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MOBIL RESEARCH AND DEVELOPMENT CORPORATION

RESEARCH DEPARTMENT

TECHNICAL MEMORANDUM NO. 67-23

AERIAL PLATFORM AND ROOF BOLTER

ANVIL POINTS OIL SHALE RESEARCH CENTER

Rifle, Colorado

September 29, 1967

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C. to JCK - WRB

C. pp 1-3 only to JRC

The primary object of the Anvil Points Oil Shale Research Center TECHNICAL MEMORANDUM is to advise authorized personnel employed by the Participating Parties(1) that various activities are in progress or that certain significant data have been obtained within the Research Center.

These TECHNICAL MEMORANDA have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses. The TECHNICAL MEMORANDA have not been edited in detail.

(1)Mobil Research and Development Corporation, Project Manager

Continental Oil Company
Humble Oil and Refining Company
Pan American Petroleum Corporation
Phillips Petroleum Company
Sinclair Research, Inc.

AERIAL PLATFORM AND ROOF BOLTER

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AERIAL PLATFORM AND ROOF BOLTER

I. GENERAL INTRODUCTION

The Green River Formation at the Anvil Points Mine is a flat-lying, sedimentary, marlstone containing beds rich in kerogen. The 73 foot thick Mahogany Ledge is the thickest mineable layer of kerogen-rich marlstone present in the Green River Formation at Anvil Points. The Mahogany Ledge has an average Fischer Assay of 30 gallons per ton but is composed of alternating rich and lean beds. The upper part of the 73 foot thick layer is mined by driving headings, and the lower part is mined by benching the floor of the headings.

The heading operation at the Anvil Points Oil Shale Mine employs headings 40 feet high in order to provide ore with Fischer Assay near 30 gallons per ton. The roof must be bolted, and all loose rock must be scaled from the ribs. Sag measuring instruments had to be read in the roof; high faces have to be powdered; and general access is needed in the high stopes. To provide access and perform the above jobs, the Truco-Denver telescoping boom-type aerial platform was purchased. Scaling was done manually from this platform because of the limited mining research program budget. A rotary percussion drill rig, mounted on the aerial platform, was used to drill holes and install roofbolts.

II. SUMMARY AND CONCLUSIONS

A. Aerial Platform

The Truco-Denver aerial platform is an efficient and versatile machine, providing access to high stopes for powdering rounds, hand scaling the roof and the ribs, rockbolting, instrument reading and various jobs on the pillar ribs. This machine has performed satisfactorily throughout the project, with the exception of a few design problems when it was first received from the manufacturer. The selection of this rig was based on its applicability to the above mentioned functions. The other alternative was to purchase separate machines for the different functions, which would have increased the cost of the project quite considerably. For a production mine, a specially designed roofbolting rig would be preferable to a combination aerial platform, scaler, bolter, etc. Although hand scaling will always be necessary, a mechanical scaler would also be required to do the heavy scaling, and this again would be a specially designed rig.

B. Roof Bolter

A rotary percussion-type drill (Gardner-Denver D93HRR) was used for roofbolting. Penetration rates in the roofstone were about 4 feet per minute. Penetration rates could be improved by increasing the stroke rate and rotation rate. For rotary percussion drilling roofbolt holes, steel and bit costs were 0.276 cents per ton. Rotary drilling of roofbolt holes has the advantages of lower steel costs, less noise produced, less power needed, but a stronger supporting platform is required to take higher thrusts. More research is needed to determine penetration rates of rotary drills in the roofstone.

III. DETAILED DISCUSSION

A. Aerial Platform

1. Introduction

In order to scale, load explosive, read roof instruments, and roofbolt in the 40 X 60 foot headings and scale at 75 foot heights economically in a short range project, a multi-purpose aerial platform was needed. The Truco-Denver aerial platform, designed to perform the above jobs, consists of a 4 X 6 foot platform supported by a telescoping boom. The telescoping boom is built of a special high tensile strength steel (Ex-ten) in order that it would be light enough to mount on a standard truck. Figure 1 shows a sketch of the aerial platform.

2. Drive System

All the movements of the boom are powered by hydraulic pistons and motors. There are two fixed displacement hydraulic pumps, one driven by the truck diesel engine and the other driven by a 50 HP, 3 phase, 440 volt electric motor. The hydraulic pumps provide fluid pressure and fluid volume to the pistons which raise the telescoping boom, the pistons which telescope the boom, and the pistons which operate the outriggers. A small fixed volume hydraulic motor operates the turret rotation through a reduction mechanism. A fixed displacement hydraulic motor powers the roofbolting drill rotation. Compressed air and water from an external source are piped up to the roofbolting drill through retractable hoses.

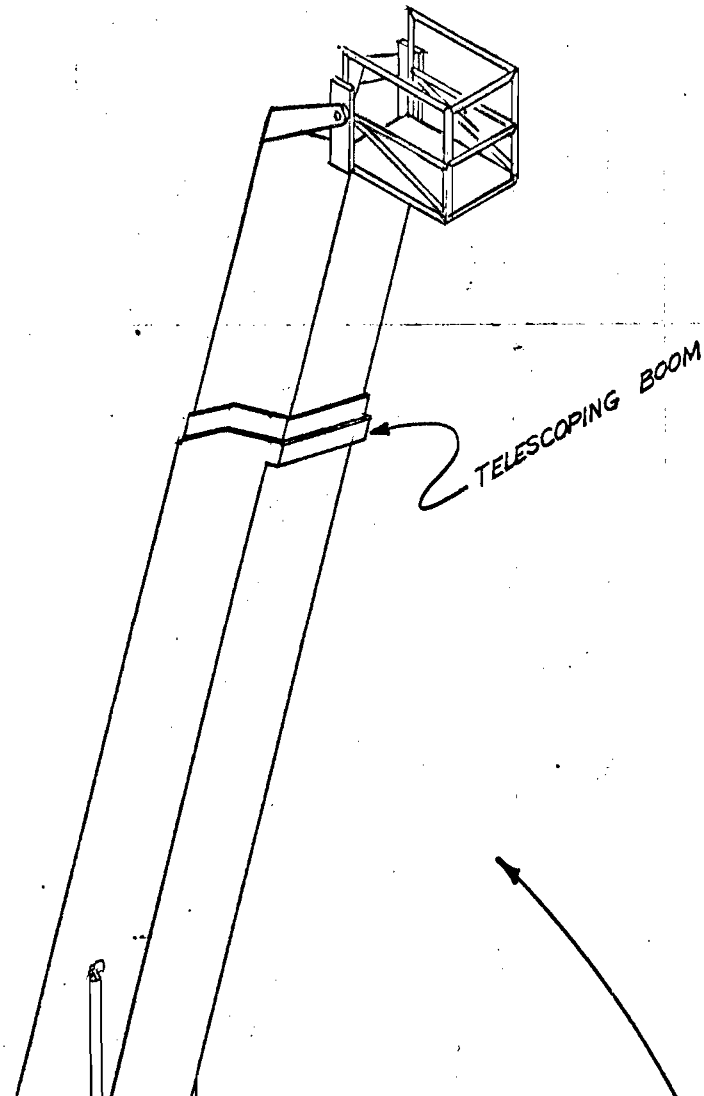
3. Control System

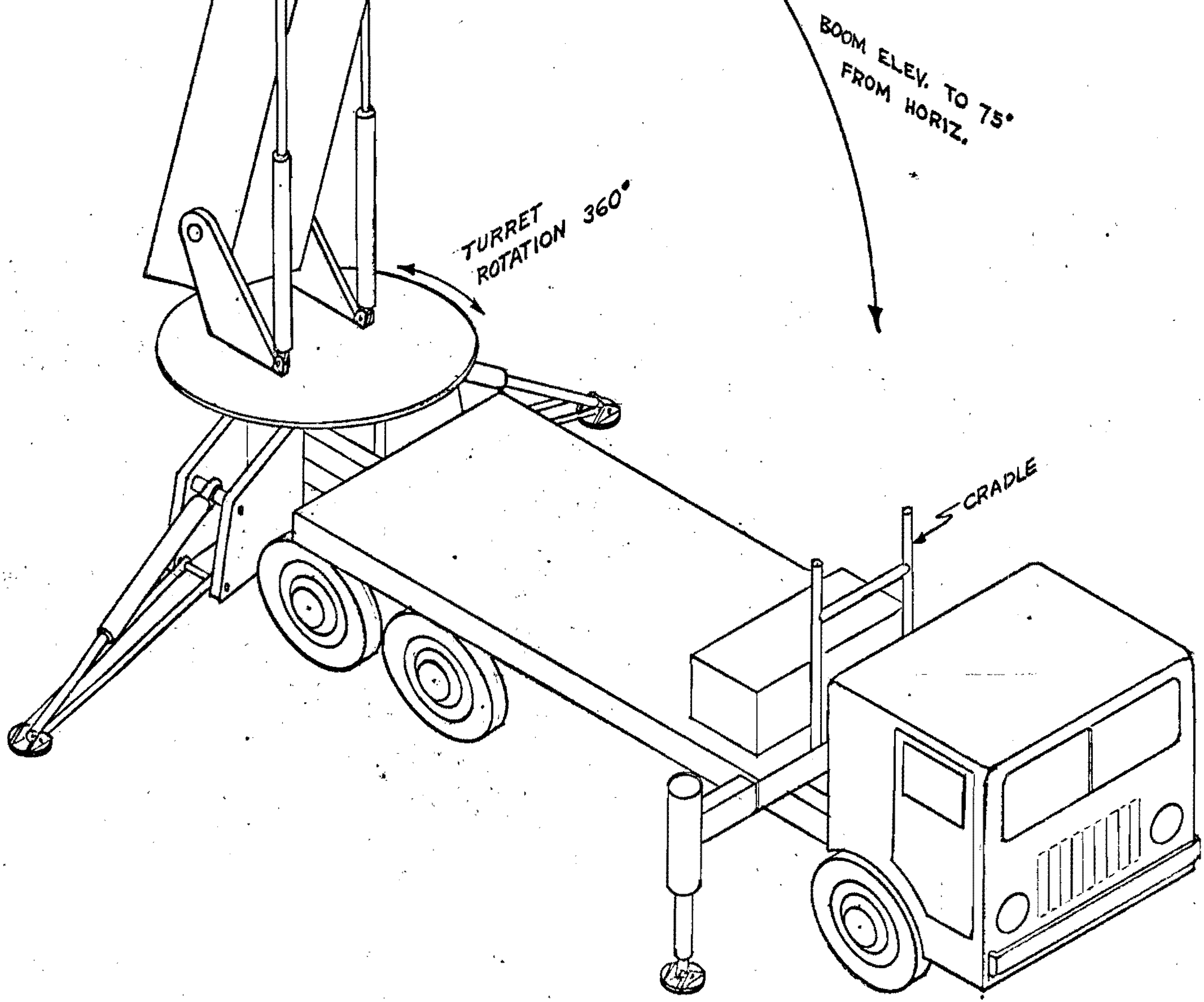
The movements of the boom can be controlled either at a panel on the operating platform or at a panel on the turret platform. At either of these two positions there are electrical switches which operate solenoid controlled 4-way valves diverting hydraulic fluid to the various pistons and the turret motor. After the desired switches are closed, the operator depresses a foot pedal which adjusts the useful displacement of the pump being operated. The foot pedal operates an air piston-valve that controls the flow of hydraulic fluid from the constant displacement pumps to the various pistons and turret motor. When the foot pedal is not depressed, all the fluid displaced by the pumps bypasses back to the hydraulic reservoir. Figure 2 shows the principle of control for the boom movements schematically.

FIGURE 1

AERIAL PLATFORM

TRUCO 7580




BOOM ELEV. TO 75°
FROM HORIZ.
TURRET
ROTATION 360°
CRADLE

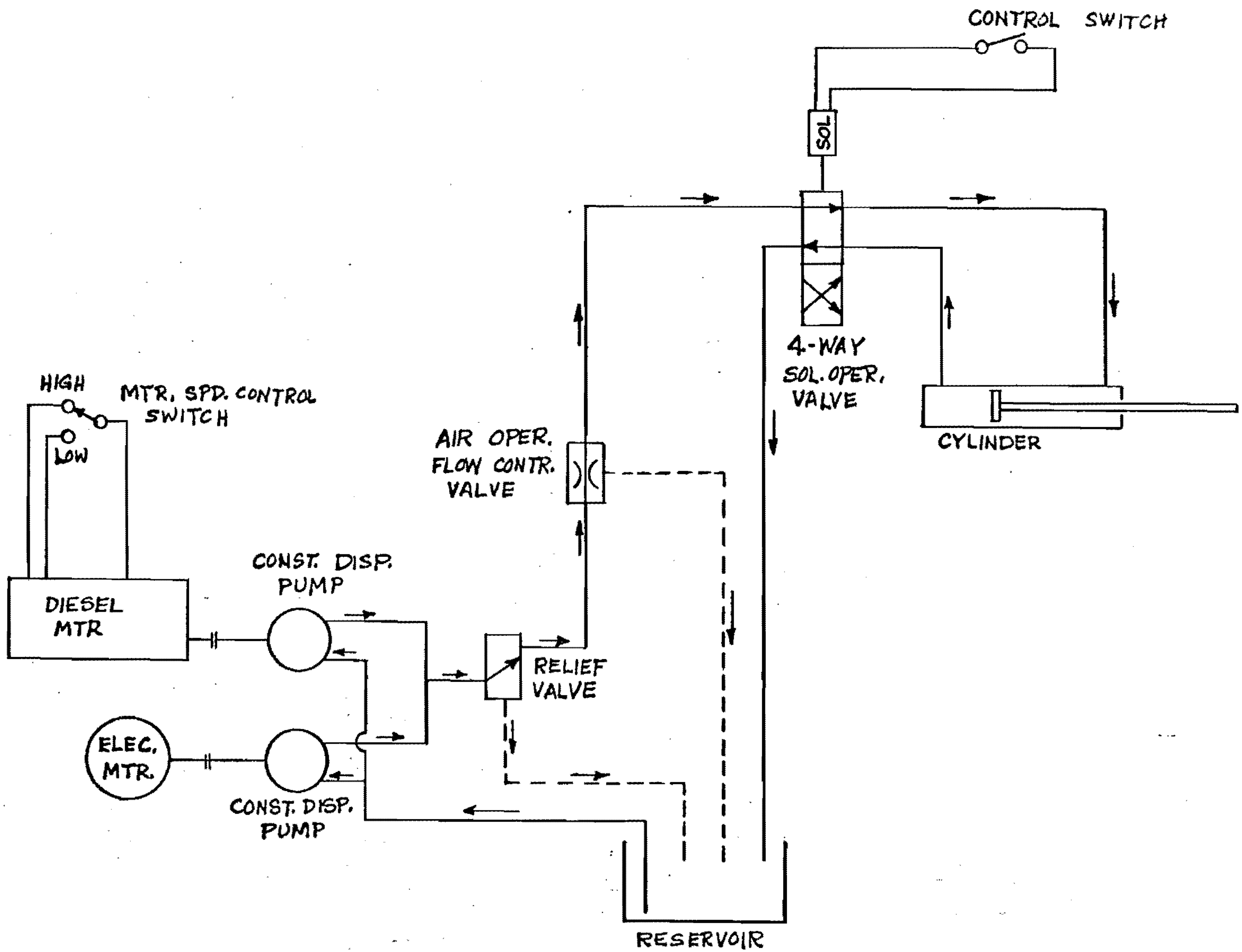


FIGURE 2

BOOM CONTROL SYSTEM

SCHEMATIC

If the pump driven by the truck diesel engine is being operated, two displacements of the pump are available by altering the truck engine RPM. A switch on the control panel operates a solenoid switch that is attached to the diesel engine throttle. If this switch is open, the engine idles; but if the switch is closed the engine operates at approximately 1000 RPM. When the pump is being driven by the electric motor only one displacement is available, which is equivalent to the greater displacement mentioned above.

The four outriggers are controlled by manually operated valves mounted on the truck bed. For safety, check valves prevent any of the pistons or the turret rotation system from losing pressure under load. The operating platform is automatically kept level as the boom is raised or lowered. To keep the operating platform level, there are two hydraulic pistons, connected between the platform and the upper end of the boom. These are in a closed hydraulic circuit with two similar hydraulic pistons connected between the turret and the lower end of the telescoping boom. As the boom is raised, the lower pistons are extended, causing fluid to flow to one side of the upper pistons thereby maintaining the operating platform in a level position. Should fluid be lost from the closed circuit or if the truck is parked on a significant grade, a hand pump located in the cage (operating platform) can be used to level the platform.

A limit switch on the turret prevents turning the turret more than 420° in one direction, protecting hoses from being twisted to failure. When cradling the boom for transport, a limit switch prevents putting a significant downward force on the cradle, protecting the turret from a large bending moment. The movements that can be executed by the boom are: (1) boom raise and lower, (2) boom extend and contract, and (3) rotation of the boom on the turret.

4. <u>Structure</u>

The telescoping boom of the Truco-Denver aerial platform is constructed with a special high tensile strength steel (Ex-ten) supplied by United States Steel Corporation. The advantage of using the special steel is that the boom can be built light enough with Ex-ten to mount on a standard truck, and yet have sufficient strength to extend to 80 feet in length. The telescoping boom is composed of fixed boom and two extension stages that have a box-like crossection about 25 X 16 inches. The fixed boom is built from 1/4 inch thick Ex-ten plate, and the first and second stages are built from 3/16 inch Ex-ten plate.

The second stage of the telescoping boom started to buckle just after the aerial platform began service in November 1966. The cause of the buckling was under-design of the second stage box section which had been built of regular carbon steel. The second stage section was replaced by Truco-Denver after having been re-designed and built of Ex-ten. Figure 3 shows the maximum loads on the operating platform that the boom is capable of supporting. At low angles of less than 45^{o} it is not possible to roofbolt, otherwise the structure would be overloaded. All the roofbolting has been carried out from the heading floor which is 40 feet below the back. However the rig could be used for roofbolting from the floor of the bench, provided the angle of the boom is kept above 60^{o}.

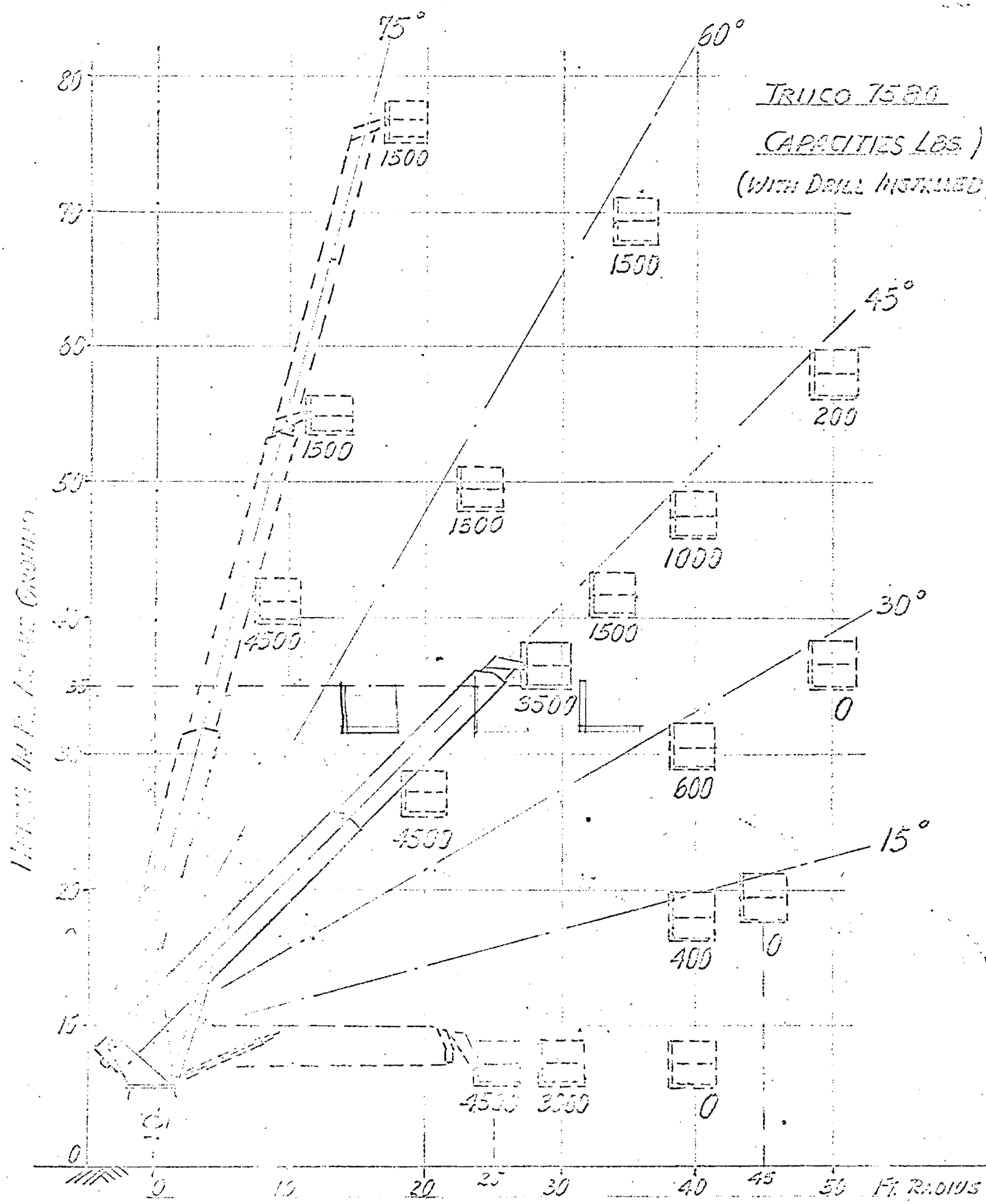
A structural failure occurred when the cradle limit switch was out of order. The boom was cradled, and a considerable downward force on the cradle built up before the operator released the hydraulic pressure on the boom lift cylinders. As a result the lower brackets of the boom lift cylinders were broken, and the turret structure was cracked and warped. Truco repaired and modified the structure, they installed a more reliable limit switch on the cradle and reinforced the brackets on the boom lift cylinders.

Another structural failure occurred at the point where the rear outrigger cylinders join the truck frame. This failure was caused by parking the aerial platform on a slope and jacking the rear wheels of the truck off the ground with the outriggers. The component of gravity parallel to the long axis of the truck caused a bending moment at the above mentioned joint. The bending moment was aggravated by dynamic loads through movement of the telescoping boom. Failure at this joint finally occurred. Truco strengthened the joint where the rear outriggers join the truck frame by gusseting. They also built a longer rear bumper and installed two hydraulic jacks on it. These two additional jacks level the truck and take the load off the outriggers thus eliminating horizontal forces on them.

5. Discussion of Design and Recommended Changes

It was found that when using the aerial platform for scaling at heights greater than 40 or 50 feet,

FIGURE 3



TRUCO 7580
CAPACITIES LBS.
(WITH DRILL INSTALLED)
75°
60°
45°
30°
15°
1500
1500
1500
1500
1500
1000
200
4500
3500
0
600
4500
400
0
4500
3000
0
0
10
20
25
30
40
45
50
FT. RADIUS
80
70
60
50
40
30
20
10

falling rocks developed enough velocity to bounce from the floor or lower rib and damage the outriggers or vulnerable hydraulic hoses. Since damaged outriggers or broken hoses could endanger the safety of the scalers, shields had to be built for the outriggers and vulnerable hoses.

The Truco-Denver telescoping boom-type aerial platform has proven versatile and adequate for the mining operation at Anvil Points. For a production operation, scaling by hand is out of the question. Therefore, an aerial platform would only be required for checking the condition of the back and ribs after mechanical scaling. For high speed roofbolting of the roof exposed by a heading round, the telescoping boom-type aerial platform could not support a sufficient number of roofbolting drills, nor could it install a regular pattern of bolts efficiently. In a production operation several roofbolting drills on a platform would be needed plus the necessary bolts and operators. A typical production machine is shown on Figure 6. Possibly, rotary drills, which require quite large thrusts, would be used.

The telescoping boom-type platform is best suited for powdering a heading round and such odd jobs as installing temporary ventilation stops, inspecting high ribs and hand scaling where necessary, reading roof instruments and installing wiring, lights, etc. Figure 4 shows an aerial platform of the "linkage" or lever type. It would perform the same jobs as a telescoping boom-type platform.

A production roofbolting aerial platform must be designed to support several drills, the drills' combined thrust, the operator(s), and a supply of roofbolts. If rotary drills are used, the required thrust for each drill will probably be near 4000 pounds for drilling a 1 5/8 inch diameter hole. Figure 5 shows an aerial platform capable of supporting a large load but having room for only two drills, and requiring several setups to roofbolt the area exposed by a standard heading round. Figure 6 shows a platform capable of supporting a large load and having a large area on which to mount drills. In this case the height of the machine would be inflexible and limited to single level bolting.

B. Roof Bolter

1. Description

The roofbolting drill, Gardner-Denver Model D93HRR, is a rotary percussion type rock drill. A fixed

FIGURE 4

80 FT. TRUCK MOUNTED SCALER AND DEVELOPMENT ROOF BOLTER

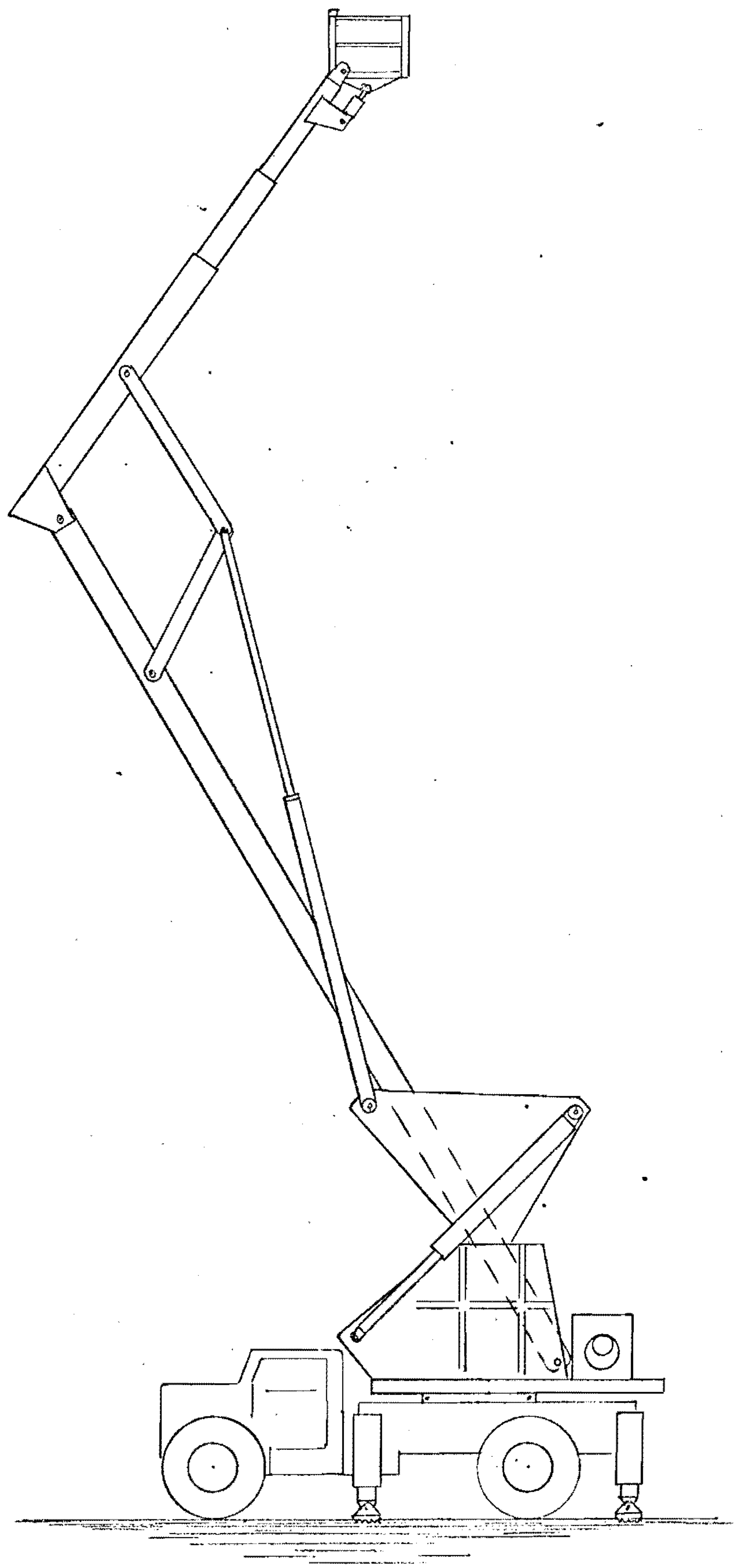


FIGURE 5

ROOF BOLTER FOR HIGH ROOF

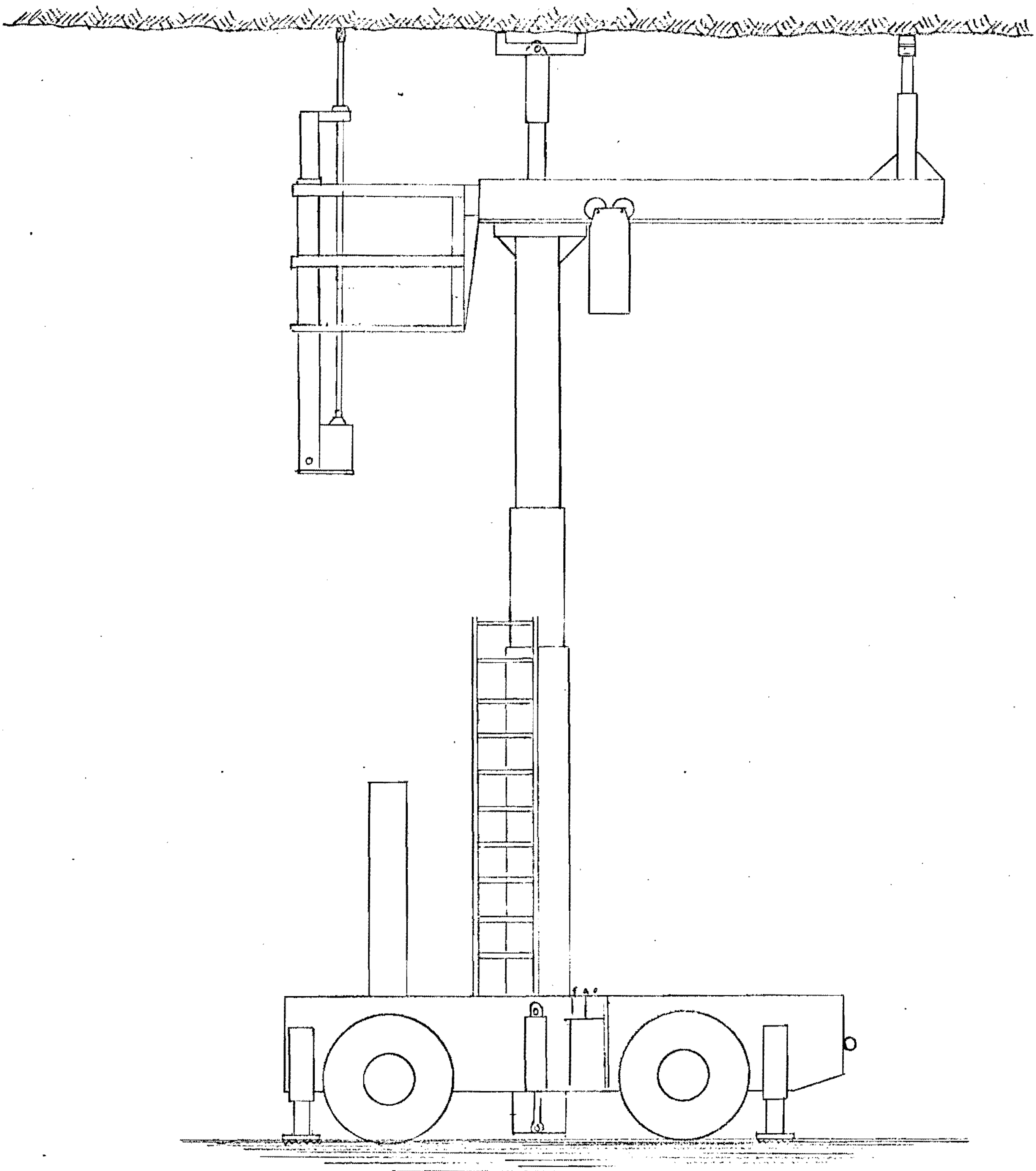
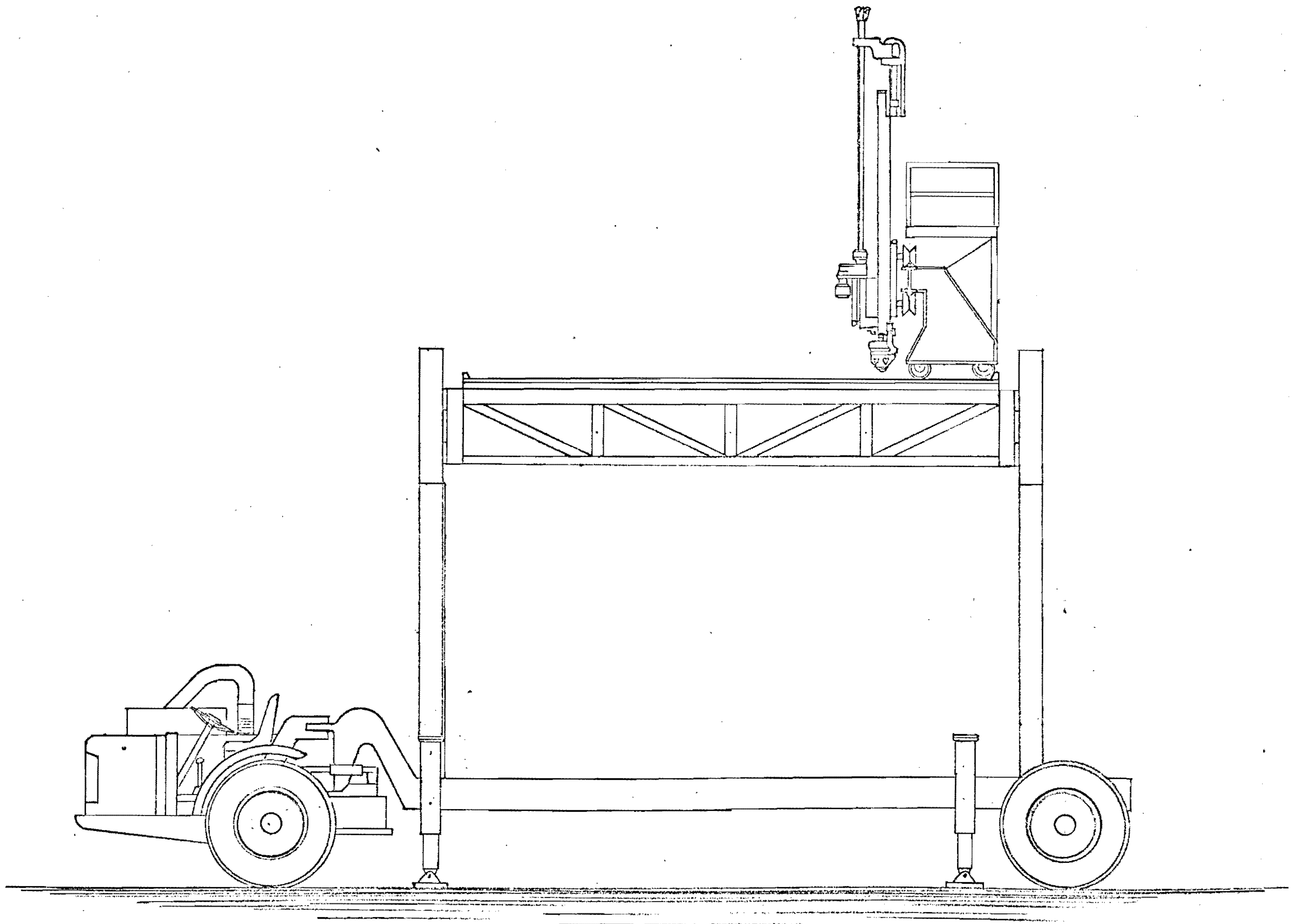


FIGURE 6

ELEVATOR TYPE ROOF BOLTING JUMBO
FOR 40 FT. BACK HEIGHT



displacement hydraulic motor provides two drill steel rotation speeds, 130 RPM and 180 RPM. Two engine speeds on the truck diesel provide the two rotation speeds. A 3 1/2 inch hammer makes about two thousand 110 foot pound blows per minute using 100 psig air. Thrust is maintained by an air motor driven screw. Maximum thrust is 1800 pounds. Water is injected through the center of the drill steel to control dust. The free air requirement for the D93HRR is 390 cfm at 100 psig.

2. Performance

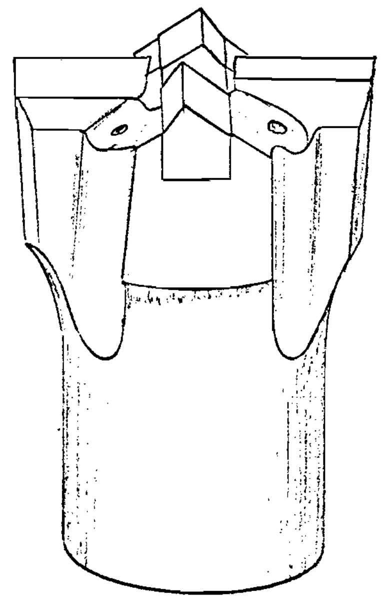
Using standard 1 5/8 inch "X" percussion bits, the roofbolting drill would penetrate 3.60 feet per minute. With rotary-percussion 1 5/8 inch bits penetration rates were 4.30 feet per minute, but rotary-percussion bits had much shorter lives than the standard percussion bits. (Technical Memorandum No. 67-26 "Time Studies of Mining Operation" by J. B. Sellers.) Figure 7 describes the two bit types used.

The performance of the roof bolter can be improved. A regression analysis of the data presented in Technical Memorandum 66-1 shows that the RPM should be near 400 for optimum penetration rates. By increasing the air pressure, the stroke rate would be increased and also the penetration rate.

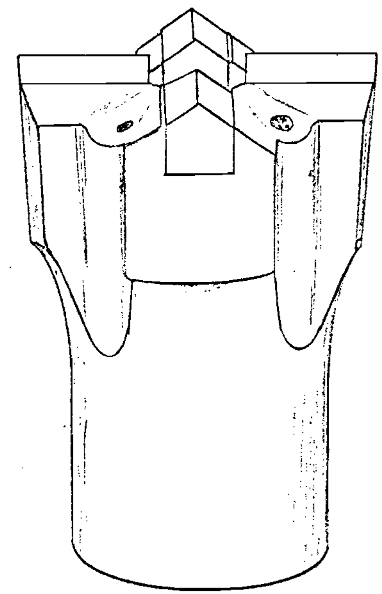
The reason that the D93HRR has such a slow rotation rate (180 RPM) is that it was designed to tighten roofbolts as well as to drill. In order to tighten bolts properly, the fixed volume rotation motor must be capable of delivering 200 foot pounds torque at an almost stalled rotation rate. Such a fixed volume hydraulic motor necessarily has a limited rotation rate when used with a fixed volume pump. A production roofbolting system could use a separate impact tool to tighten bolts, so that the drill can operate at optimum rotation rate. A variable displacement rotation motor driven by a constant volume pump would solve the problem. This type of motor is built by New York Air Brake. For tightening bolts, the motor would be adjusted to maximum displacement (lowest RPM), and for drilling the displacement would be decreased allowing higher RPM's.

The penetration rates reported above are known to be on the low side even for the drill as installed. After a few weeks of operation, dirt and sludge from the drilling operation entered the ports and the chuck bearing area, clogging up the hammer mechanism.

FIGURE 7



ROTARY PRECUSSION BIT



STANDARD PRECUSSION BIT

ROCK BIT TYPES

This slowed down the penetration rates quite radically, and although seals were put on the drill steel and a silencer put on the exhaust it was a continuous problem. This will always be a problem with rotary percussion drills drilling vertically upwards, however it would not be a problem on rotary drills.

3. Steel Costs

The type of steel used for drilling roofbolt holes was 1 1/8 inch round carburized steel, 102 inches long with 1 1/8 inch hexagonal ring seal shank and 1" X 11° taper. Average steel life for roofbolting at the Anvil Points Mine was 680 feet of 1 5/8 inch hole per steel. This translates to 6 cents per foot of 1 5/8 inch hole or 0.204 cents per ton for mining a 75 foot thick layer of oil shale (using a 6 X 6 foot bolt spacing). The average life of standard 1 5/8 inch percussion bits for roofbolting was 228 feet. This translates to 2.08 cents per foot of 1 5/8 inch hole or 0.072 cents per ton. The total steel and bit cost observed at the Anvil Points Mine is 0.276 cents per ton using rotary percussion drills. It must be noted that the observed steel costs for rotary percussion drills includes the cost of several damaged steels resulting during the training period of the miners.

4. Comparison of Rotary and Rotary Percussion Roof Drilling Methods

Table 1 is a comparison between rotary and rotary percussion drilling methods for drilling 1 5/8 inch roofbolt holes. As can be seen from Table 1, rotary drilling has advantages over rotary percussion drilling regarding the following factors: steel cost, bit cost, power costs and noise characteristics. Rotary drilling has the disadvantage of requiring a more expensive supporting platform to drill roofbolt holes. More research is needed to compare penetration rates between the two methods of drilling roofbolt holes. Considering the advances in rotary drilling technology since the U. S. Bureau of Mines did the rotary drilling experiments in oil shale, rotary drilling of roofbolt holes may be the better of the two methods.

TABLE 1

COMPARISON BETWEEN ROTARY PERCUSSION AND ROTARY DRILLING METHODS FOR DRILLING 1 5/8 INCH ROOFBOLT HOLES

Factor	Rotary Percussion	Rotary
Thrust	<1800 pounds required	≈4000 pounds required
Rotation Rate	≈400 RPM	?
Penetration Rate	3.60 fpm with standard percussion bits[(2)] 4.30 fpm with R-P bits[(2)] 7 fpm observed when D93HRR drill was new.	4 fpm[(3)]
Steel Cost	0.204 cent per ton[(2)]	0.006 cent per ton[(4)]
Bit Cost	0.072 cost per ton[(2)]	0.054 cent per ton[(4)]
Power	Compressed air and hydraulic. Compressed air power is more expensive than hydraulic power.	Hydraulic
Noise	May damage operator's hearing	Low noise.
Supporting Platform	Lower thrust means less investment for supporting platform.	High thrust for each drill requires that supporting platform be built stronger.

(1) Drilling 7 foot roofbolt holes in the strata of the Anvil Points Mine roof.

(2) Observed at Anvil Points Mine.

(3) Bureau of Mines Bulletin No. 611.

(4) Technical Memorandum No. 66-5 by J. B. Sellers

FWBrackebusch
9/29/67

IV. REFERENCES

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4. Technical File 310.00 - 319.99, Refer to Technical Memoranda by C. J. Verdeur on file system for access information.