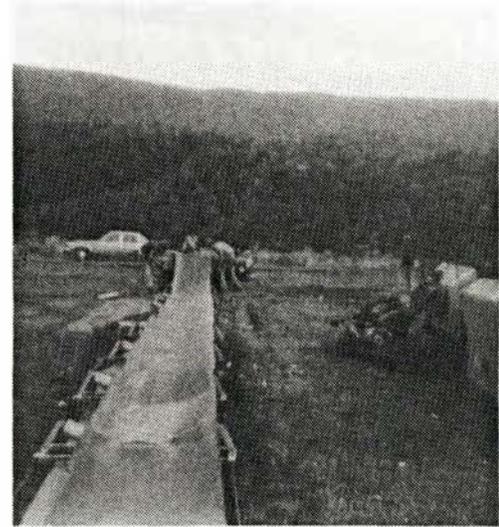
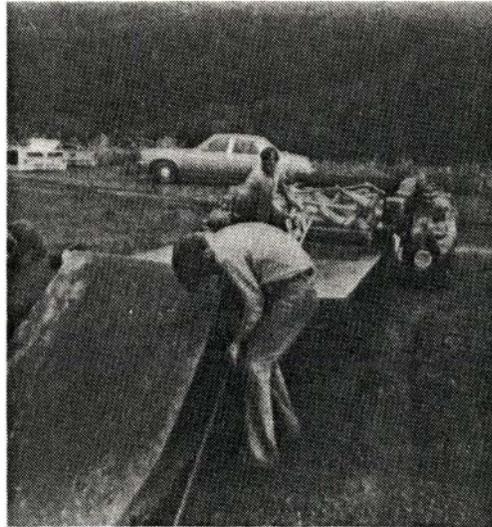
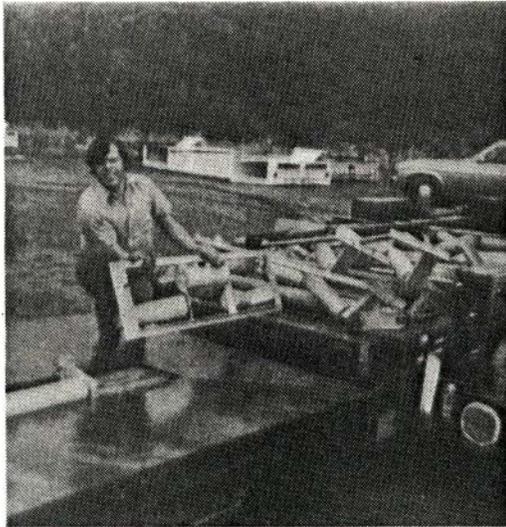


FIGURE 3-7
USE OF CBSM AND WORK TABLE ABOVE GROUND DEMONSTRATION

Tracor MBA

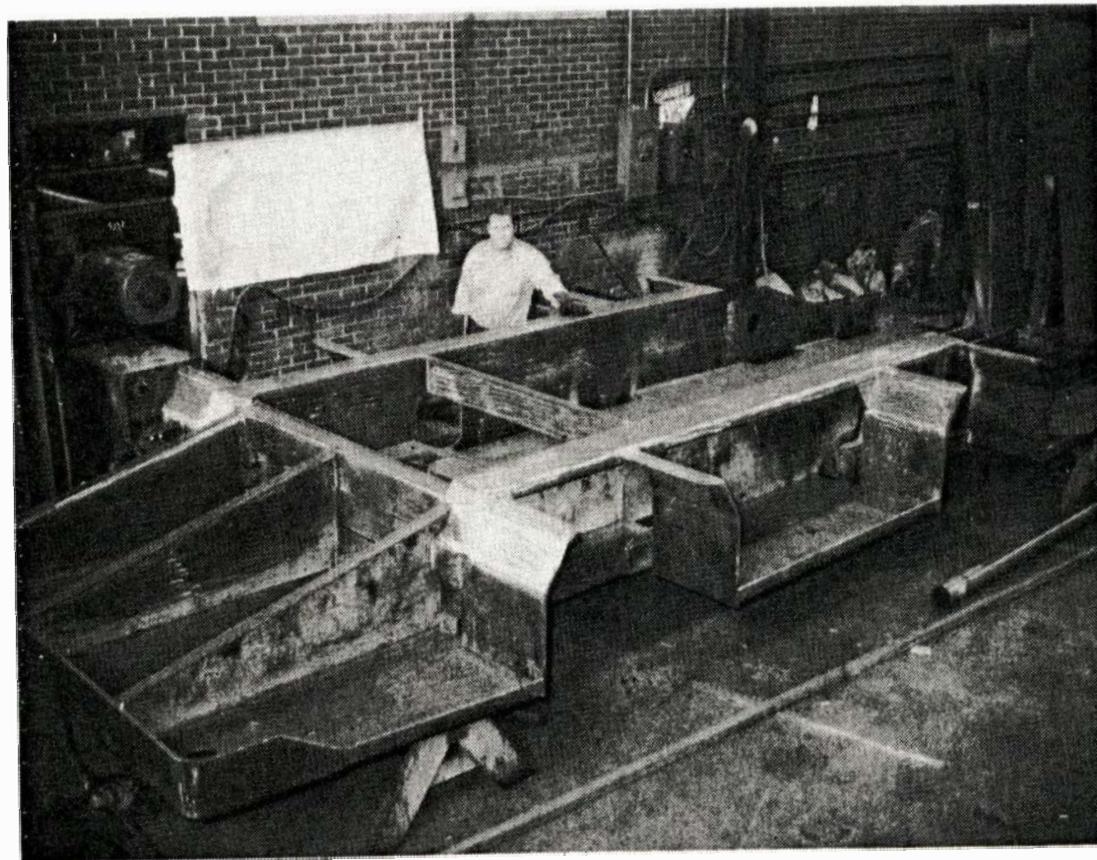
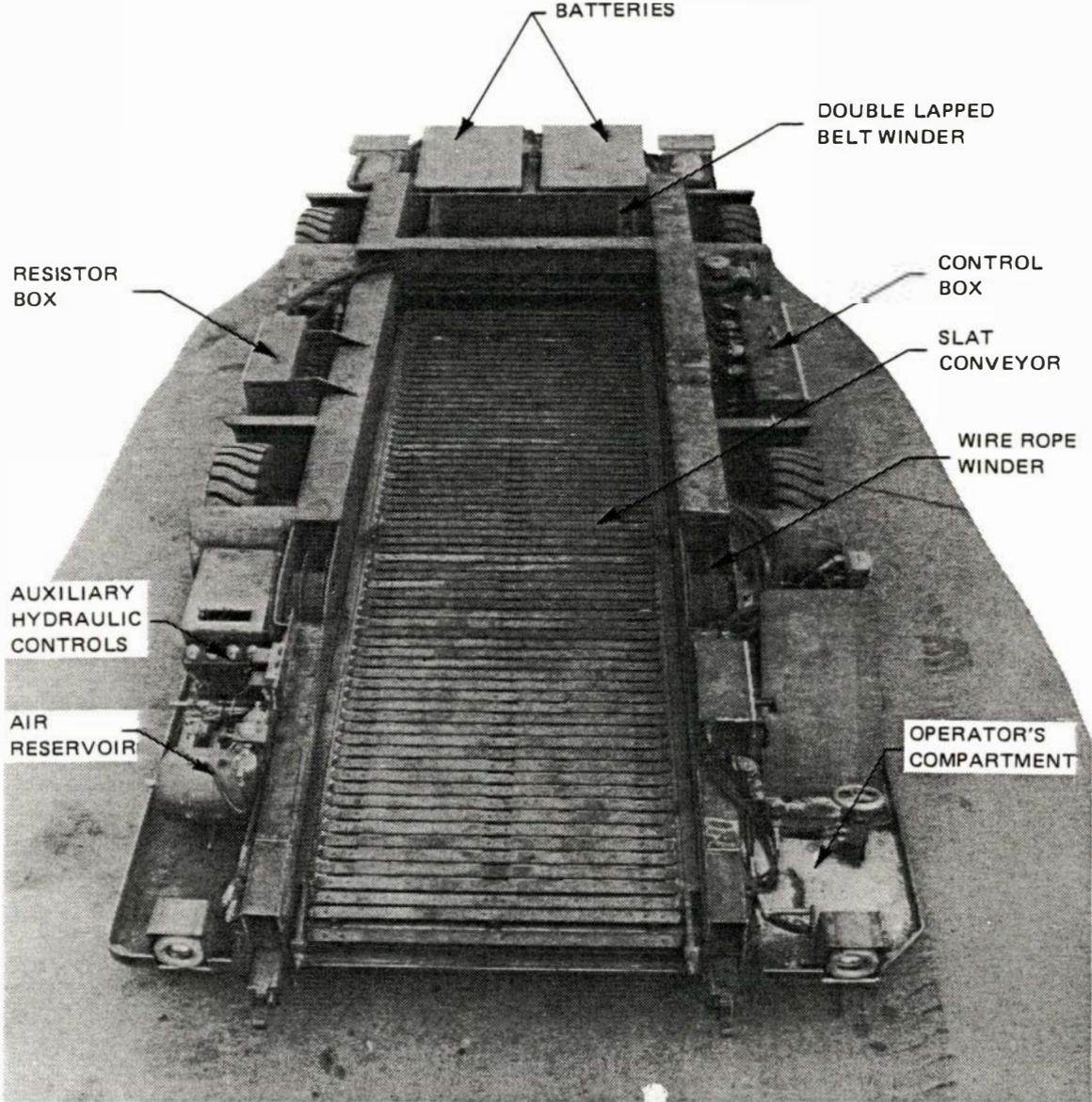


FIGURE 4-1
FRAME WELDMENT

Tracor MBA



TOP VIEW

FIGURE 4-2
CONVEYOR BELT SERVICE MACHINE

0398-16210

Tracor MBA

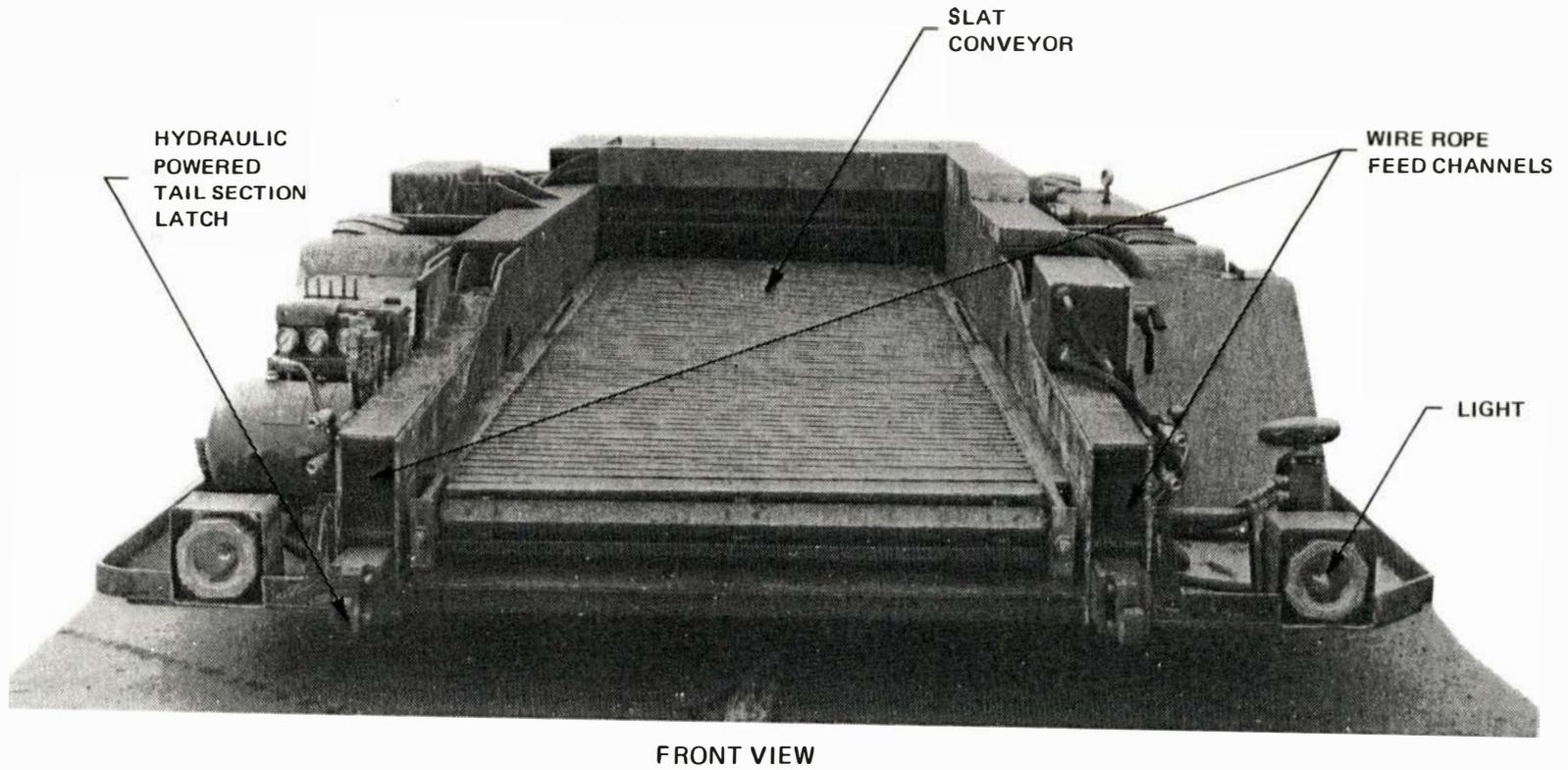
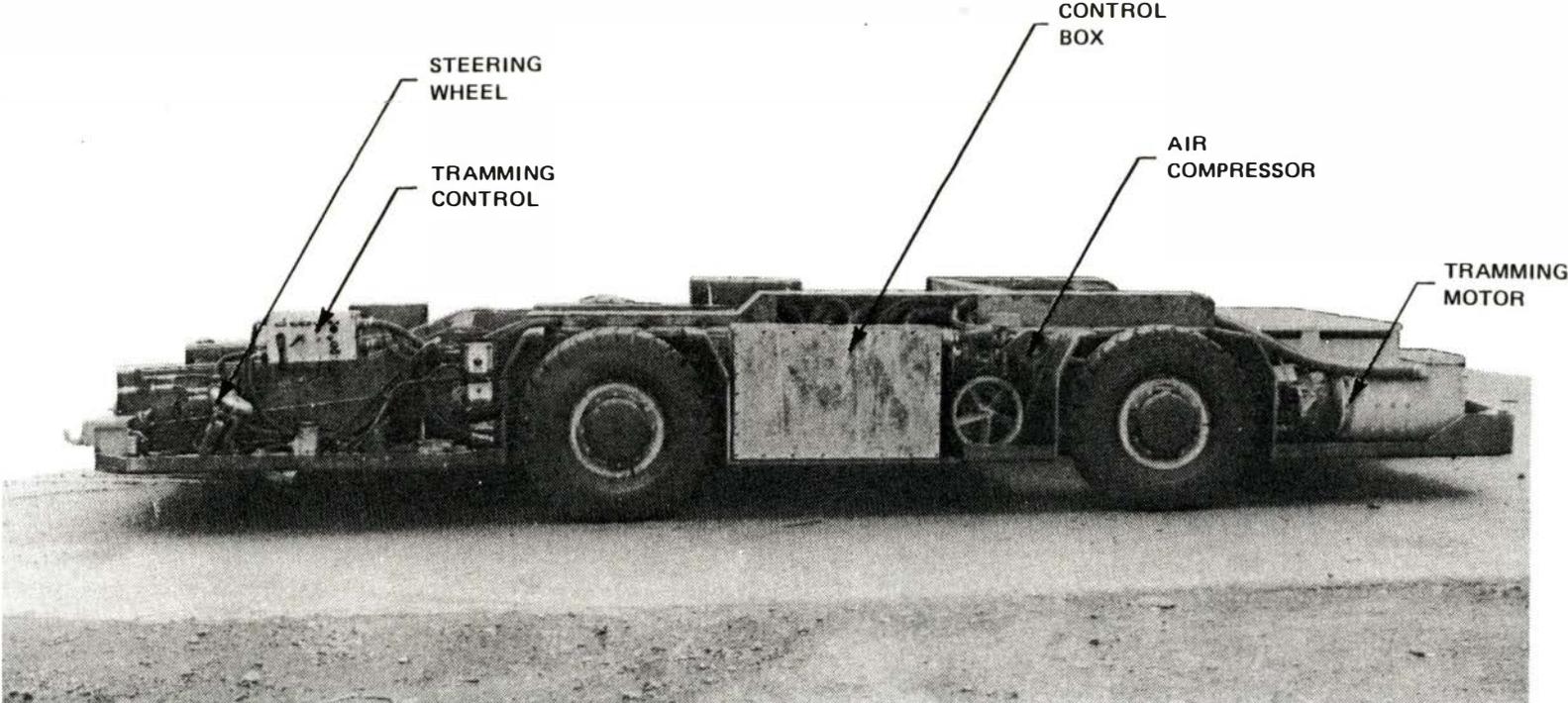


FIGURE 4-3
CONVEYOR BELT SERVICE MACHINE

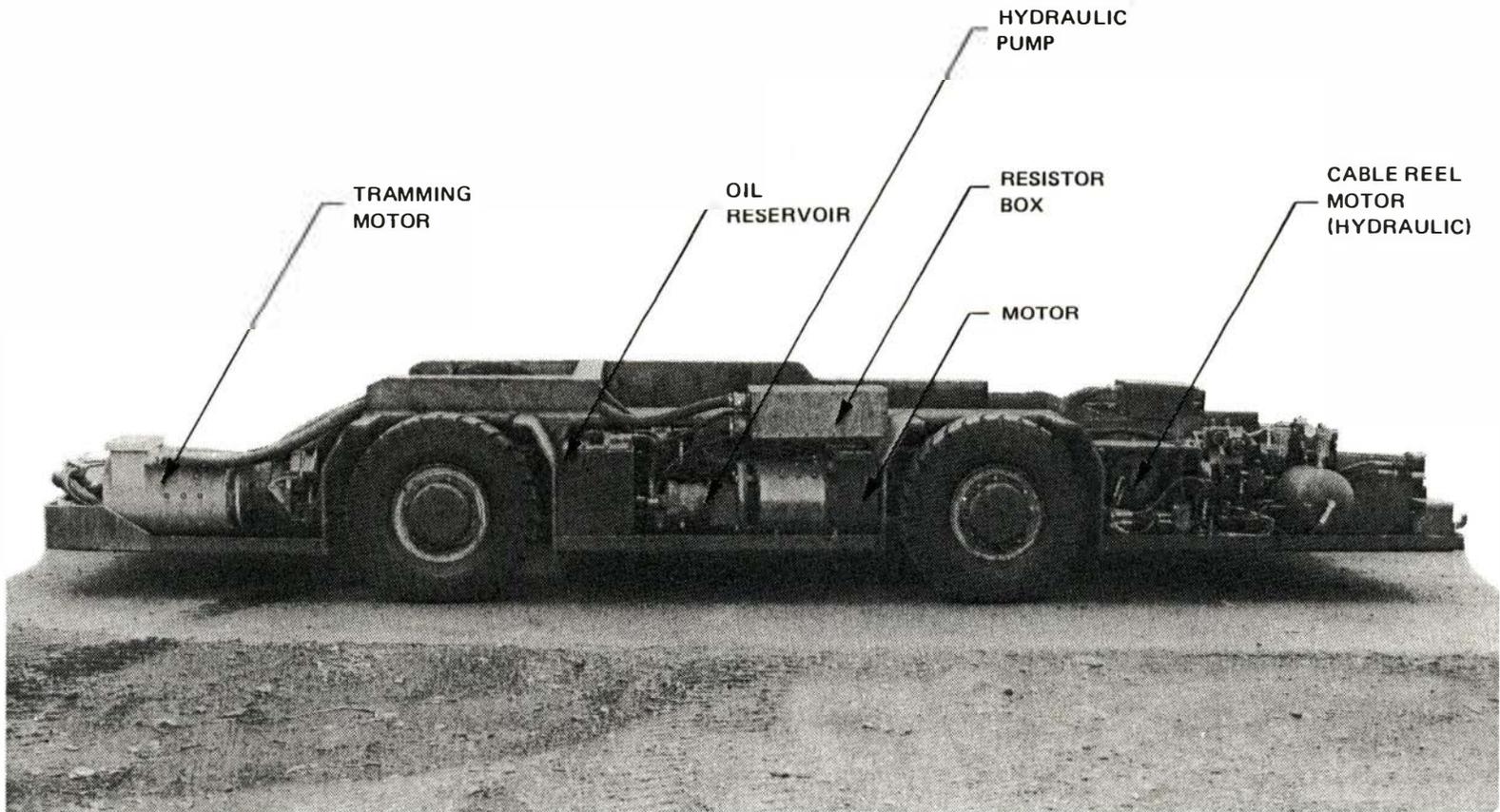
Tracor MBA



LEFT SIDE VIEW

FIGURE 4-4
CONVEYOR BELT SERVICE MACHINE

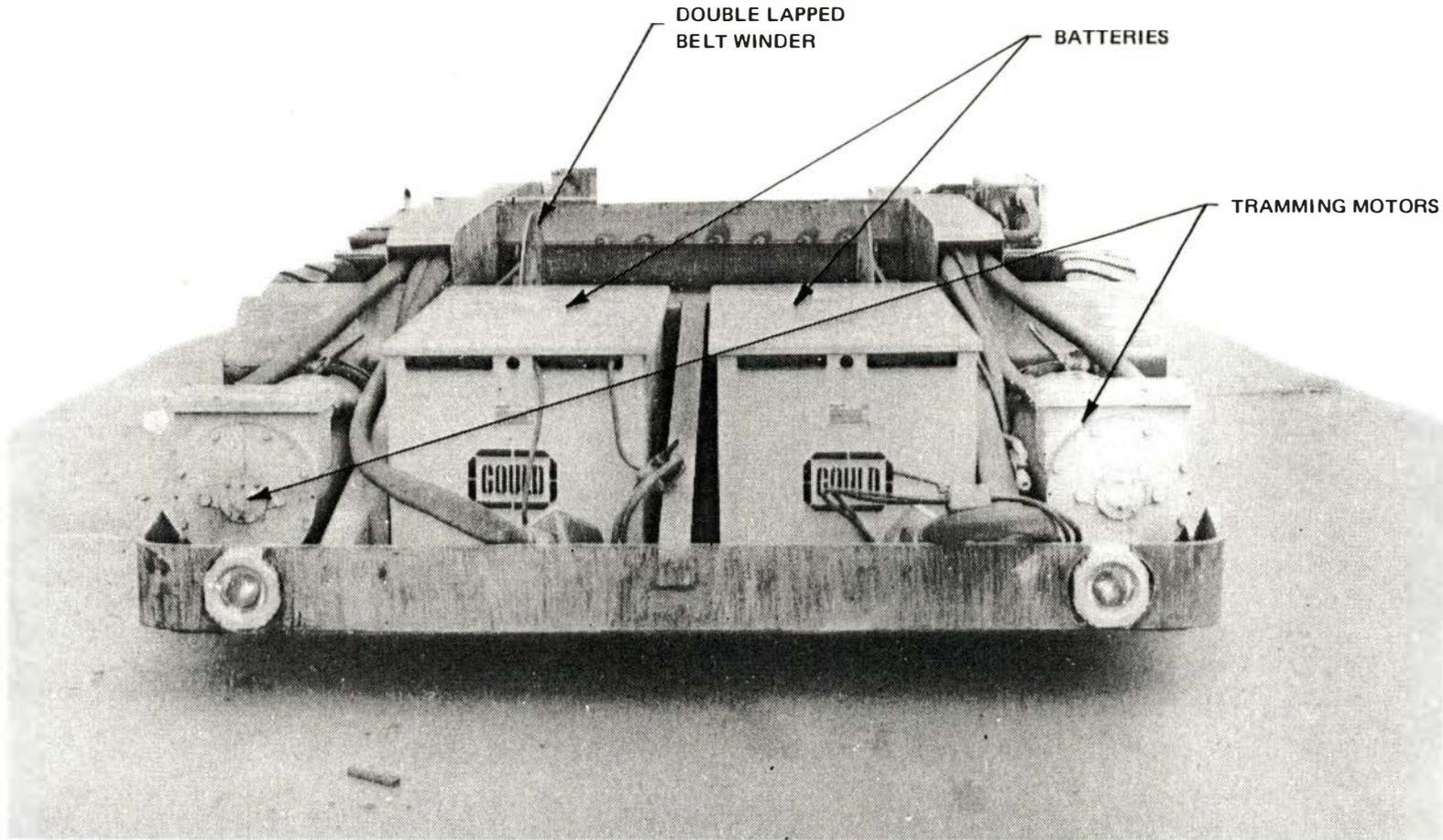
Tracor MBA



RIGHT SIDE VIEW

FIGURE 4-5
CONVEYOR BELT SERVICE MACHINE

Tracor MBA



REAR VIEW

FIGURE 4-6
CONVEYOR BELT SERVICE MACHINE

0398-16213

Main Frame, overall length	270.5 inches
Main Frame, overall width	121 inches
Wheelbase	104 inches
Battery end overhang	73 inches
Hitch end overhang	93.5 inches
Tire size	10.0 x 15
Estimated weight	28,000 lbs
Inside turning radius	9.5 feet
Outside turning radius	22.75 feet
Battery power	128V, 680 amp/hr.
Traction drive	(2) 30HP @ 1200 rpm 128V, Series wound
Traction drive gear box	One speed, 1.668:1 ratio
Braking	Built-In park brake and service brake
Wheel drive	4 required
Steering capability	$\pm 22.5^\circ$
Load carrying capacity	10,000 lbs. each wheel
Overall gear reduction	28.98:1
Traction drive controller	SCR, 1,000 amp, 2 motor with braking
Maximum drawbar capability	16,000 lbs. (equivalent to 50 percent fully loaded gradeability)
Ground speed at 2000 rpm	4.14 mph motor speed

Parking brake	50,000 ft/lbs. at wheel drives
Steering system	4-wheel, full power, hydraulic, closed center, non-load reaction
Drive Motor	20HP @ 1800 rpm, 128V, compound wound
Pump	20GPM at 1500 psi pressure compensated, variable displacement piston pump
Hydraulic Reservoir	17 gallons
Filter	10 micron, throw-away
<u>Air System</u>	
Drive	Hydraulic motor
Compressor	5HP, 2-stage, 100 psi, 20 CFM
Receiver	7.5 gallons
Operating range	80 to 100 psi
<u>Wire Rope Winders</u>	
Drive	Hydraulic motor
Maximum tension	6,000 lbs
Maximum winding speed	60 rpm
Type	Planetary gear reduction
<u>Double Lapped Belt Winder</u>	
Primary drive	Hydraulic motor
Gear reduction	Enclosed spur gear
Maximum speed	50 rpm

Maximum tension	1,400 lbs. at 1500 psi
Secondary drive	Hydraulic motor
Maximum speed	50 rpm
Maximum tension	2,000 lbs. at 1500 psi

Slat Conveyor

Drive	Hydraulic motors
Conveyor chain tension	6,000 lbs. @ 1500 psi
Maximum speed	20 rpm
Lift travel	6 inches
Lift	Hydraulic cylinder
Lift capacity	5,000 lbs at 1500 psi

Tail Section Hitch

Type	Hydraulic cylinder
Lift capability	2,000 lbs. per side @ 1500 psi
Lift control	Individual
Lift height	10 inches.

5.0 INITIAL TEST

The initial above ground tests were performed at West Virginia Armature's New River Manufacturing Plant to determine the functional ability of the machine's components. Conveyor belting, wire rope and belt support structures were used in simulating an actual sectional belt extension and retraction.

Lengthening the belt with relative ease and efficiency was demonstrated in the first above ground test when an untrained crew* was able to put 60 ft. of belt, rope and structure in place in six minutes. This was not a complete simulation since the starting point was taken with belt and wire rope connections made up and the tail section attached to the vehicle. Furthermore, this demonstration did not include the belt release and tail section tiedown that would be necessary in a full moveup operation. Even so, the ease and efficiency demonstrated in lengthening the belt were impressive considering the limited equipment and crew preparation provided.

Attempts to retract the belt section with equal ease and efficiency were not as successful. While the belt was successfully retracted, it took considerably more time than the extension operation. The problems observed were primarily due to the fact that more operator skill was required to control the takeup of the belt winder and wire rope reels than was required in the extension. Some indication of marginal takeup torque on the belt winder was also observed.

* Without mining experience and with only about 10 hours exposure to the belt extender.

The four-wheel drive, four-wheel steering capability combined with a very rugged chassis construction makes the basic vehicle system well qualified for underground service. It proved itself more than adequate in both power and precision during above-ground maneuvering tests with the full weight tail section rigidly attached.

The initial test could not be considered significant in terms of testing for durability underground. It was indicated that some of the auxiliary system components such as the air pressure controller might require replacement with more rugged models, however, the basic vehicle frame, power train and power system were considered to be equal to existing shuttle cars in durability.

Representatives from several underground mines were present at the initial demonstration. They had been invited to obtain their reactions and opinions regarding the need for equipment of this type and which improvements should be considered. While the reactions were varied on the equipment design (see typical comments below) general agreement seemed to be reached that there was a need for equipment development in this area. It was not possible (and not expected) to get complete agreement from the group on what improvements they would like to see since each mine has its own problems and constraints. Typical comments from the group are listed below in rough order of priority as assessed by Tracor MBA.

- o A good thing about this theory is if you had everything ready on this machine the belt can be moved without a plan. (If there is a mine equipment breakdown you can move this machine in and change the belt while the other breakdown is being repaired)
- o Must get underground to give it a test before any comments can be made
- o Must be able to tram from section to section or take it outside and load the equipment
- o Controls should be eliminated (or simplified) as much as possible
- o Controls should be placed where they are available to only one operator

6.0 SYSTEMS MODIFICATIONS

Additional above ground tests were made after the initial demonstration test to determine more accurately the extent of modifications that would be necessary before the underground demonstration.

The modifications deemed necessary and carried out were:

- o Increased the hydraulic power capacity by changing pumps.
- o Changed control valve system of the hydraulic power to the air compressor.
- o Revamped hydraulic hose circuits to reduce back pressure in return lines.
- o Re-designed and fabricated a work table that could be readily dismantled, reassembled, height adjusted and readily moved from one tail section to another.
- o Disassembled and rebuilt belt winder improving its windup capabilities.

7.0 SELECTION OF A TEST MINE

During the course of the contract several mines were selected and agreements reached for underground demonstrations. The mine where the first underground demonstration took place was the No. 9 mine of ARMCO's Robin Hood Division.

The test was not carried out in either of the three mines selected earlier due to several factors which altered the conditions to the extent they would not be favorable for the demonstration. Two of the mines had management changes (change in ownership) which resulted in cancellation of the original agreement. In another mine, the development changed from down and up dip to across dip. The sloping hard smooth floor was not ideal for a rubber tired vehicle to maintain footing with a straight line tension effort.

ARMCO's Robin Hood Division manager Mr. Bill Dulin was greatly interested in the possibilities of the service machine and most cooperative.

The ARMCO mines utilized 160 foot sections of sectional conveyor belts (two cross cuts 80 feet each) but Mr. Dulin agreed to accommodate the machine's design and make 80 foot moves for the demonstration tests. However, the management of this division also changed, resulting in a change in demonstration plans.

Thus the first underground demonstration test was performed making a 160 foot retraction move. The new management also had development and production scheduling plans that would not accommodate any further underground demonstration testing thus further arrangements were made to perform additional underground demonstration tests at Big Mountain Coal Mine which is also an ARMCO mine.

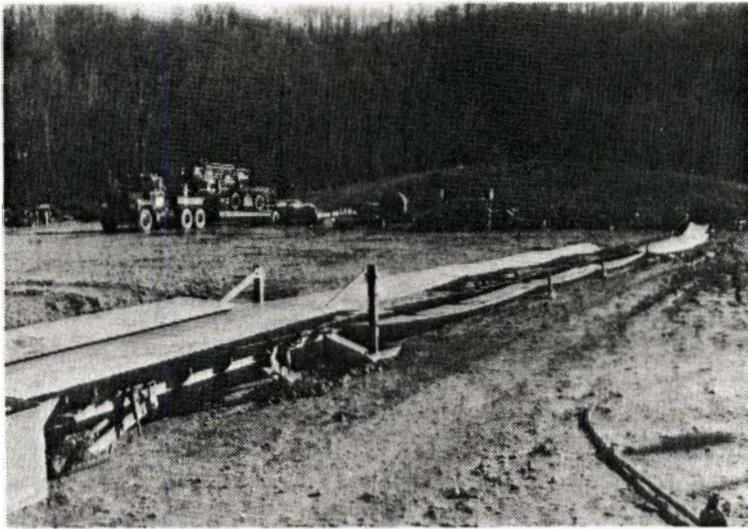
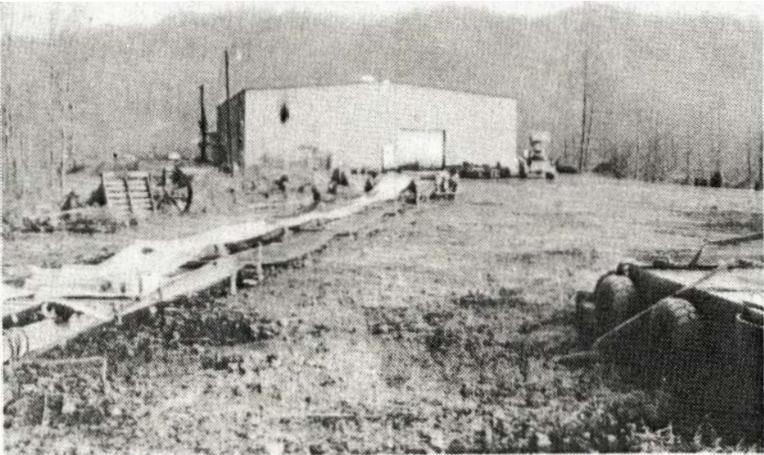
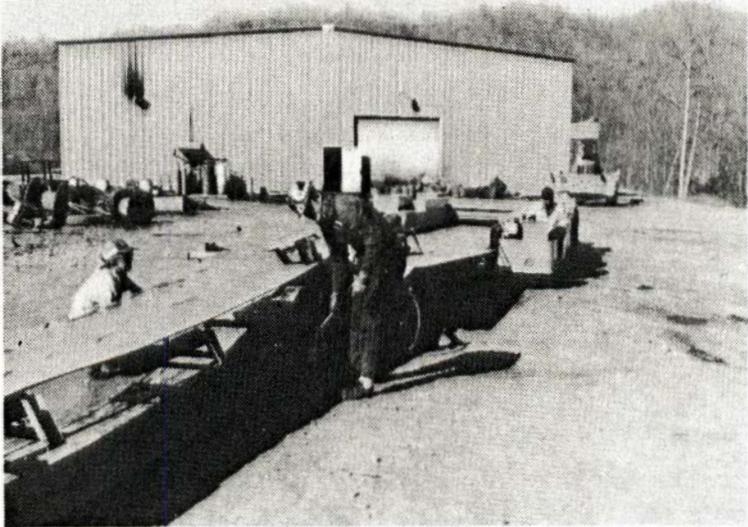
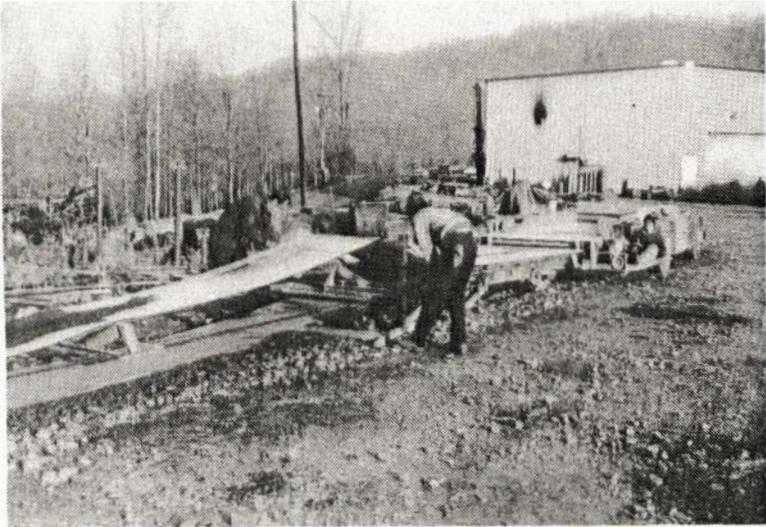
8.0 ABOVE GROUND DEMONSTRATION

When the Service Machine was deemed ready for an underground demonstration, an above ground demonstration was performed for selected mine officials from the #9 Robin Hood mine, where the underground demonstration test was to take place. The mine officials attending the above ground demonstration were:

- o Tony Basko, industrial engineer
- o Steve Richards, safety supervisor, ARMCO Robin Hood Mines
- o Bill Miller, day shift foreman, ARMCO Robin Hood #9 Mine

The demonstration consisted of displaying the unloaded machine in the shop and explaining all the components and their functions. The machine was then loaded with belting, cables and structures and an 80 foot extension made. See Figure 8-1. The machine performed well and the men were impressed with the capabilities of the machine and intrigued with its possibilities. However, they made several suggestions and pointed out several changes that must be made before the machine could be taken underground for demonstration.

Tracor MBA



**FIGURE 8-1
ABOVE GROUND DEMONSTRATION - SOUTHERN EQUIPMENT COMPANY**

9.0 MODIFICATIONS TO ACCOMMODATE DEMONSTRATION MINE

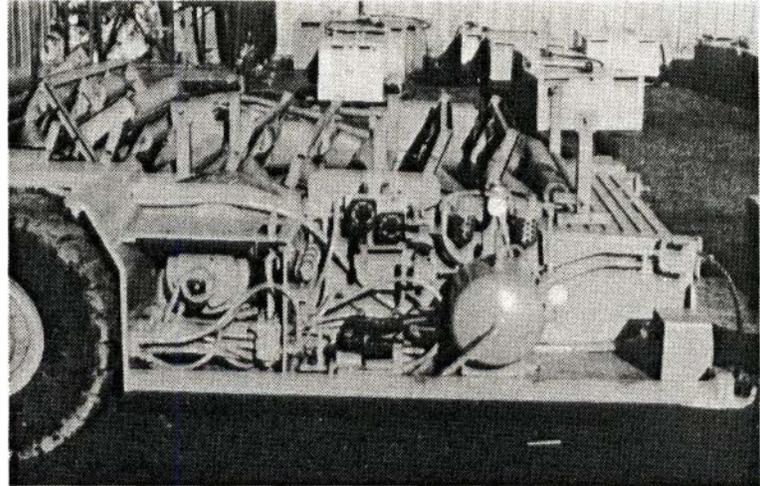
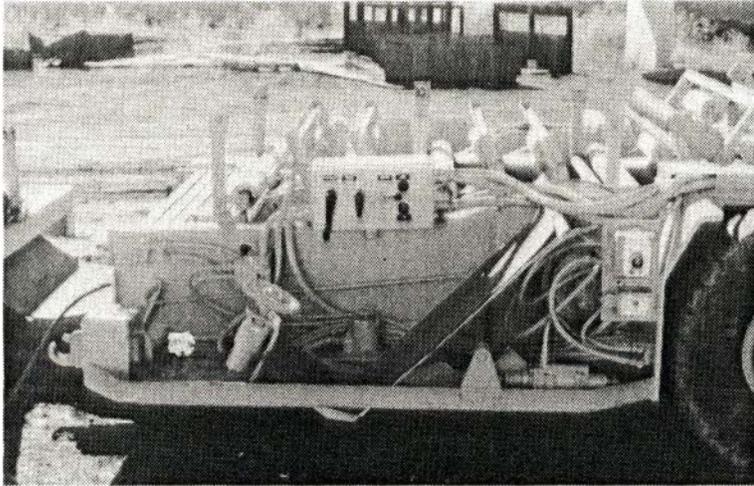
It was suggested that bumper protection be installed for the preservation of the batteries and that a hydraulic take off provision be made for the operation of a hydraulic drill. It was also pointed out that several modifications had to be made before the machine could be taken into the ARMCO mine, in order to comply with the mine's safety requirements and the state of West Virginia's new safety regulations. These were:

- o Lock devices for the battery connectors
- o Covers for the cable reels
- o A seat and compartment for the hydraulic control operator
- o Dual seats and controls for the vehicle driver
- o Panic bars for both driver and hydraulic control operator to shut off both tramping and hydraulic functions.
- o A low battery indicator

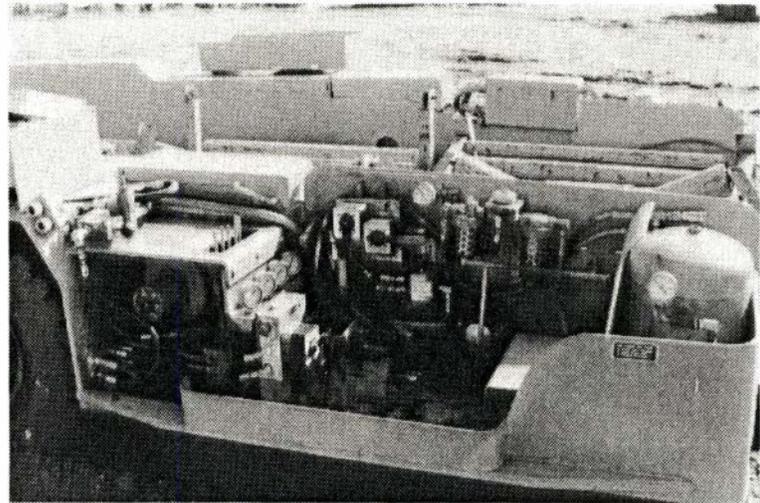
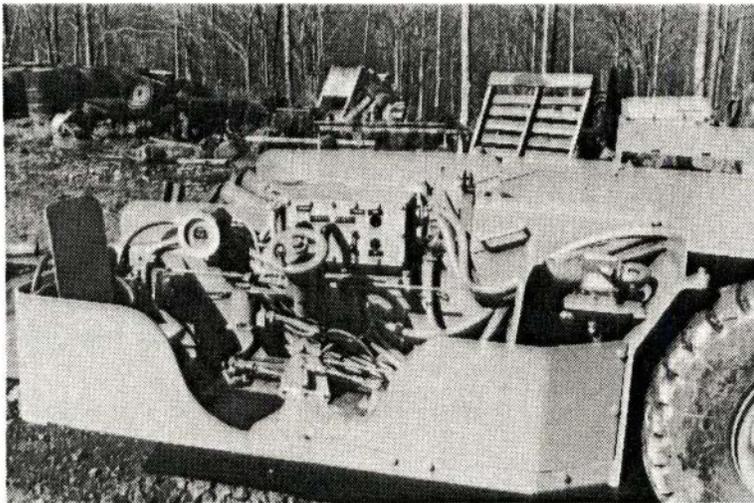
Figures 9-1 and 9-2 are photographs displaying the specific modifications.

In addition, to avoid welding on the tail section for the first underground demonstration, bolt-on attachment arms were designed and fabricated to attach the service machine to the tail section. Their handles connect to the hitches of the service machine and the clamp end attaches to the channel iron legs of the tail section. Figure 9-3 is a series of photographs showing the arm and its application.

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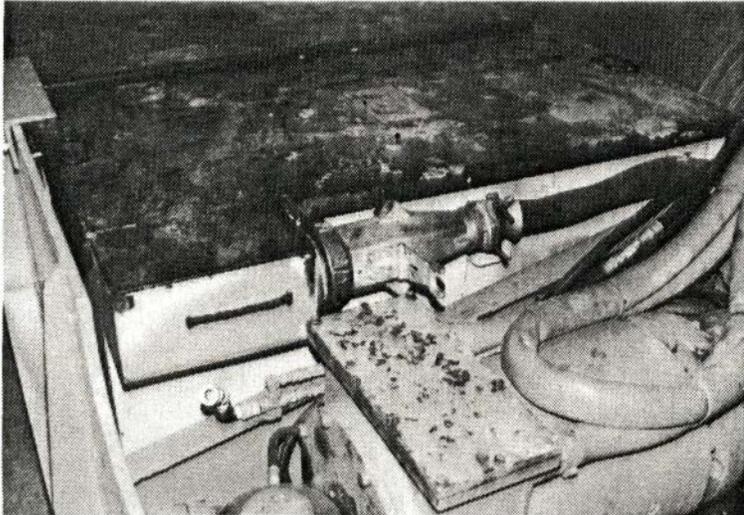
BEFORE REVISIONS



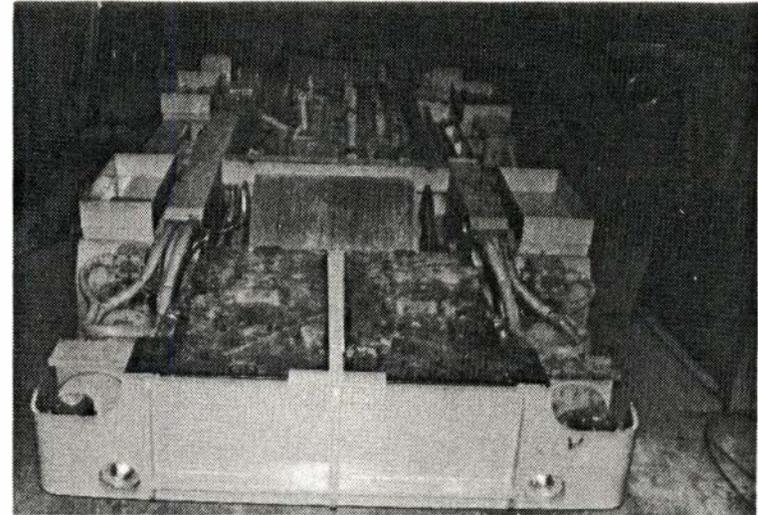
AFTER REVISIONS

FIGURE 9-1
OPERATOR COMPARTMENTS

Tracor MBA



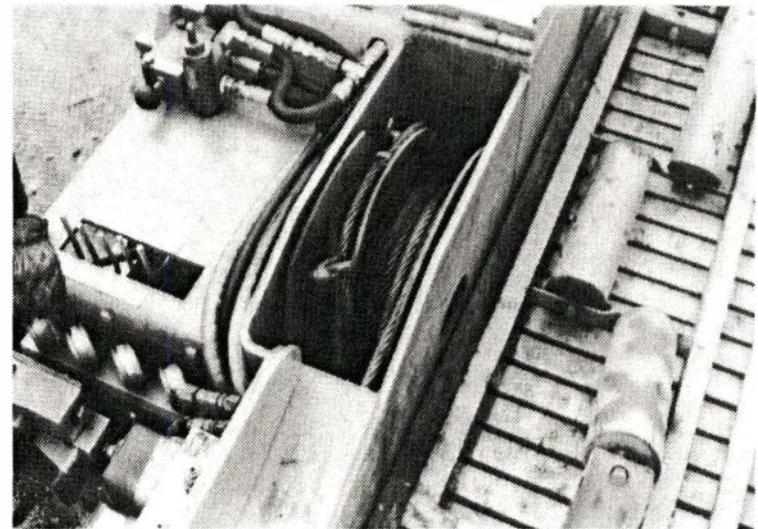
ELECTRICAL CONNECTOR LOCK OPEN



BATTERY PROTECTOR



ELECTRICAL CONNECTOR LOCK CLOSED



HYDRAULIC TAKE-OFF

FIGURE 9-2
MACHINE REVISIONS

Tracor MBA

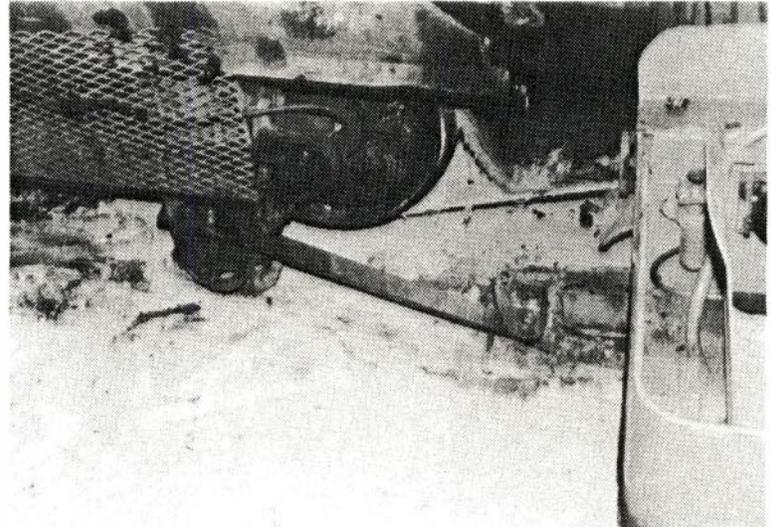
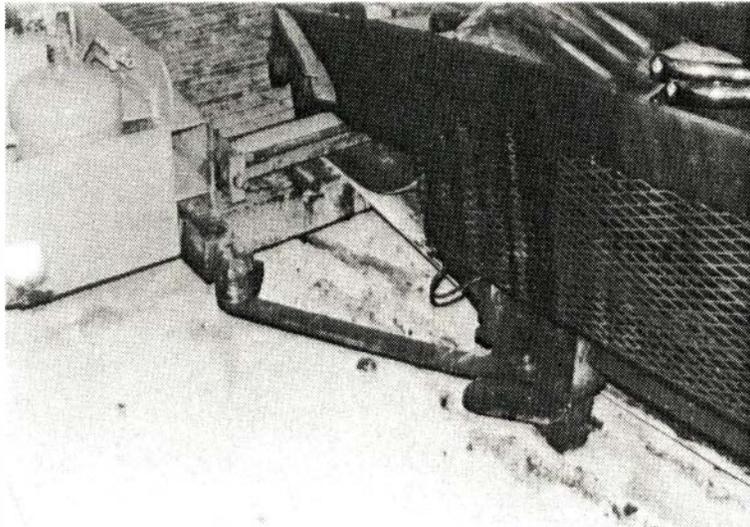
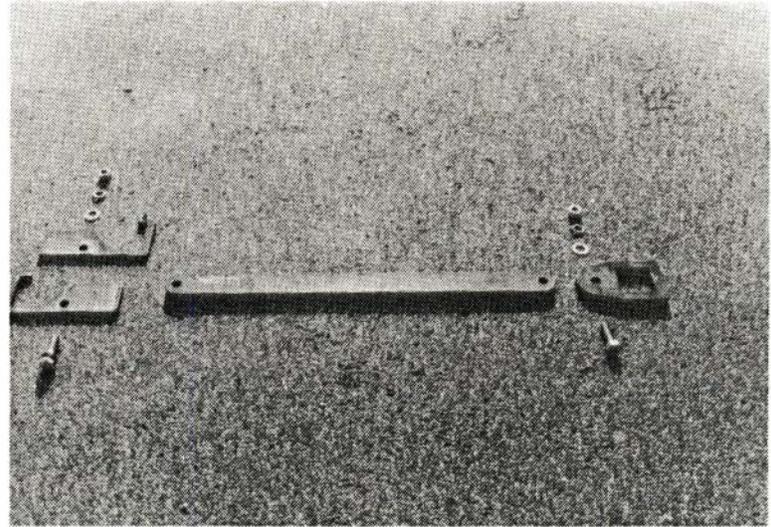
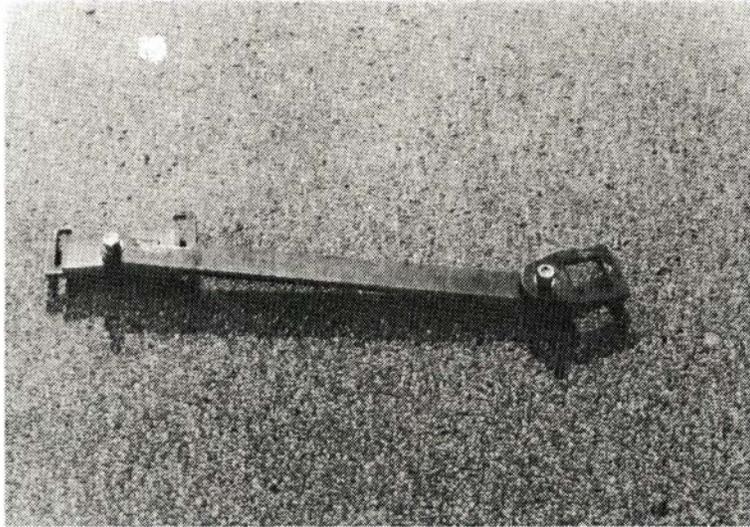


FIGURE 9-3
ATTACHMENT ARMS

Tracor MBA



PHOTO A



PHOTO B

- PHOTO A - MACHINE WITH BELT LOADED
- PHOTO B - MACHINE LOADED WITH BELT AND SOME STRUCTURES
- PHOTO C - MACHINE FULLY LOADED

PHOTO C

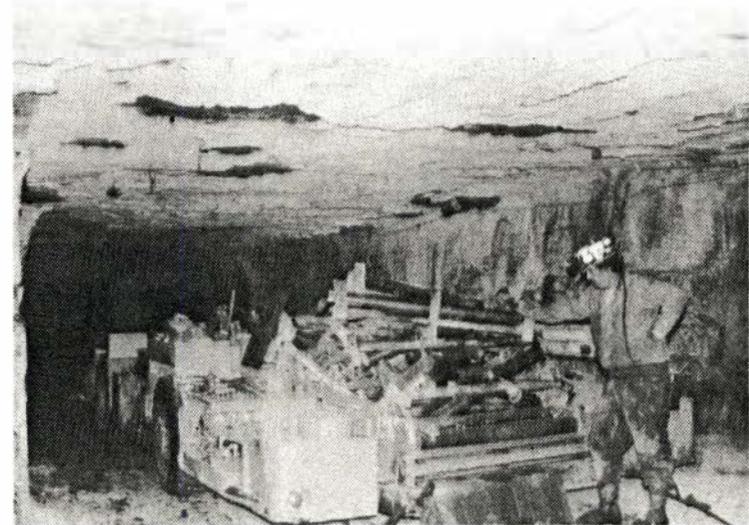


FIGURE 10-1
INITIAL UNDERGROUND TESTING

10.0 UNDERGROUND DEMONSTRATIONS

10.1 ARMCO's Robin Hood Mine

The underground demonstration was performed on March 17, 1981 at ARMCO's Robin Hood Division No. 9 mine at Twilight, West Virginia.

Tracor MBA engineers, J.L. Eirls and D.C. McHuron accompanied the machine, provided the task training to the ARMCO man who was to drive the machine, operated the hydraulic controls and provided instruction and assistance as needed for the on-the-job training in the use of the service machine for the belt move.

The belt move was a 160 foot sectional conveyor belt retraction. There were no changes made in the mine's normal belt move procedures to accommodate the service machine. The machine was used to replace the use of the scoop that was normally used to move the tail section. The service machine was also used to wind up the 320 feet of 1/4" thick 36" wide conveyor belting and transport it along with the belts's structural supports and wire rope, sail anchors and auxiliary material to the storage area two sections further in the mine.

The belt retraction was a challenging assignment for the service machine as this belt move was a normally scheduled belt move that could not be delayed without affecting production.

The service machine performed its assignment exceptionally well and impressed the belt crew with its manoeuvrability, power, and ease of handling the belting and structures. Figure 10-1 is several photographs taken during the belt move.

However, the mine's new management had established a development and production plant that would not accommodate any underground demonstration testing of new equipment, thus the CBSM was moved to ARMCO's Big Mountain Coal Co.'s mine in Prenter, West Virginia for the continued demonstration test.

10.2 Big Mountain Coal Co.

The next demonstration was performed at Big Mountain Coal Co. where the seam was relatively thick varying from 8 to 12 feet or more. In the thinner sections the plan was to use the CBSM as designed except for alteration of the work table so it could be extended to a 4 to 5 ft table height and increasing the capacity of the wire rope winches for 120 ft moves. In addition the operation of the belt winder was improved by the installation of a semi-automatic locking device to hold the drum in a set position while pulling in the belt to the drum with the lead wire rope and when discharging the last portion of the belt (see Figures F and G, page 114). The lead wire rope follower was redesigned to improve its function of preventing wire rope cross-over or overlapping on the sheave.

The procedure to load or unload belt using the new locking device on the belt drum is as follows: When the belt hook is attached to the belt and in front of the machine, the belt reel drum must be held in a specific position as the lead cable pulls the belt into the machine and to the belt reel. This is accomplished by the belt reel lock. As the belt clamp reaches the center of the belt reel, the belt reel drum must be allowed to rotate. This is accomplished by lowering the slat conveyor which releases the belt reel drum latch. The belt is then wound on the drum using both the left and right hydraulic drive motors. In an extension or discharging the belt, the slat conveyor is raised just prior to the completion of the last revolution of the belt reel drum before the belt hook separates

from the belt reel. This places the latch in the spring loaded locking position which engages the lug at the proper position on the drum. During the discharging of the belt, both hydraulic drive motors are operating providing the assistance needed to turn the belt reel drum to the proper position. When the latch engages the lug on the belt reel drum, the hydraulic motors are turned off and the belt completely discharged by continuing to move the machine in the reverse direction, or in-by.

10.2.1 First Conveyor Belt Extension

The machine was first loaded with the belting that was to be used in the extension. The belt was stored on two pallets in a folded position. The operation consisted of connecting the belt hook to the mid point of the belt and pulling the belt into the machine and winding it on the belt drum using the hydraulic power system. Two men helped straighten the belt as it came off the pallets as the stacks of belting were 180^o out of phase with each other. They also guided the belt so that it entered the center of the machine and wound evenly on the belt drum. The belt was completely loaded in about 20 minutes, with the hydraulic power more than sufficient. The foreman had earlier expressed his concern that the belt loading operation would be time consuming taking about 2 hours in his estimation.

The machine was then trammed to another section to obtain the belt structures which were then taken to the section scheduled for the belt move.

The extension operation the following evening was in an area where the belt was to be hung approximately 6 feet from the floor, thus it was not possible to use the work table. The machine was used only to move the tail section and layout the belt. Part way through the move the CBSM had difficulty moving through a bad section

of floor until the hole was filled with three 6 x 6 timbers. During this time the traction motors overloaded and a 400 amp main fuse was blown. After the tail section and belt were in position, the structures were installed and the CBSM's hydraulic take-off was used to operate a hydraulic drill to drill anchor pin holes.

Even without being able to utilize the full capabilities of the machine the miners and foreman were impressed with how well the machine performed under adverse conditions.

10.2.2 Second Belt Extension

In preparing for the second belt extension two miners were trained to operate the machine by loading a belt on the machine and using the CBSM to reposition another tail piece in another section of the mine. The belt had to be retrieved from a dismantled belt line. This consisted on first pulling the belt into an adjacent entry and then winding the belt on the machine's drum. The miners were impressed with the power and maneuverability of the CBSM and admitted that the operation was much easier than using a scoop to retrieve the belt and move it to its new location.

The actual belt extension was made at a later date when Tracor MBA representative was not present. Also, the miners trained to operate the machine were not available. As might be expected trouble did develop and Tracor MBA was informed the machine became inoperative.

Investigation disclosed that the machine could not be started because of an electrical fault, that the belt had been discharged from the drum, that a steering drag link had been broken and rewelded, and that a steering linkage pin had been sheared. Details as to the use of the machine and the actual breakdown were not obtainable. The steering linkage was temporarily repaired and the machine trammed out of the mine where proper repairs could be made.

10.2.4 Repair of CBSM

To repair the steering linkage it was necessary to cut access doors in the frame in order to be able to reach the critical positions of the steering linkage. Photographs of these access doors are presented in Figure 10-2. The linkage and pins were redesigned to provide greater strength and the drag links were rebuilt.

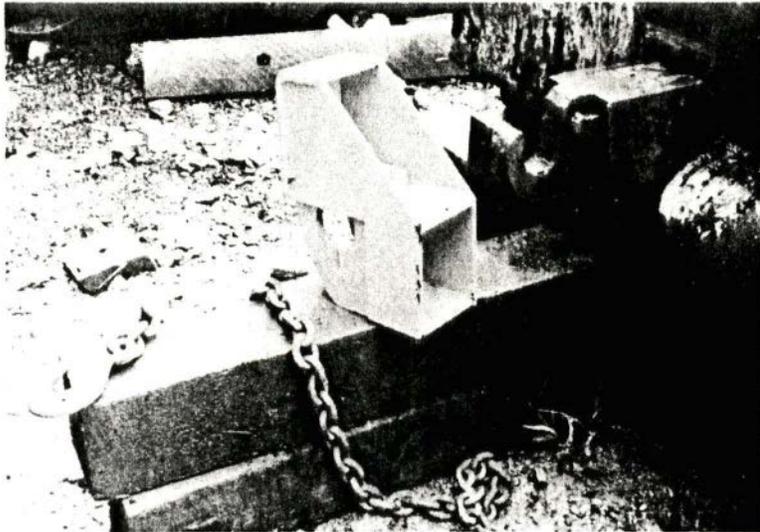
Also during this repair period hitch adaptors were designed and fabricated to replace the attachment arms that had not functioned well under a high pushing stress. The hitch adaptors shown in Figure 10-2 slip over the hitch hooks and are locked in place by means of the chains and locking pins. The chains have open locks on one end and are used to pull the tail section. The flat faces on the adaptors push against the tail section when moving the tail section out-by.

To eliminate the down time experienced to replace blown main line fuses a circuit breaker was installed in the main line to eliminate the protection fuses. This circuit breaker can be seen in a photograph of Figure 10-3.

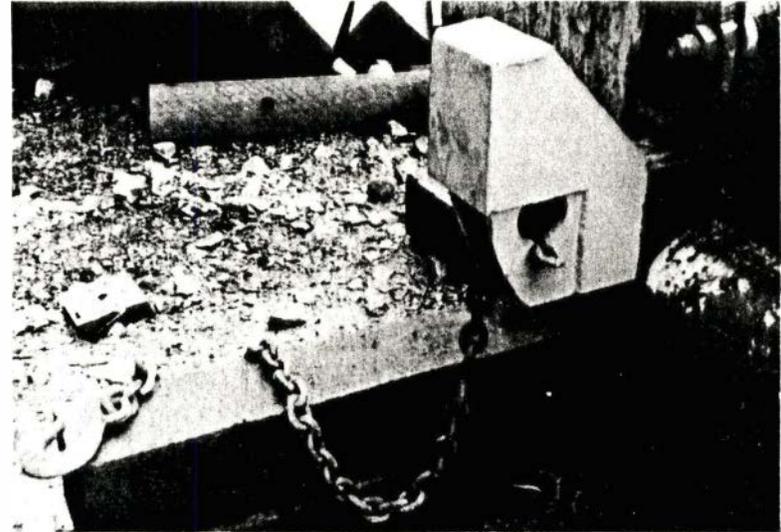
During this repair period a bridge for installing belt structure (BIBS) for use when installing roof suspended conveyor belts was designed and fabricated. The BIBS is a substitute for the work table and can be used with or without the CBSM. A description of the BIBS is presented later in this report.

Also, during this time ARMCO indefinitely suspended the coal production operation at Big Mountain Coal. Thus, steps were taken to move the CBSM to another test mine for the continued demonstrations.

Tracor MBA



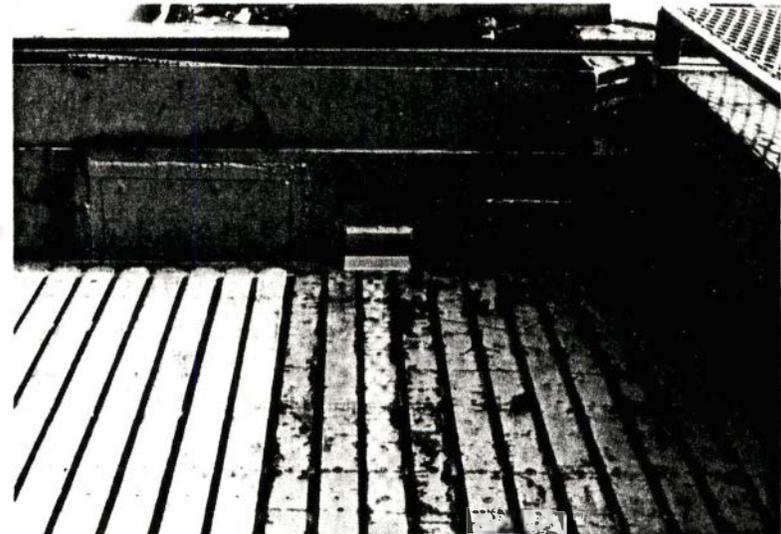
HITCH ADAPTER PARTS



HITCH ADAPTER ASSEMBLY



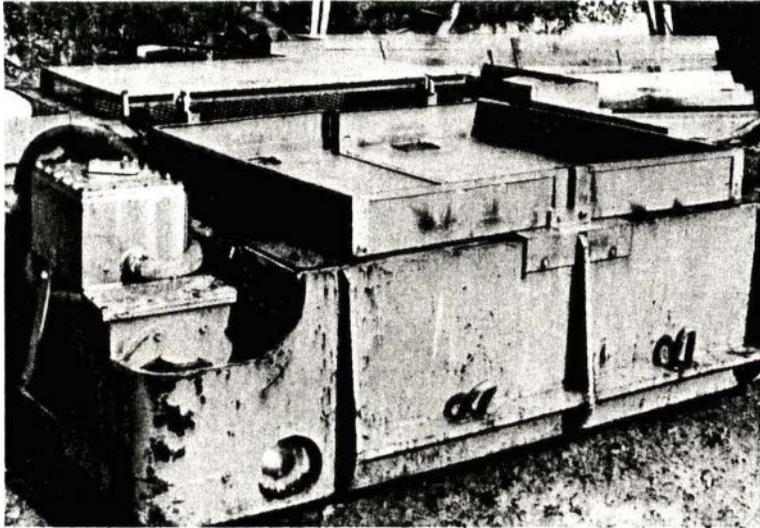
LEFT ACCESS DOOR TO STEERING LINKAGE



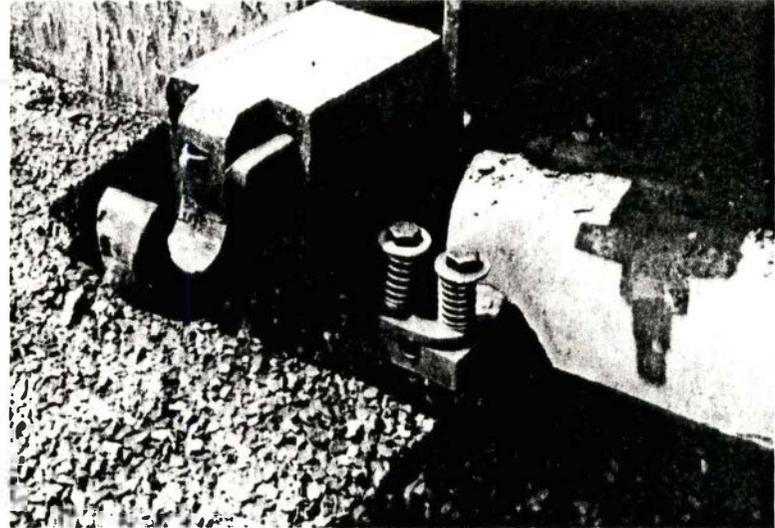
RIGHT ACCESS DOOR TO STEERING LINKAGE

FIGURE 10-2
MODIFICATIONS

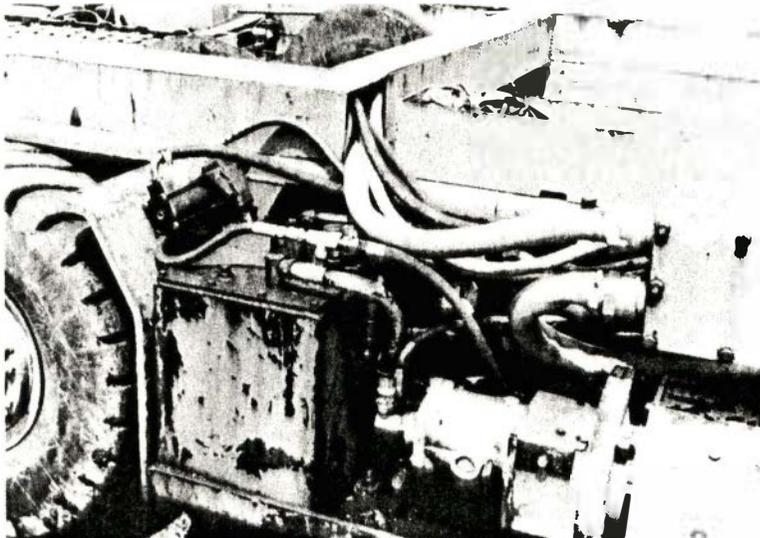
Tracor M6A



BATTERY PROTECTION & CIRCUIT BREAKER



WIRE ROPE FRICTION PULL



HYDRAULIC PUMP'S SOLENOID VALVE



WHEEL COVER

FIGURE 10-3
MODIFICATIONS

Dr. Richard A. Wolfe, Vice President of Research and Development for United Coal Company became interested in the CBSM and agreed to provide a mine in which to continue the demonstration testing and provide assistance if needed. The mine selected was one of UCC's contract mines located in Kentucky. One of UCC's R & D project managers, Geoff Blackmore, was selected as the technical representative for Tracor MBA and trained to operate the CBSM.

The demonstration mine was relatively thin seam coal varying from approximately 42 to 60 inches with good floor and roof. Belt extensions were two entries or approximately 120 feet. The mine does not cut wire rope for each 125 foot extension, but uses a full 500 foot length which is looped around each extension anchor. This required friction guides on the front of the CBSM as the rope winders could not be used except for final tensioning. In Figure 10-3 is a photograph of the wire rope friction guide.

Additional changes were made in the CBSM because of the restricted head room. The wheel cover boxes were removed and rubber fenders installed over the front wheels. The cover platform over the belt winder was also removed. The operator seats were lowered and the hinge pins on the wire rope winch covers altered so they could be removed readily in restricted head room areas.

In order to eliminate the need to open hydraulic valves when starting the CBSM to minimize the load on the hydraulic pump's electric motor, an electric solenoid was installed to provide an automatic hydraulic oil by-pass circuit during the four second start up period. The solenoid valve is shown in Figure 10-3.

10.3.1

Demonstration Tests at UCC Contract Mine

A series of five belt extensions were conducted using the CBSM. Each was with new inexperienced crews except for the representatives of Tracor MBA and UCC who were present at each belt move to perform the on-the-job training in the use of the CBSM. They also assisted in the operation of the machine when there was a crew shortage. At least one of the representatives was present at each belt move and both were present for most of the demonstrations.

Prior to the first demonstration at this mine one of their normal belt extensions was observed to determine an operational procedure for the CBSM that would require the least amount of deviation from normal belt extension procedure. Photographs of this observed belt extension are shown in Figures 10-4 and 10-5. Note the effort required to lift the belt for the insertion of the belt structures shown in Figure 10-5.

The CBSM performed well during the five belt extensions with no major mechanical failures. Even using men not familiar with the machine on each move the total time required reduced from four hours for the first extension to three hours for the fifth extension. All belt extensions were 120 feet. The time to install the belt structures was only 15 minutes on the fifth extension.

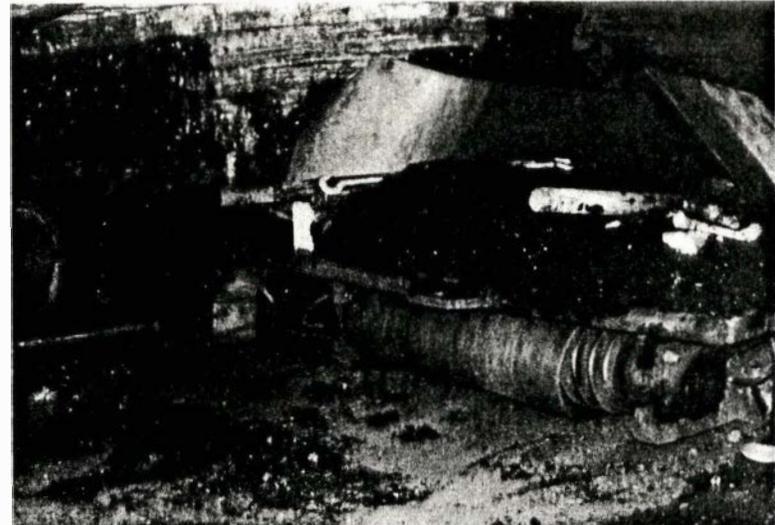
Changes were made in the operational procedure for each succeeding belt extension in order to arrive at the most suitable application for this particular mine.

The first belt extension utilized the service machine as per its original concept installing all structures, wire rope and belting as the tail section was being moved to its new location and with the work table

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TAIL SECTION READY TO MOVE TO NEW POSITION



TAIL SECTION READY TO MOVE TO NEW POSITION



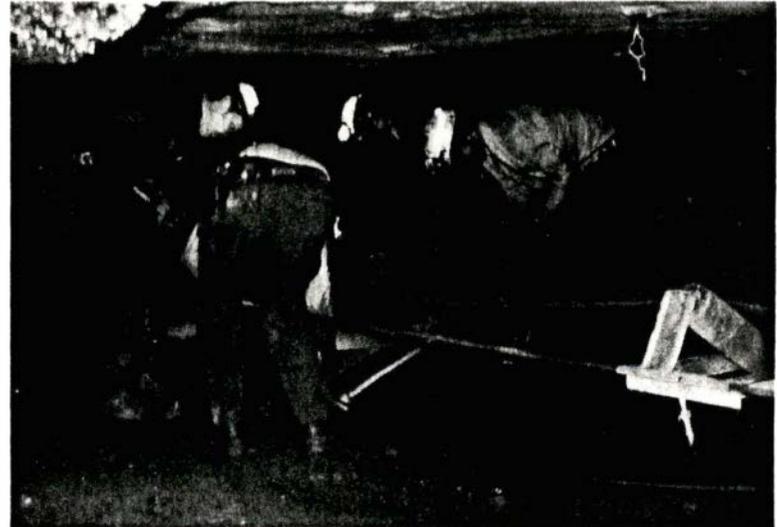
STRUCTURES LAID OUT IN DESIRED POSITIONS



LIFTING BELTS AND INSTALLING WIRE ROPE SUPPORT WITH RETURN IDLER

FIGURE 10-4
BELT EXTENSION WITHOUT CBSM

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LIFTING TOP BELT AND INSTALLING TROUGHING ROLLERS



INSTALLING BELT STRUCTURES



INSTALLING BELT STRUCTURES

FIGURE 10-5
BELT EXTENSION WITHOUT CBSM

attached to the tail section. During the fifth belt extension the CBSM was used to first position the belt structures along the entry, then move the tail section to its new location while dispensing the belt. After the wire ropes were in position and tensioned the CBSM wire rope winder was used to pull the work table along the belt line raising and separating the belt for the insertion of the belt structures. Figures 10-6 through 10-9 are photographs showing the first belt extension demonstration. Figure 10-10 is a sketch showing the procedures of the first and fifth demonstration. Photographs of the fifth belt extension are shown in Figures 10-11 through 10-14.

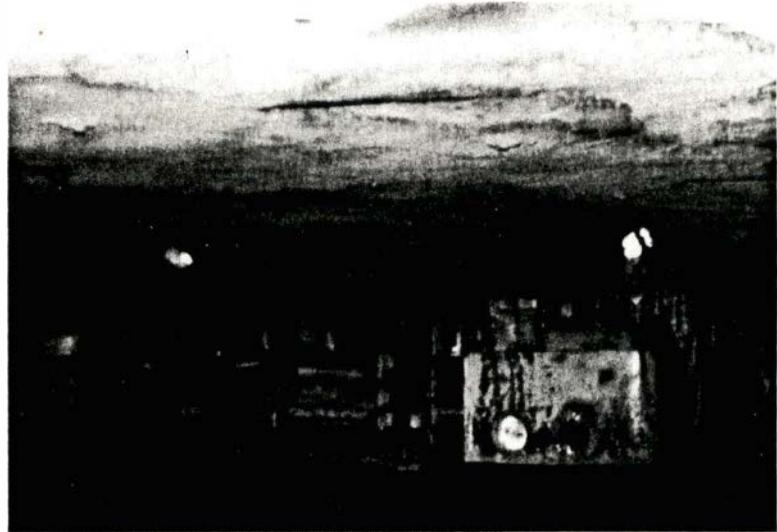
The first belt extension went well using the CBSM as per its original concept except for the alignment of the conveyor belt. Each of the structures had to be loosened and repositioned. This non-alignment resulted from inadequate tension control of the wire ropes using the wire rope friction pulls installed for this mine since they did not want to cut their 500 ft wire ropes. If the machine could have been used as designed with wire ropes the proper length for each 120 foot move and the wire rope reels dispensing the rope with their controllable tension, it is believed the alignment would not have been a problem.

The procedure of dispensing the belt structures along with the belting was changed to improve the safety of operation. When operating in relatively low head room the operator must work between the CBSM and the tail piece. This is not the problem in sufficient head room areas where the operator can work from on top of the slat conveyor and tail section.

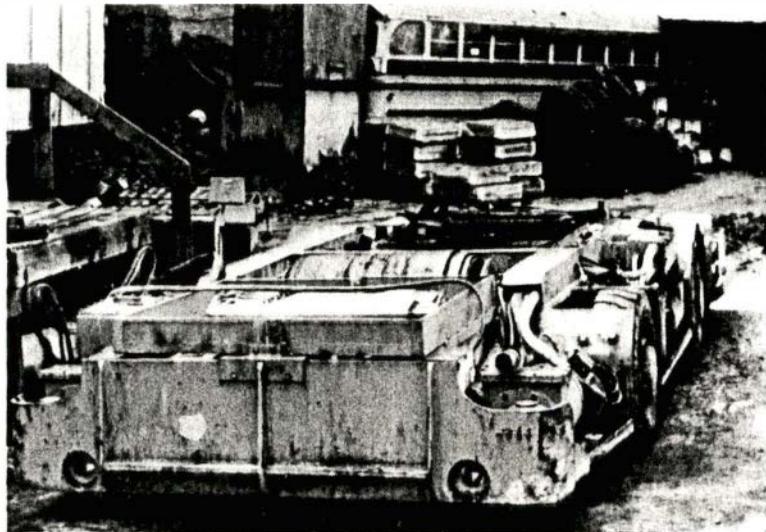
Tracor MBA



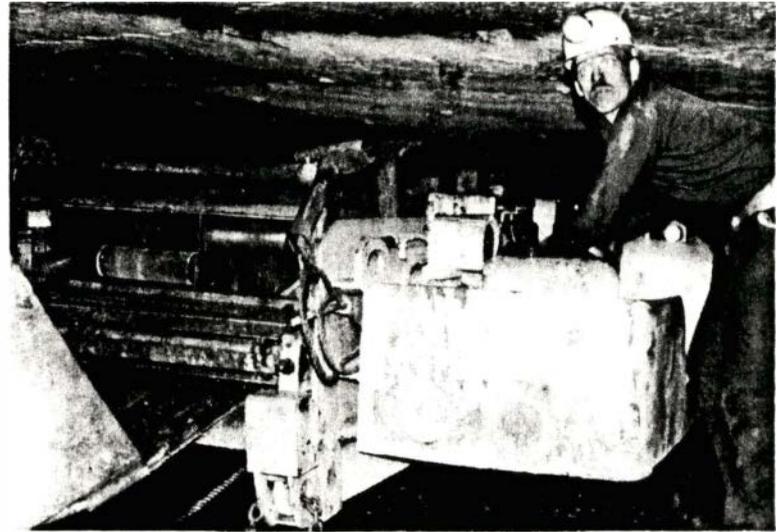
INSIDE MINE



LOADED MACHINE



LOADING MACHINE AT CHARGING STATION



STARTING BELT EXTENSION

FIGURE 10-6
BELT EXTENSION OPERATIONS WITH CBSM

67

2233-17815

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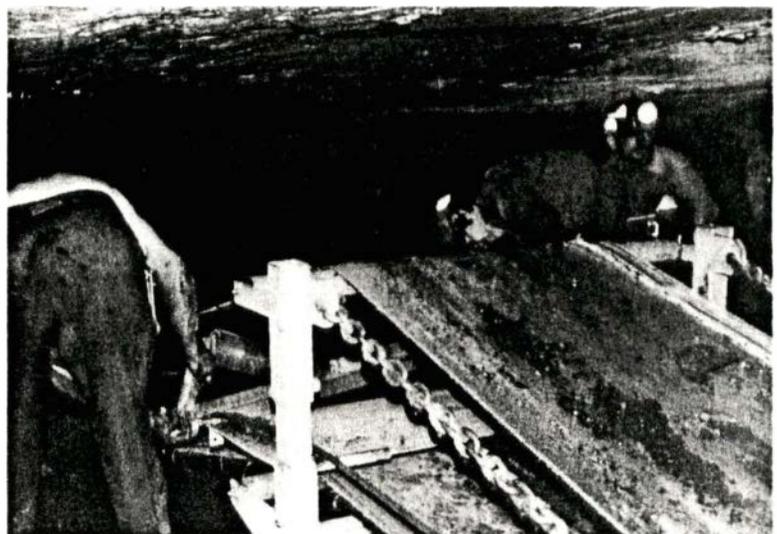
MOVING STRUCTURES TO BELT



STRUCTURE ARRIVING AT WORK TABLE



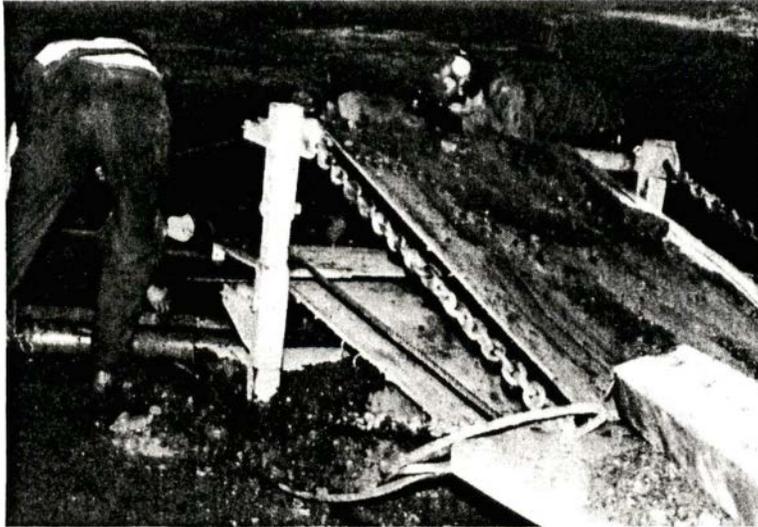
INSTALLING TROUGHING ROLLERS



INSTALLING TROUGHING ROLLERS

FIGURE 10-7
BELT EXTENSION OPERATIONS WITH CBSM

Tracor MBA



INSTALLING BELT STRUCTURES



INSTALLING BELT STRUCTURES



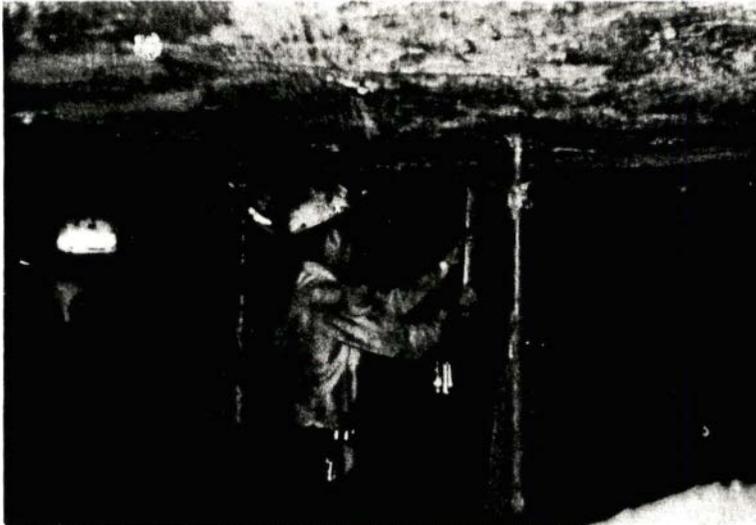
INSTALLING TROUGHING ROLLERS



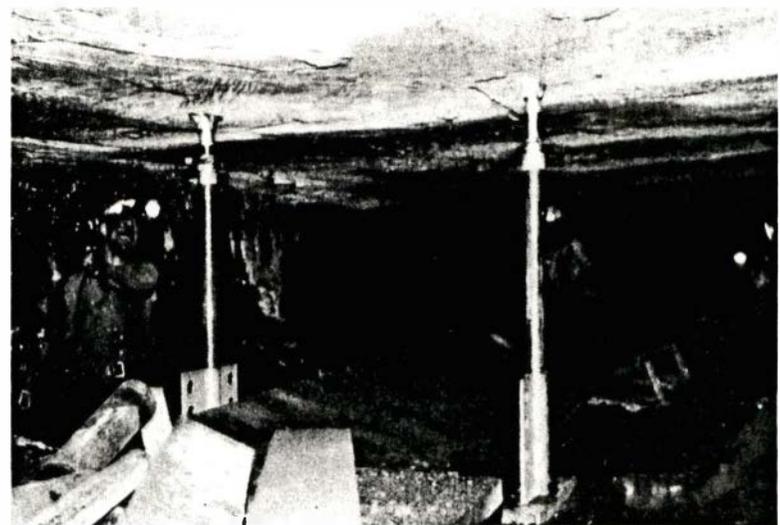
INSTALLING TROUGHING ROLLERS

FIGURE 10-8
BELT EXTENSION OPERATIONS WITH CBSM

Tracor MBA



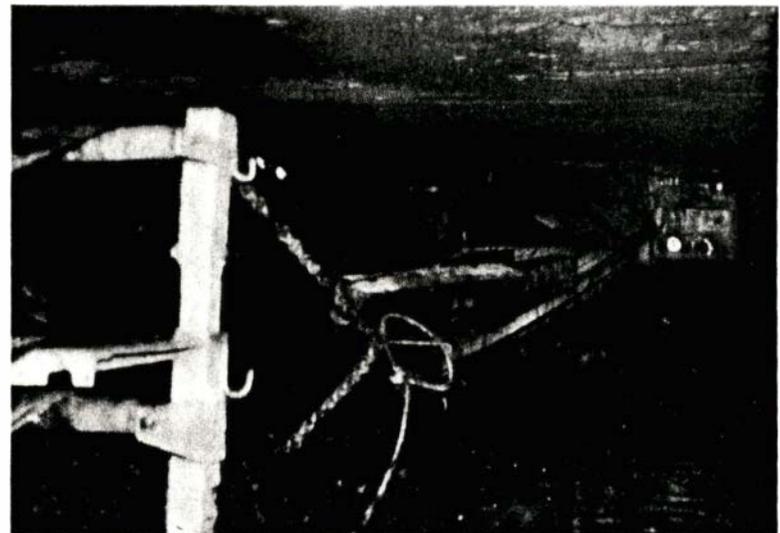
INSTALLING SAIL ANCHORS



INSTALLING SAIL ANCHORS

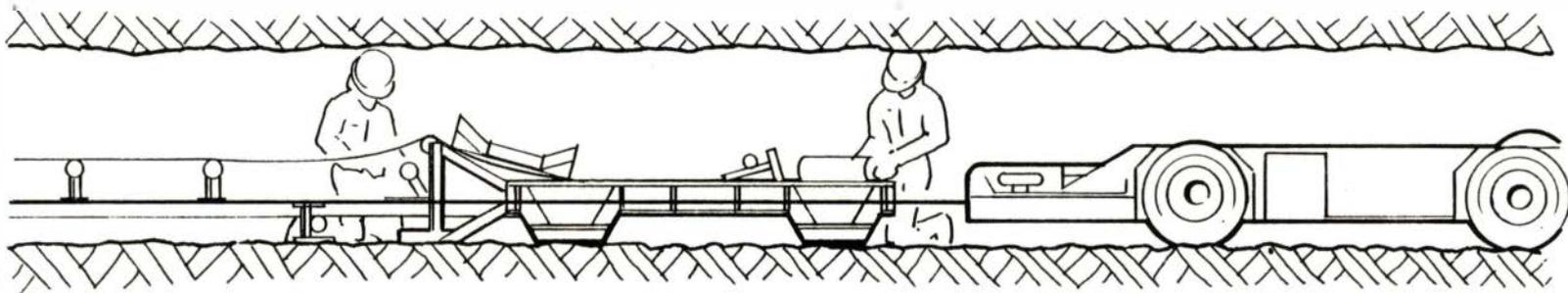


TENSIONING WIRE ROPES

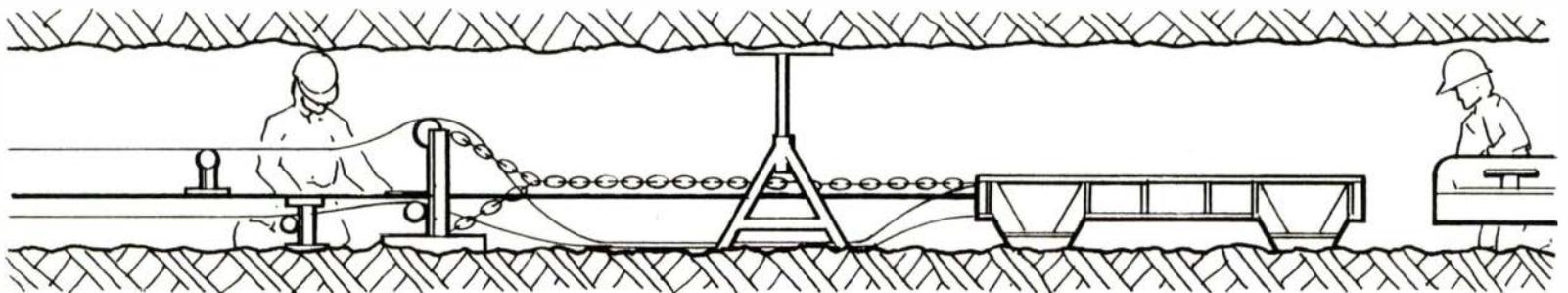


WORK TABLE - TAIL PIECE - CBSM

FIGURE 10-9
BELT EXTENSION OPERATIONS WITH CBSM



INSTALLING BELT STRUCTURES WITH WORK TABLE ATTACHED TO TAIL SECTION



INSTALLING BELT STRUCTURES AFTER TAIL SECTION IS IN PLACE AND BELT IS IN POSITION

FIGURE 10-10
CONVEYOR BELT EXTENSION USING CBSM

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PULLING TAIL SECTION



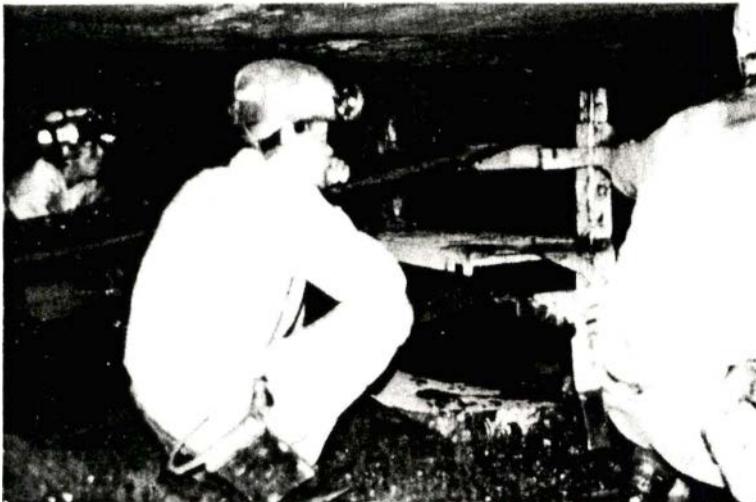
OBTAINING SLACK IN BELT

FIGURE 10-11
PREPARING FOR BELT SPLICE

Tracor MBA



ASSEMBLING WORK TABLE



WORK TABLE ASSEMBLED & IN USE

FIGURE 10-12
ASSEMBLING WORK TABLE

Tracor MBA



SLIDING STAND INTO POSITION



ATTACHING STAND



SLIDING TROUGHING ROLLER INTO POSITION

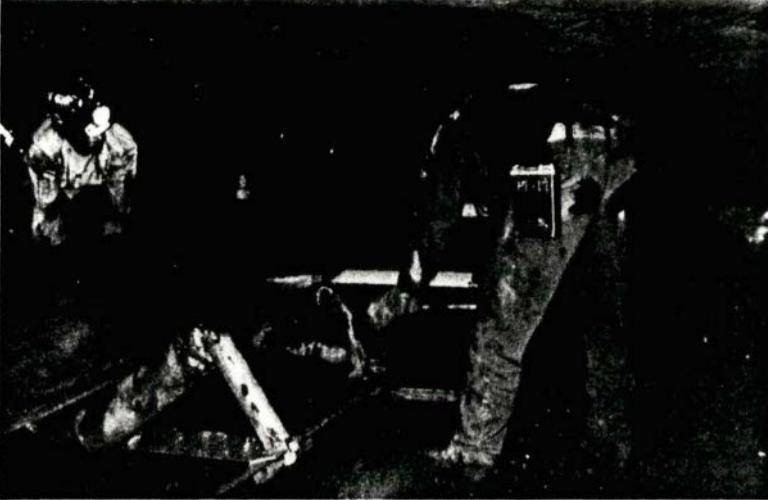


FIGURE 10-13
INSTALLING STRUCTURES

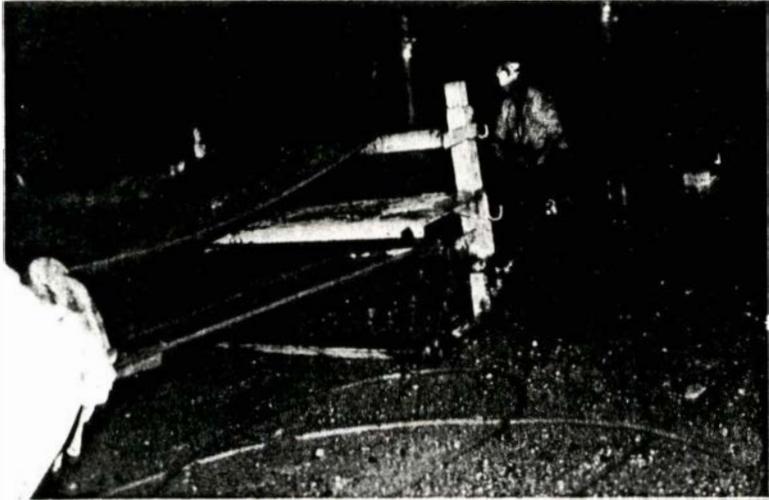
Tracor MBA



CONNECTING TROUGHING ROLLERS



PULLING WORK TABLE WITH WIRE ROPE



END OF THE LINE



FIGURE 10-14
INSTALLING STRUCTURES (Cont'd)

11.0 A BRIDGE FOR INSTALLING BELT STRUCTURES

The development of a device to substitute for the work table (used in the extension of floor mounted conveyor belts) which could be used when installing roof suspended conveyor belts resulted in a bridge for installing belt structure (BIBS). When the prototype was ready for testing, the mine for which it had been designed was not in operation and the BIBS eventually was put on test at Westmoreland's #4 mine in Clothier, West Virginia.

11.1 Construction

The BIBS (Bridge for Installing Belt Structures) is composed of three main parts, i.e. the frame, front locking security cams and rear locking cams. Figure 11-1 is a photograph of a onequarter scale model.

The frame is of angle iron construction. The base is the main bridge that rides on the suspended wire ropes. Its upper structure supports a normal return idler (idler roller shown installed). This complete upper structure folds down to facilitate its placement on the installed ropes under the troughing belt. The bridge has two cross plates on the trailing edge on which to slide the troughing rollers when they are inserted.

The front locking security cams are connected to an axle which is suspended from and attached to the frame by a simple hook and pin arrangement. The cam holds the wire rope in position on the frame slide bar and is designed to wedge against the wire rope to prevent the frame being pushed in the reverse direction. The cam is activated when coming in contact with the rope support. As the rope

support passes through the cam, moving the upper part of the cam from the frame slide, the lower part of the cam rotates upward engaging the frame slide keeping the wire rope in the frame slide, Figure 11-2. After the passage of the rope support, the cam returns to its original position by virtue of its weight distribution design, eliminating the need for springs or other mechanisms, thus minimizing the potential for failures or maintenance requirements, Figure 11-3.

The rear cams are identical in construction and use, but have a double hook and pin connection as this axle also supports the return idler that elevates the return belt.

11.2 Use

The BIBS is assembled on the suspended wire ropes by inserting the folded frame under the troughing belt and placing the slides on each wire rope. The front cams are then hung in place securing the frame to the wire ropes. The rear cams are then hung in place under the return belt. The roller can be installed on the rear cam's axle later, if desired. The top structure containing an idling roller is raised elevating the belt.

The BIBS is then slid along the wire ropes in the direction the belt is being extended, manually, by a powered wheel vehicle, a winch or tugger, etc. The conveyor belting lying on the floor is raised with minimum effort (rolling friction on belt) separating the troughing and return belts.

A worker on one side of the suspended wire ropes picks up a troughing roller structure and places one end on the frame cross bars sliding that end to his partner on the other side of the wire ropes. The troughing roller structure is then slid into position on

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FIGURE 11-1
BIBS MODEL
CONSTRUCTION

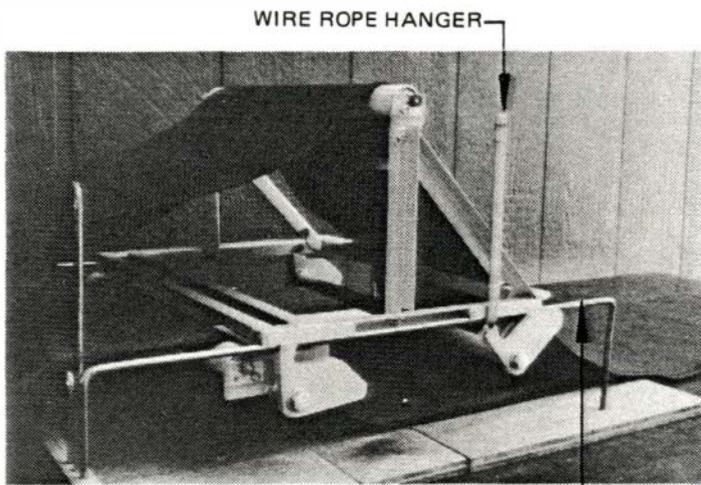
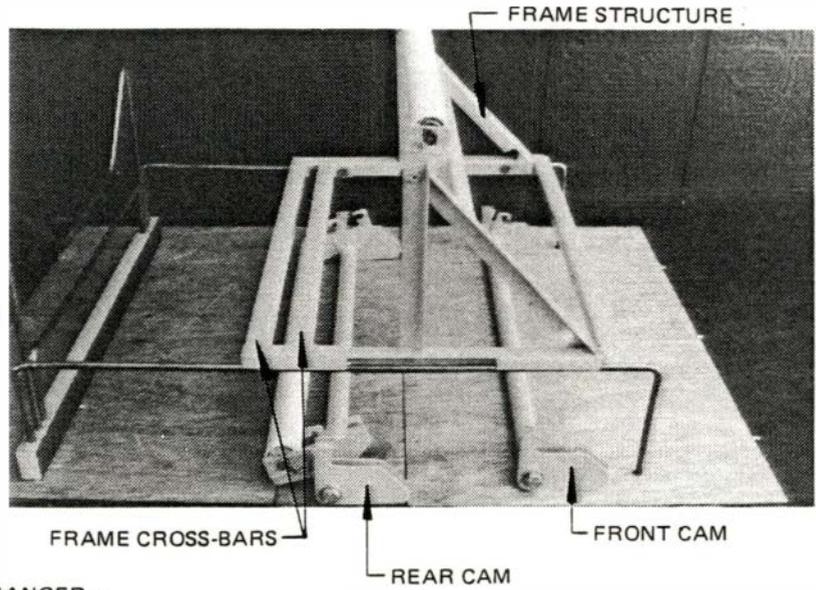
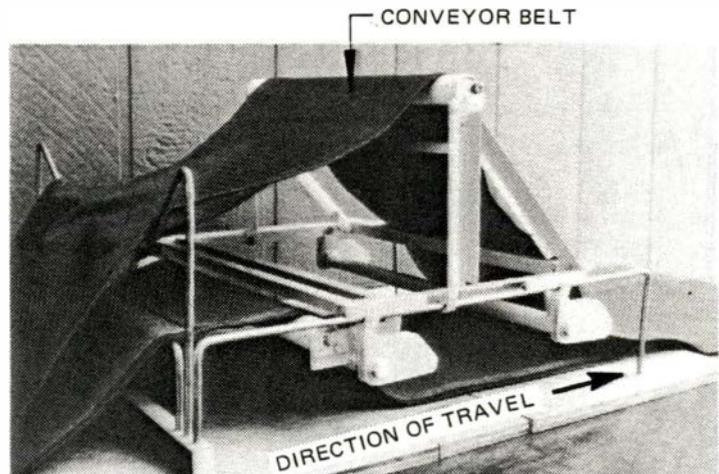


FIGURE 11-2
BIBS MODEL
CAM ACTION

FIGURE 11-3
BIBS MODEL
ASSEMBLED



the ropes and secured as needed. The return idlers are hung as required with minimum effort as the return belt is also held up by the BIBS providing open access to the wire ropes. Figure 11-4 is an illustration of how the BIBS and the CBSM would be used when extending a highly hung conveyor belt.

After the last belt structure is installed, the BIBS is disassembled in the reverse order of installation. Two men can assemble the BIBS in less than three minutes. Removal from the wire ropes or disassembly can be accomplished in less than two minutes.

11.3 Test Results

The BIBS was used only once in an operating mine prior to this final report. The test took place at the Westmorland #4 mine in Clothier, West Virginia. Mine manager, George Nelson reported that the BIBS performed as designed with two men able to slide it along the wire ropes lifting and separating the belts. He also reported that it took the men longer to make the belt move because of the time required to set up the BIBS, approximately 30 minutes. Thus they decided not to continue to use the BIBS.

At this mine the belt is suspended approximately 30" to 36" off the floor requiring only minimum effort to lift the belt for the insertion of the roller structures. Also, it appears that the miners are very dedicated, systematic, take pride in their work and are reluctant to deviate from their established procedures. It is understandable that the first trial of the BIBS with only printed instructions on the setup procedure would require more setup time. However, it is believed that after several setups to become familiar with the unit, two men should be able to set up the BIBS in less than five minutes.. During a belt extension, the two men who normally lift the belt for the insertion of the

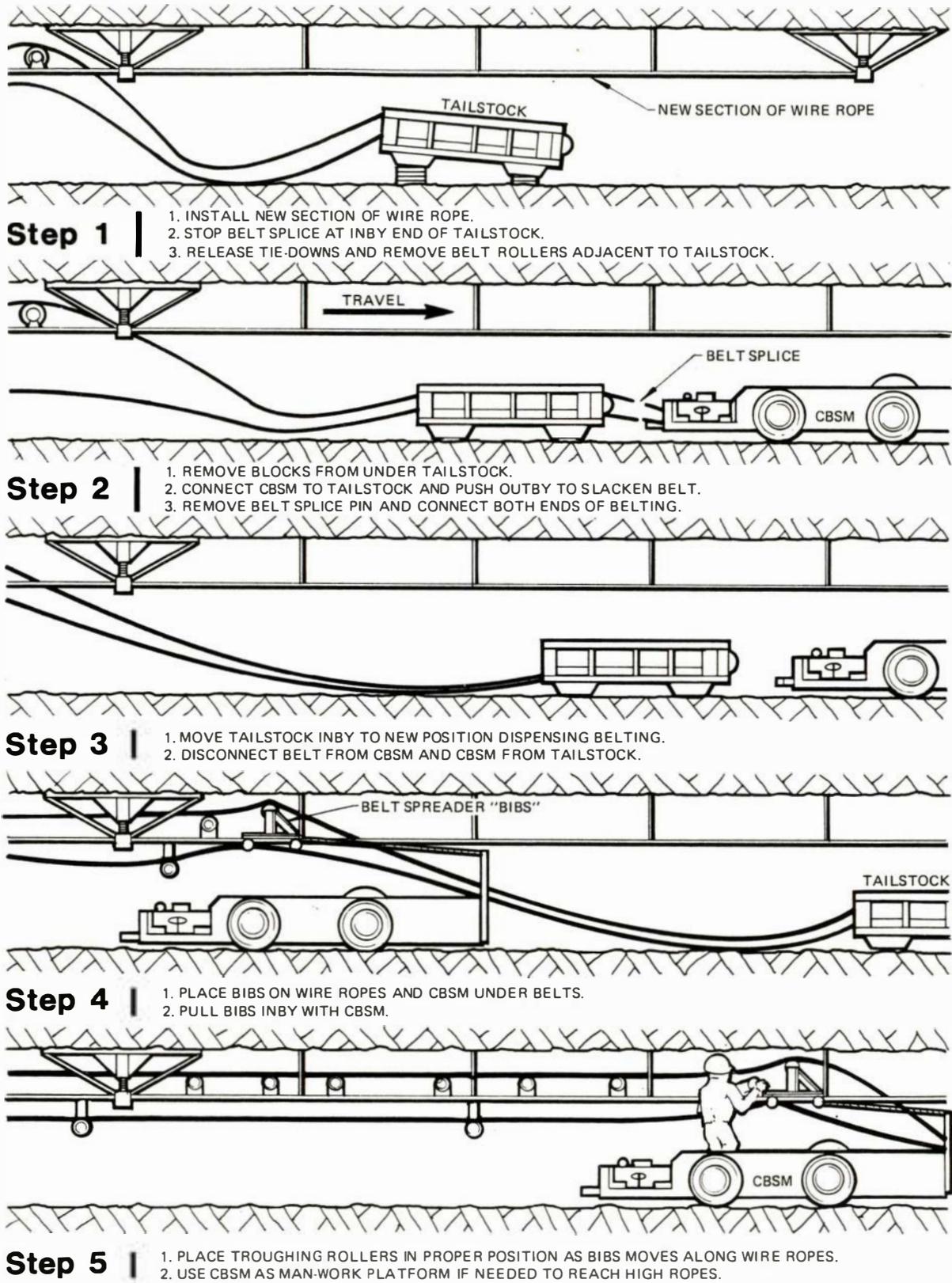


FIGURE 11-4
CBSM AND BIBS EXTENDING HIGHLY HUNG CONVEYOR BELT

roller structures, could be released for other tasks, thus reducing the overall time for a belt move. Therefore, it is believed that if the designer could have helped with the first trial to shorten the setup time, or after several test trials, the BIBS could prove to be a useful piece of equipment in making a conveyor belt extension. It should be particularly helpful in reducing the effort to lift belts where the belts are suspended further off the floor (four to five feet or more). In this regard the BIBS would be an added safety feature, helping to reduce possible back strains.

BIBS can be made for any size belt, but can best be utilized on belts using the open "J" hangers for wire rope supports. Other clamp-on or bolt-on hangers would require the release of each hanger for the BIBS to pass by.

12.0 SUMMARY

MBAssociates entered into a contract with the U.S. Department of the Interior's Bureau of Mines, Contract No. H0357102 formerly DOE ET-75C-01-8886 and DEAC-01-75ET 11083 now J0333926 to design, develop, fabricate and demonstrate a conveyor belt service machine for use in underground coal mines. It was stipulated that it be self contained, battery powered, rubber tired, and capable of handling, storing and transporting conveyor belting, wire rope and associated structures for sectional conveyor belts while at the same time moving the tail section to its new location during a sectional conveyor belt extension or retraction. The machine was to be able to perform all the heavy, strenuous and critical tasks during a sectional conveyor belt move decreasing the belt move time and associated costs.

A machine of such description and capability was designed and fabricated and tested. It contains a hydraulic system that:

- o Assists steering and braking
- o Powers components for winding or unwinding, under controlled tension, conveyor belting from 30-42 inches wide 1/4 to 1/2 inch thick and 200 to 400 feet long
- o Powers cable reels to wind the 3/8 inch wire rope

Powers a slat conveyor for loading, unloading, storing and transporting the sectional conveyor belt structural supports and accessories

Powers a pneumatic system for the operation of hand-held air powered tools.

Powers hydraulic cylinders for raising and lowering the slat conveyor

Powers hydraulic cylinders for operation of the machine's grab hooks that connect to the tail section of the section conveyor

The machine was demonstrated above ground to mine officials and then modified to suit the mine's requirements to enable it to be tested underground in actual belt moves. The first underground demonstration test was successfully completed in a retraction belt move of 160 feet. It was then operated in two other mines, one in West Virginia and one in Kentucky. The first two were in relatively thick seam coal with both floor mounted and roof supported belts. The third mine was relatively low coal with floor supported belts.

13.0 CONCLUSIONS

In conclusion it can be stated that the contract objectives have been met. A machine to extend conveyor belts was designed, fabricated and successfully tested in underground coal mines. The machine was demonstration tested in three different

operating coal mines under a variety of conditions, none of which were ideal, with new crews (no previous experience with the machine) on most of the belt moves. The results of these tests indicate that under ideal conditions (i.e. an adapted tail section, powered belt clamps, good belt splices and with a dedicated experienced well trained crew following procedures to conform with the machines capabilities that a belt extraction or extension of 80-100 feet could be made with four to six men in 15 to 30 minutes.

It was further concluded that minimum changes in overall design would be needed for a commercial vehicle. These would be consolidating and centralizing all controls a for one man operation and elimination of unnecessary components or functions such as the pneumatic system. To further enhance the commercial appeal the overall size of the vehicle could be reduced slightly and the belt winder redesigned so the wound belt could be removed in a coiled configuration for storage. The last mine to test the Conveyor Belt Service Machine requested and received permission from the Bureau of Mines to continue to use the machine for a period of three years which is additional proof of the machines desirability and functional capabilities.

14.0 RECOMMENDATIONS

The underground demonstration tests at three different coal mines plus interviews with officials at many other mines has been sufficient to suggest the design criteria for the CBSM that would be most desirable throughout the coal mining industry.

The machine would be adaptable to either floor mounted or roof suspended conveyor belt systems. It would be somewhat smaller than the present prototype. It would not have a pneumatic

system or powered hitch hooks. All controls would be centered in the driver's compartment for one man operation. The slat conveyor would not be elevating and the power of the wire rope winches would be reduced. It would also be desirable to be able to remove the belt roll from the machine in its rolled condition for storage of belts in a coiled form. It is recommended that such a machine be designed, fabricated and proof tested. There are several manufacturers who are interested in the possibility of producing such a proven machine for commercial purposes.

APPENDIX

OPERATION AND MAINTENANCE
MANUAL

★ CONVEYOR BELT SERVICE MACHINE

Model J
Serial No. 0333296

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I. OPERATION SECTION

1.0 MACHINE TRAVEL

1.1 Start-Up (Figures A, B and C)

- Move circuit breaker lever to reset position. (Figure C)
- Push start button on drivers control panel. (Figure B)

1.2 Travel (Figure B)

- Turn on lights by moving light switch lever toward direction of travel.
- Raise parking brake valve button (off position).
- Release mechanical foot brake.
- Move forward/reverse lever to direction of intended travel.
- Move acceleration handle SLOWLY clockwise until desired speed of travel is obtained.

1.3 Stop Travel (Figure B)

- Slow with dynamic brake by quickly reversing accelerator (counter clockwise) the full throw distance.
- Rapid stop use mechanical foot brake.
- Return accelerator handle to neutral and direction lever to neutral vertical position.

1.4 Shut Down Machine (Figure B)

- Set parking brake by pushing down parking brake valve button and lock foot brake.
- Stop hydraulic pump by pushing on panic bar or stop button.

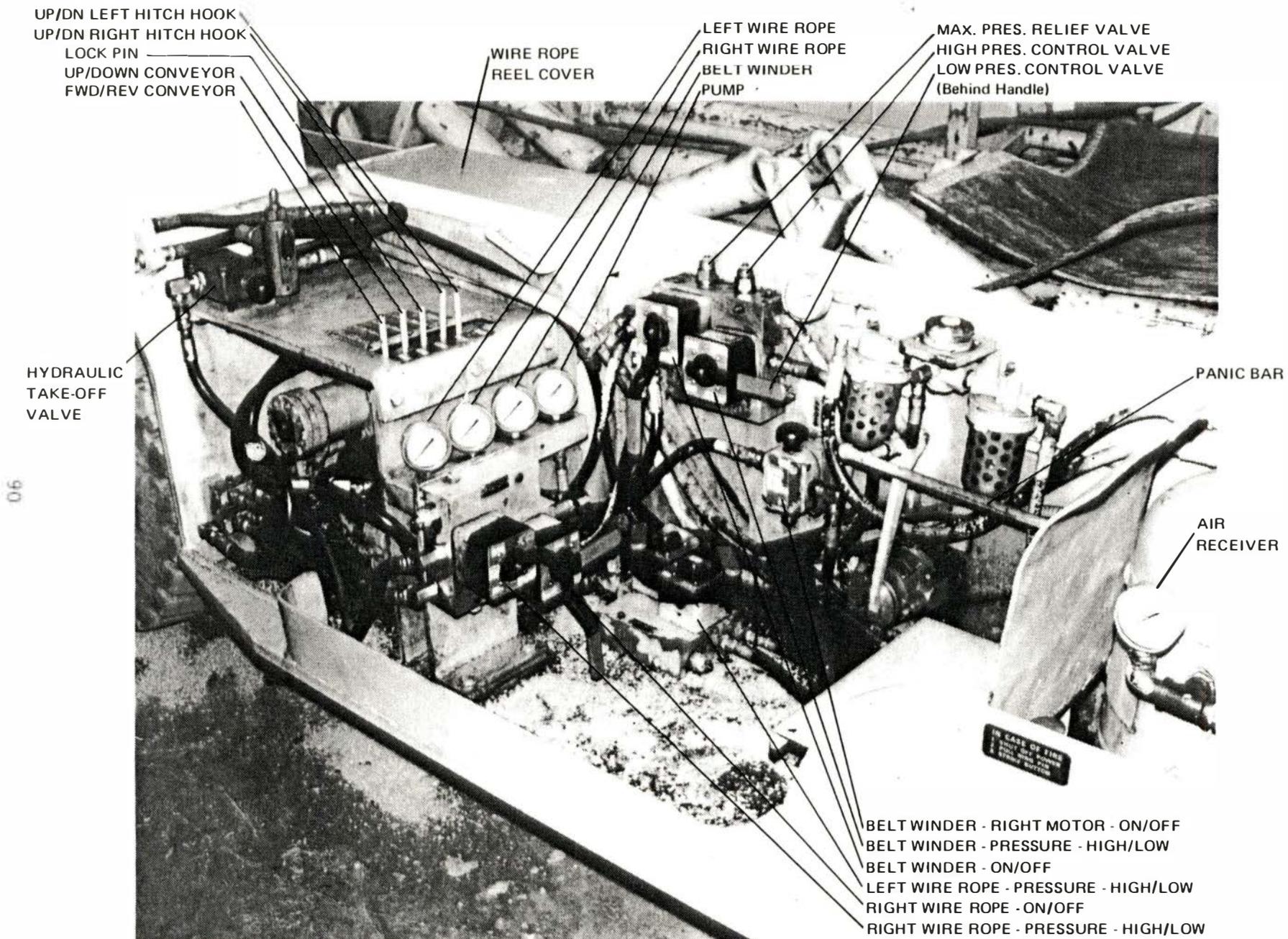


FIGURE A
HYDRAULIC CONTROLS

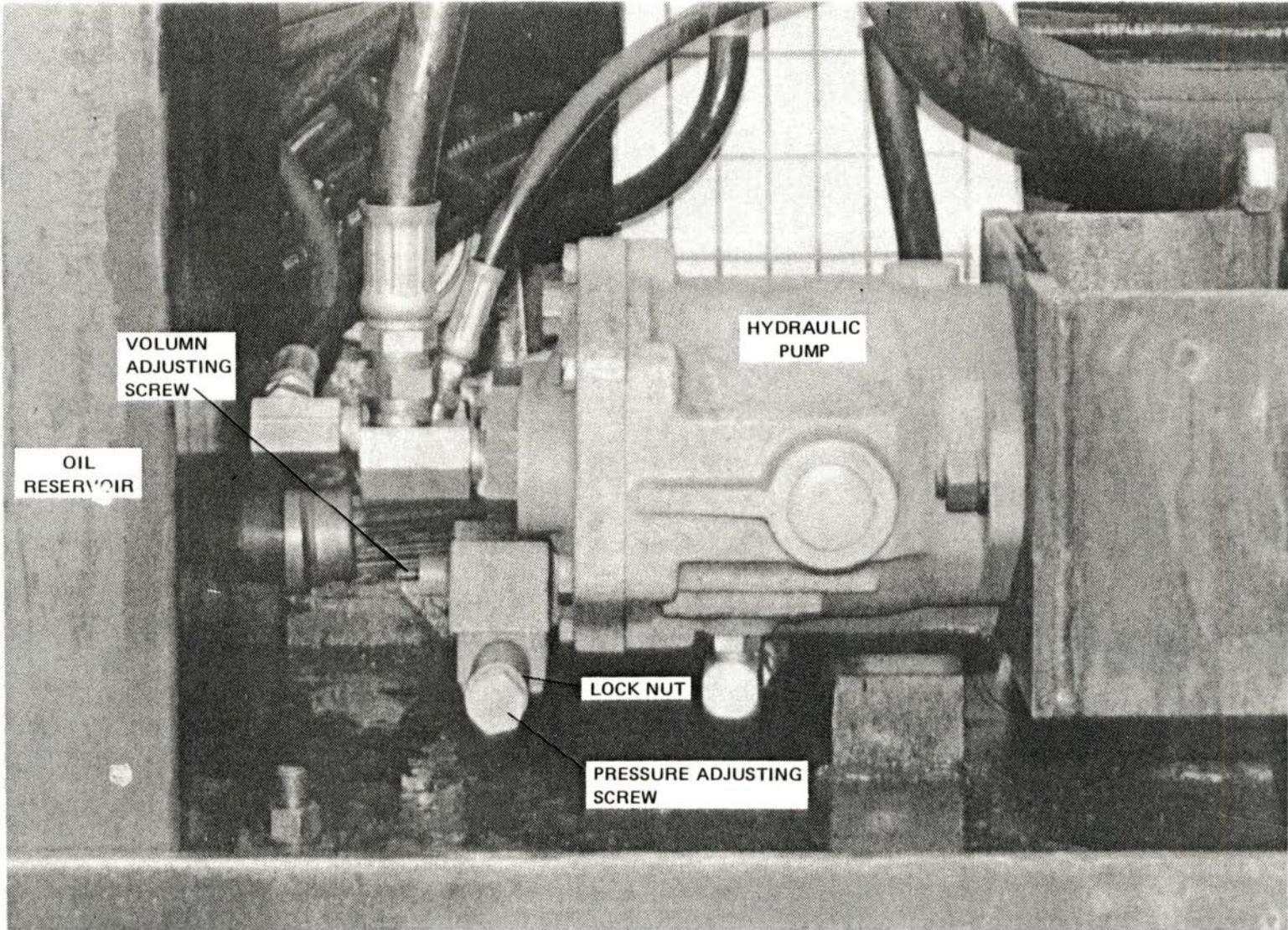


FIGURE B
HYDRAULIC PUMP

2.0 OPERATION OF HYDRAULIC COMPONENTS

2.1 Belt Winder (Figure A)

- Set pressure control valve to low pressure position.
- Turn ON/OFF control valve to ON. Wire rope reel (left hydraulic motor) will rotate, winding wire rope on lead reel until belt hook reaches belt winder drum. Lower slat conveyor. At this time torque will be transferred to belt winder drum. Automatic latch will disengage.
- If additional torque is required move pressure control valve to HIGH pressure position.
- When more torque is required raise button on the right hydraulic motor control valve to ON position. Both (left and right) belt winder hydraulic motors will then be operating.

2.2 Wire Rope Winders (Figure A)

- Set pressure control valves of left or right wire rope winders (as desired) to the low pressure position.
- Turn On/Off control valves of left or right wire rope winders (as desired) to ON.

NOTE: Low pressure setting will be sufficient for the wire rope winders in most cases.

2.3 Pneumatic System

The pneumatic system will automatically operate with the hydraulic system.

2.4 Slat Conveyor (Figure A)

- Raise/Lower slat conveyor by moving valve lever in the direction indicated (toward rear of vehicle to raise and opposite direction to lower).
- Move conveyor (rotate) by moving forward/reverse lever in the desired direction of motion.

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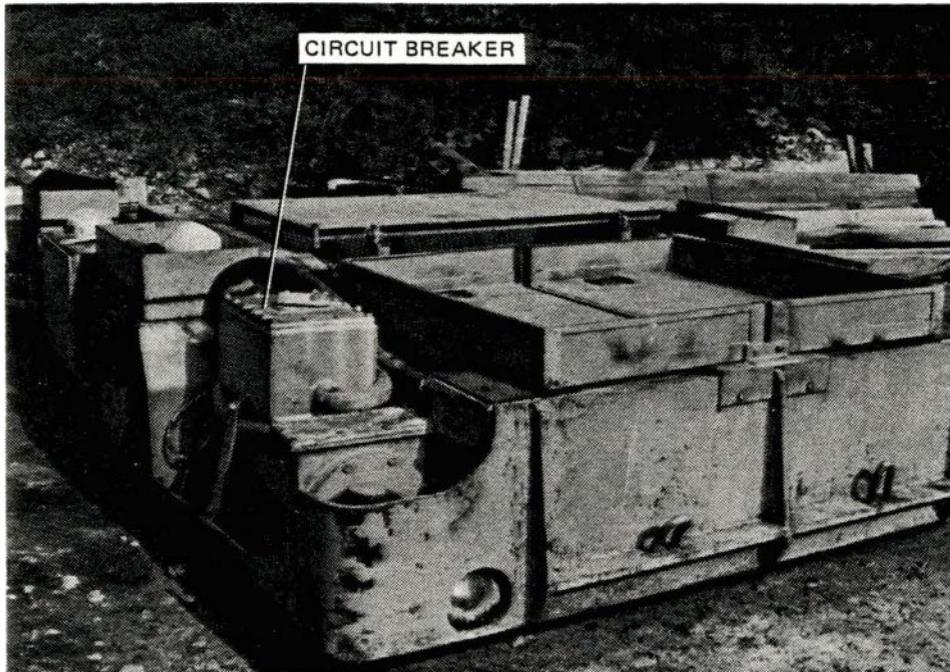


FIGURE C

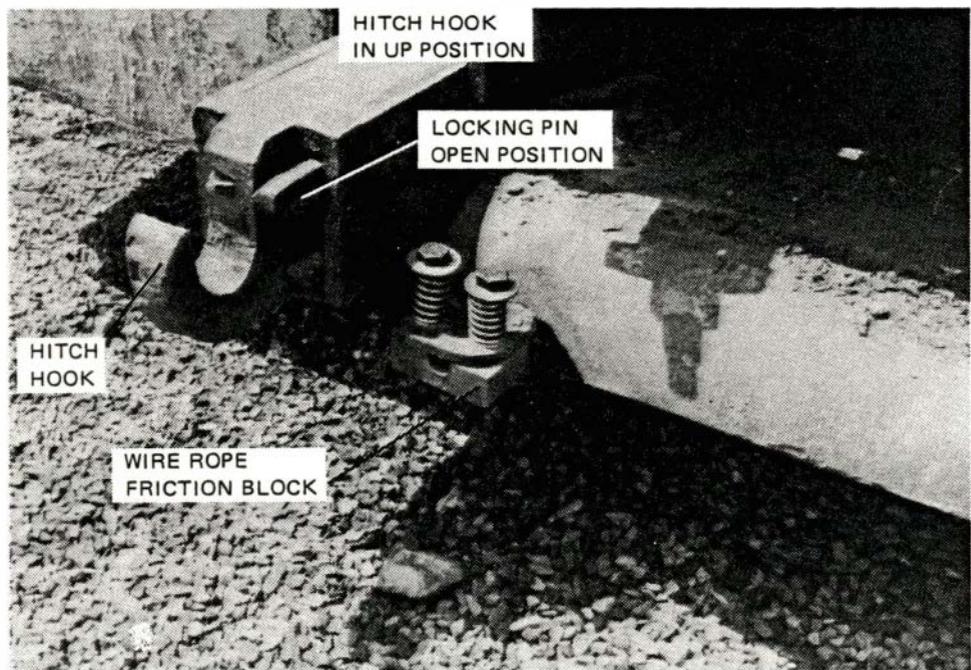


FIGURE D

2.5

Hitch Hooks (Figures A&D)

- Open or close locking pins by moving control levers in desired direction (toward front of vehicle to close and in opposite direction to open).
- Raise or lower hook arms by moving levers in direction indicated (toward rear of vehicle to raise and in opposite direction to lower).

3.0 OPERATING PROCEDURE

3.1

Belt Winding (Figures A and E)

Loading machine or retrieving belt as in a conveyor shortening operation.

- Connect belt hook clamp by placing tube portion inside bend of belt (mid-center of belt section to be wound)(*) and bolt to wire-rope spreader. (Figure E)
- Raise slat conveyor to maximum height. Belt drum lock should be engaged.
- Set belt winder valve to LOW pressure setting. Push-button valve must be OFF (down).
- Turn ON/OFF belt winder valve to ON.
- When belt hook reaches and is snug in center of belt drum, release belt drum lock by lowering slat conveyor.
- When additional torque is required to wind belt, raise button on right motor ON/OFF valve.
- When still more torque is required to wind belt, turn pressure control valve handle to high pressure setting.
- When belt is fully wound, re-engage belt drum lock automatically & manually. Turn off control valve and set pressure control valve to zero position. Raising slat conveyor will allow belt drum lock to engage. (Figures F&G)

(*) Return belt (bottom) should be 12 ft. longer than load or upper belt. For ends to be even when a full 320 feet of belt is loaded on the machine.

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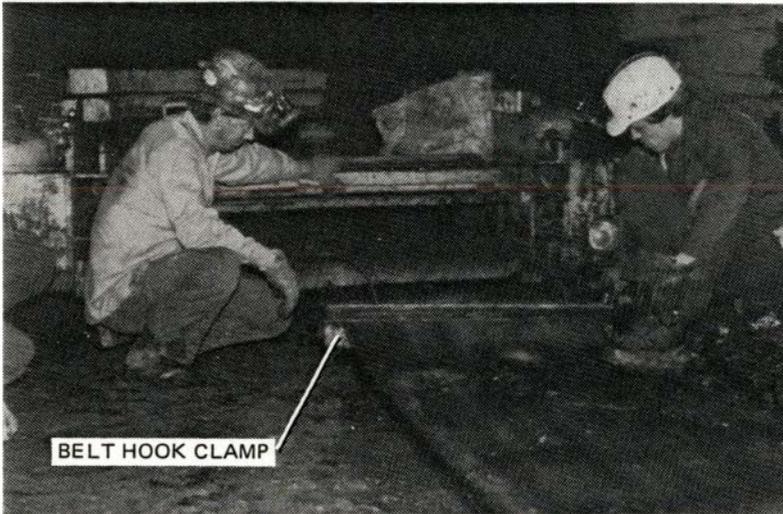


FIGURE E



FIGURE F

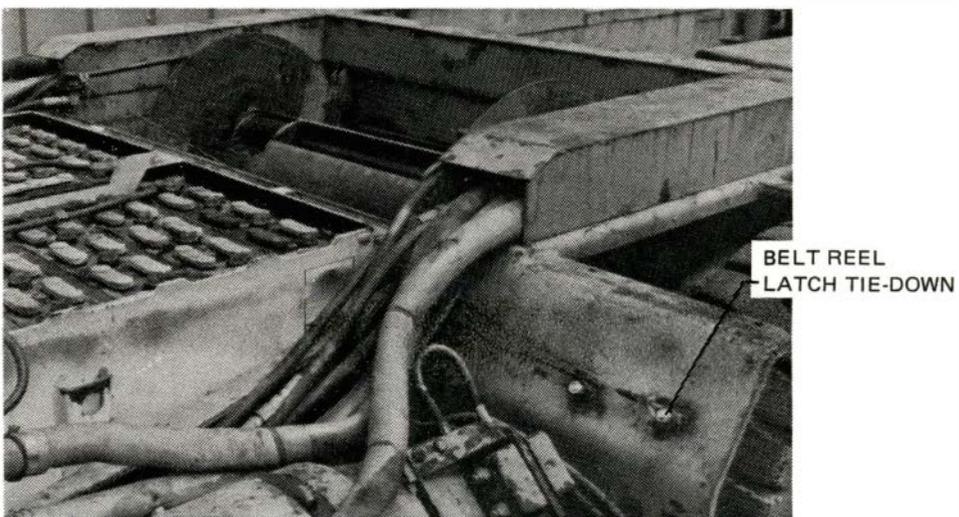


FIGURE G

3.2

Off Loading or Discharging Belt (as in conveyor belt extension operation) (Figure A)

- Connect belt ends.
- Set belt winder pressure control valve to high pressure position and turn ON/OFF valve on. Do not turn off until belt hook is in position to separate from the drum and drum is locked.
- Release belt drum lock manually.
- With belt ends connected to other belt being extended or to an anchor when off-loading, move machine away from the anchor (or inby) pulling belt from machine.
- As belt approaches the end, raise slat conveyor to maximum height.
- Belt drum lock will engage just before belt hook clamp separates from belt drum.
- Set pressure control valve to zero position and ON/OFF valve to OFF.
- As belt hook exits machine, stop motion of machine. Lock belt drum manually. Lower slat conveyor.
- Disconnect belt hook clamp from belt.

3.3

Winding Wire Ropes (Loading); (Figures A, H & I)

- Open covers on wire rope reels.
- Push wire rope ends into feed channels, and connect to pins on reels.
- Close reel covers.
- Set pressure control valves to low pressure position (500) and ON/OFF valve to ON.

Tracor MBA

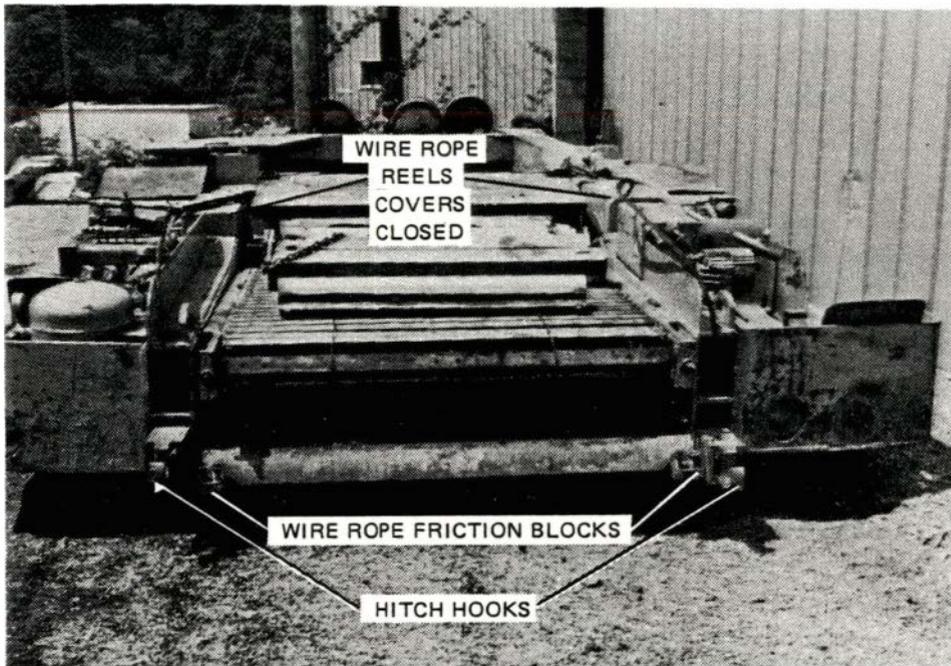


FIGURE H

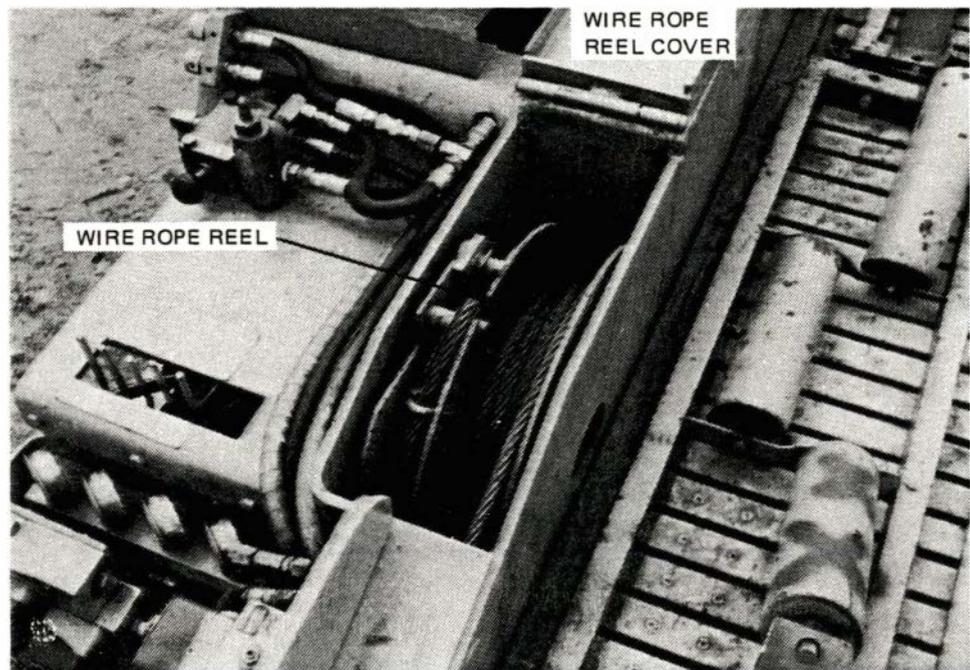


FIGURE I

3.4 Unwinding Wire Rope (Dispensing)

- Anchor free end of wire rope.
- If tension is desired (conveyor belt extension) set pressure control valve at low pressure position and ON/OFF valve to ON.
- If no tension is needed (off-loading wire rope) set ON/OFF valve to OFF and pressure control valve to ZERO position.
- Back machine, moving away from wire rope anchor.
- When end of wire rope is reached turn off pressure and control valves, open reel cover and unhook wire rope.
- Pull wire rope end free of machine by hand and close reel cover.

4.0 ADJUSTING HYDRAULIC PRESSURES

4.1 Hydraulic Pump Pressure Adjustment (Figures A & J)

- Set all pressure control valves to zero position and ON/OFF valves to OFF (Figure A)
- Loosen locknut on pressure adjustment screw. (See Figure J)
- Turn pressure adjustment clockwise to increase pressure, counter clockwise to decrease pressure.
- Set pressure at 2000 psi (recommended) on pump pressure gauge (See Figure A)
- Tighten locknut on pressure adjustment screw.

4.2 Pressure Control Valves Adjustment (Figure A)

The high and low pressures are controlled by regulating (reducing and relief) valves mounted in valve manifolds.

- Anchor belt and wire rope ends.
- Loosen locknuts on all three (3) regulating valves.
- Loosen all adjusting screws fully (turn counter clockwise)

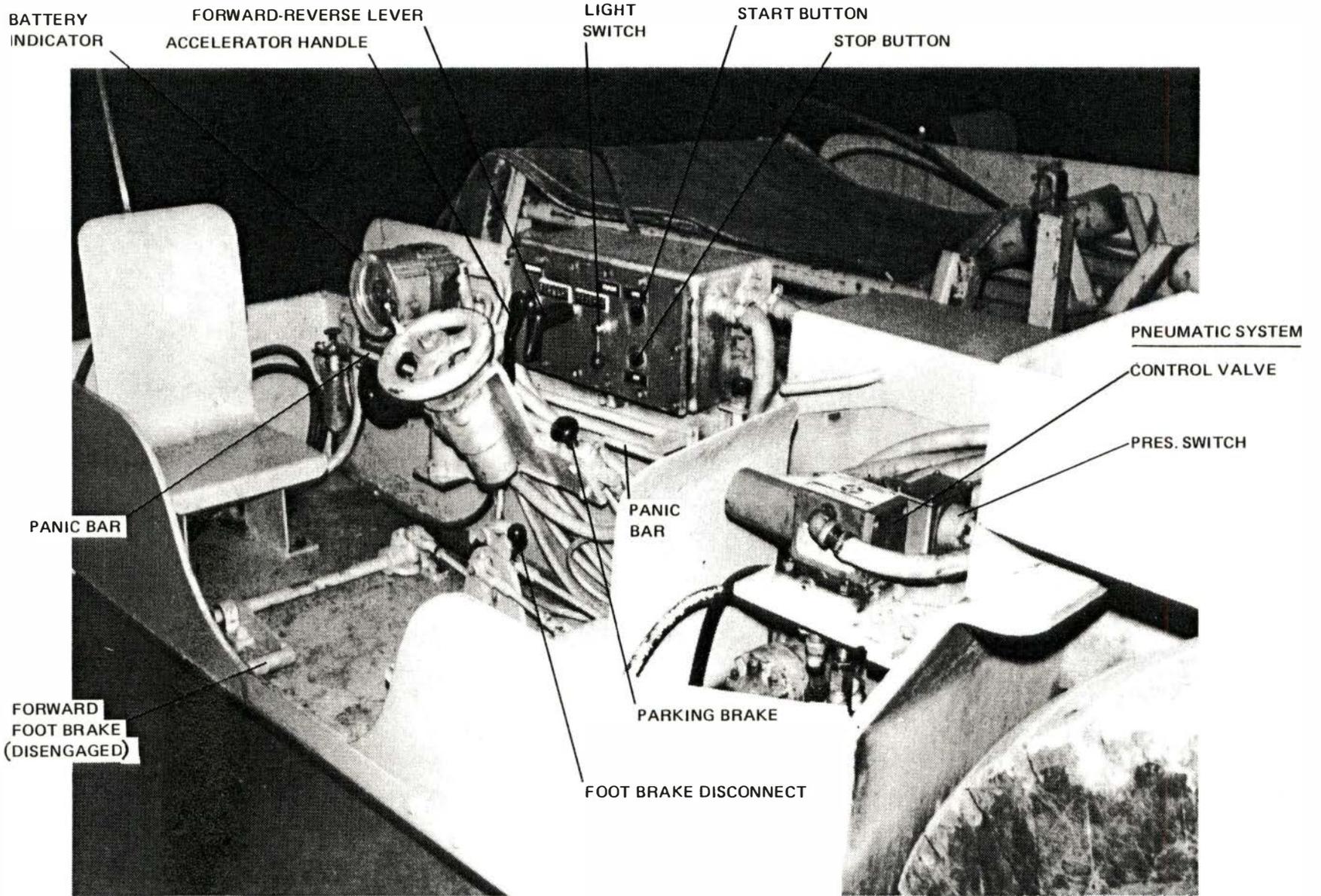


FIGURE J
DRIVER'S CONTROLS

- Turn ON/OFF valve handle to ON position and pressure control valve handle to HIGH position.
- Turn both MAX and high pressure control valve's adjusting screws clockwise simultaneously until respective pressure gauge reaches 1800 psi (recommended pressure) and the MAX pressure screw is controlling the pressure. Then tighten lock nut on MAX pressure adjustment screw.
- Turn high pressure control valve adjusting screw counter-clockwise until pressure gauge reaches 1500 psi (recommended pressure) and tighten locknut.
- Set pressure control valve handle to low pressure position.
- Tighten low pressure control valve adjusting screw clockwise until pressure gauge reaches desired low pressure. (500 psi recommended) and tighten locknut.

FOLLOW ABOVE PROCEDURE FOR EACH SET OF (3) VALVES -
BELT REEL (1) AND LEFT AND RIGHT WIRE ROPE WINDERS (2)

II MAINTENANCE SECTION

5.0 DAILY MAINTENANCE (when machine is used daily)

- 5.1 Check batteries with hydrometer to verify low battery indicator, or by observing low battery indicator.
- 5.2 Check battery water level (add water only during charging cycle when needed).
- 5.3 Check operation of all four headlights.
- 5.4 Check oil level in air system lubricator and fill if needed.
- 5.5 Check pressure in air system.
- 5.6 Check for air and hydraulic oil leaks.
- 5.7 Check hydraulic pump pressure.

6.0 WEEKLY MAINTENANCE (when machine is used daily) or monthly if machine is used intermittently.

- 6.1 Grease zerk fittings on belt winder, wire rope winders, steering linkage and in driver's compartment.
- 6.2 Grease wire rope on wire rope lead reel of belt winder.
- 6.3 Visually inspect belt winder's wire rope for frayed or broken strands.
- 6.4 Check all fasteners in slat conveyor for tightness or missing units by visual inspection. Also straighten any bent slats.

APPENDIX a
PURCHASED PARTS AND ACCESSORIES

SPARE PARTS SOURCES

PURCHASED PARTS AND ACCESSORIES

SOURCES FOR SPARE PARTS

<u>Description and Source</u>		
1.	Traction Drive Motors 128V Series wound	Two(2) 30HP 1800 RPM West VA Armature Bluefield, W.Va.
2.	Traction Drive Reducers 1.668 Ratio (includes FMC #8053-C2-M2)	Two(2) w/Parking& Service Brakes FMC San Jose, Calif.
3.	Steering Arm	Two(2) FMC 8057-01-C5 FMC San Jose, Calif.
4.	" "	" " 8057-D1-C4 " "
5.	Propeller Shaft Assy	Two(2) FMC 8053-D4 " "
6.	Propeller Shaft Assy (32-39¼ Trunion Centers)	Four(4)FMC 8053-03-M3 " "
7.	Quill Shaft	Two(2) FMC 8053-C4-B1 " "
8.	Bearing Pillow Block (2" Bore, Exccentric Locking Collar, Lip Seals)	Link Belt P3-Y232N Indianapolis, Indiana
9.	Wheel Drive (1) one	FMC 8053-D2-M1 FMC San Jose, Calif.
10.	Wheel Drive (1) one	FMC 8053-D2-M2 " "
11.	Wheel Drive (2) Two	FMC 8053-D2-M3 " "
12.	Tire&Rim Assy (4) 10:00-15 14-ply - 100 psi rated Bearcat Tire	FMC 8053-D1-D2 Armor Guard Heavy Mine Service " "
13.	Mico - Open Center Hydraulic Power Brake Valve #06-460-550	West Va. Armature
14.	Parking Brake Valve Energy #B-1152	" " "
15.	Adaptor Plate Ball Bearing	Two(2) New Departure Double Sealed 299609 " "
16.	Pinion Gear Seal to Adaptor Plate	John Crane #225-2997-12 " "

Double Lapped Winder Group

17. Bearings, Shafts, Drums, etc. See Drawing 033-036
18. Silent Chain 1/2 pitch, 1" wide 32 pitches lg.
19. Main Bearings Two (2) Link Belt #FC3-U235N Indianapolis, Indian.
2-3/16" Bore Flange Cartridge Type, Lip Seals
20. Hyd. Motor Drives Two (2) Ross MAE-24 SAE 6B Shaft
Standard Mount
21. Operating Valve, Sun Cartridge RPG Clan Relief Valve
Set at 1800 psi (3ea Total Systems)
 - o Sun Cartridge PBFBLAN Reducing Valve
Set at 1500 psi (3ea total systems)
 - o Sun Cartridge RPGCLAN Relief Valve
Set at 500 psi (3ea total systems)
 - o Republic 4-way Valve 8043E-10HS2
(3ea total systems)
 - o Republic 2-way Valve 8013E-10HS2
(3ea Total Systems)
 - o Gresen Selector Valve SM50 (2ea total systems)
22. 1/4" - 3/16" Dia. Wire Rope 60' long 7x19 Flexible Air Craft
Cable Galvanized

Steering Group

23. Ball Studs Four (4) 1-1/2" Dia. Ross Gear Co.#042031 Lafayette, Indiana
24. Balance Bars 2 short & 2 Long
25. Bearings Six (6) Fiberglide CJS 2416 Lear Siegler Santa Ana, Calif.
26. Bearings Two (2) Bunting #P250-16 2 1/2" Bore, 3" O.D., 2" long

27. Bearings, Four (4) New Departure Z499609,
a snapping bearing with 2 seals, 45mm bore,
100mm O.D. 3309 series
28. Drag Link - Michigan Div. TRW
#76-6-23-21 (L24HA Ref)
Fan 1½" Dia. Ball - 47.5 Ball center length
Sterring Heights
Michigan
29. Steering Cylinders Four (4)
Cessna 43300 MAB 3" Bore 8" Stroke
Cessna
Distributor
30. Power Stearing Unit One (1) Ross #HGB-16
30 cu in per revolution. Closed Center Hyd.
with short shaft and cross hole
31. Drive Shaft Sprockets Six (6) 9-tooth plate
sprocket 9RC100 #100A9 Type A
Link Belt
32. Chains Three (3) RC-100-278 Pitches (347 inches)
with connector link made with 139 Kl attachment
links and 139 std. links. Alternating Kl and
Std. links.
33. Bearings Two (2) Seal Master St.-29
34. Hydraulic Motors Two (2) Ross MAE-34
Standard Mount 6B Spline - 1"
35. Bearings Six (6) Bunting P.M. Bronz #P250-16
36. Bearings Two (2) Bunting P.M. Bronz #P350-24
37. Lift Cylinders Cessna Two (2) 3x4 MHA43300
38. Snap Rings External Truarc 5100-177
39. Bearings Two (2) New Departure Z99509
3209 Series w/2 seals 1.7717 Bore
3.3454 O.D. .748 width

Hydraulics Group

40. Electric Motor West Va. Armature #55560
20HP 1800 RPM 128V DC Compound Wound
41. Vickers Variable Pump PVB-29 RS 20CC11
29 GPM 2000 psi CW Rotation
42. Hydraulic Motor Air Compressor Drive
Tyrone Gear Type M2-45-5J2-F
43. Filter Return Line Gresen FS251-1A1E
44. Motor Pump Coupling Morse ST 5016C
45. Double Roller Chain Coupling Type FB
Finished Bore Morse Chain #FB5016
 $\frac{1}{2}$ Bore, 1-5/8 w/3/8 Keyway $\frac{1}{2}$ Bore 1 $\frac{1}{4}$ w/5/16 Keyway
46. Steel Cover for Coupling Morse No. ST5016C
47. Closed Center Directional Valve on Pump
5 Sections w. relief valve 2200 psi Husco Model 5000
1 Motor Spool and 4 Cylinder Spools
48. Hitch Cylinders Two (2) Cessna 43240 MBA
2 $\frac{1}{2}$ " Bore x 8" Stroke
49. Hitch Lock Cylinders Two (2) Cessna #43140 KAA
1-1/2" Bore 4" Stroke
50. Motors, Two (2) For Wire Rope Winders
Charlynn Model S 6 cubes #103-1075-007
51. Rubber Mounts, Hungtington Rubber Co. #M602-70-CR Portland, Oregon
52. Adjustable Yokes, McMaster Carr #6071K14

Air Compressor

53. Air compressor Kellogg American 47414
54. Sq.D Micro Switch Class 9007 CO-3 Pressure Control
80-100 psi
55. Solenoid Valve 125V DC DG45H - .012A Paul Monroe
56. Filter Regulator Lubricator Automatic Drain Wilkerson #CB2-03-F00

Electrical System

57. Lights and Switch Gear, West Virginia Armature, Bluefield, W.VA
58. Battery, Two Boxes 32 Cells each, Series connected, 128 V system, 680 Amp hour. General Battery 26.38" wide 53.78" long 23.88: high 8000 lbs. weight.
59. Low Battery Indicator, Batteries Inc. Sprague, W. VA.
Pow-R-gard 850 Anderson Power Products (304)252-6420
Part No.850-1-128
60. Battery Charger Model BC 12789 Serial No.800445, Guyan Machining Co.
Chapmanville W.VA
61. Traction Drive Electrical System Siemens-Allis
Solid State CT-Module AY-ACT-30
 - (2) 250A 125V Fuses - circuit control
 - (2) 10A 125V Buss Fuse Circuit Control
62. Hyd. Pump Control Box Components
Fuse - Mainline 175 Amp. 125V slow blow
Snub Resistors One (1) 250 Ohm 125V - 68 A70-A20C
Two (2) 74GE 148B6203 850 000 ohms 125V
Timer ARTISAN 4 second solid state
Standard GE Two (2) Breakers.
Main Resistor by West VA. Armature

APPENDIX b

ELECTRICAL SCHEMATIC DRAWING

