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A Portfolio of Advanced Mining Equipment Ideas

George L. Wilhelm

Mining 204
Spring Semester, 1958

A Paper
Submitted to
Professor Koehler S. Stout.

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May 10, 1958
MONTANA SCHOOL OF MINES
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GEORGE L. WILHELM, RESEARCH FELLOW
GRADUATE SCHOOL

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BUTTE, MONTANA

May 10, 1958

Professor Koehler S. Stout
Mining Department
Montana School of Mines
Butte, Montana

Dear Professor Stout:

I hereby respectfully submit the following paper, A Portfolio of Advanced Mining Equipment Ideas, in partial fulfillment of the requirements for Mining 204, Special Investigations.

This paper presents, as a series of idealized sketches and accompanying descriptions, several equipment ideas applicable to underground mining methods of materials handling, drilling, mucking, and rock transportation. The demand for new designs in mining equipment is shown by the enveloping concern of the mining industry toward expanded, efficient mechanization of its operations to reduce costs of mining and development.

It is hoped that some of these equipment ideas will pattern the design of practical mine machines which reduce cost of mining, and result in faster, safer, mining methods.

Respectfully submitted,

George L. Wilhelm

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PLATES

A PORTFOLIO OF ADVANCED MINING EQUIPMENT IDEAS

INTRODUCTION

This paper presents a series of idealized sketches and accompanying descriptions of mining equipment. The ideas contained herein apply broadly to the mechanization of underground mining and development. Considered here are new techniques of material handling, drilling, mucking, and rock transportation.

Essentially, the main purpose of the sketches is to present ideas and principles; consequently, they lack mechanical detail, dimensions, and construction development. Without exception, each sketched idea requires considerable additional evaluation of the principle, and elaboration of the mechanical details to justify additional development. In fact, to broaden the scope of this particular paper, the writer has purposely paid little attention to these details, other than to proportion the over-all dimensions to the approximate size required by the service for which the equipment is intended.

In general, these ideas have originated as products of informal discussion among several students. The presentations here have developed from numerous rough sketches drawn during discussions relating to the mechanization of underground metal-mining operations.

Incidental to the main topic of mining equipment development is the general interest expressed by students in the advancement of mining equipment and techniques. This interest is especially evidenced by the lively and absorbing discussions of this topic, and further indicated by the efforts of undergraduate students to develop various ideas and techniques in model constructions and special investigations. Exceptional examples of this activity are the presentations of Walter J. Smit on the Application of the Rotary Principle to Underground Mucking, The Mechanical Hoe, by Moske Sheinkin; and Report on Shaft Mucker Design, by P. J. G. du Toit. These papers are on file in the Mining Department of the Montana School of Mines.

This paper desires to give special acknowledgment to the contributions of Professor Koehler S. Stout, associate professor of mining, to Mr. Jeremy C. Farmin, mining engineer, and to students. Each has participated in the development of the ideas presented in the following text.

MONO-RAIL FORKED LIFT

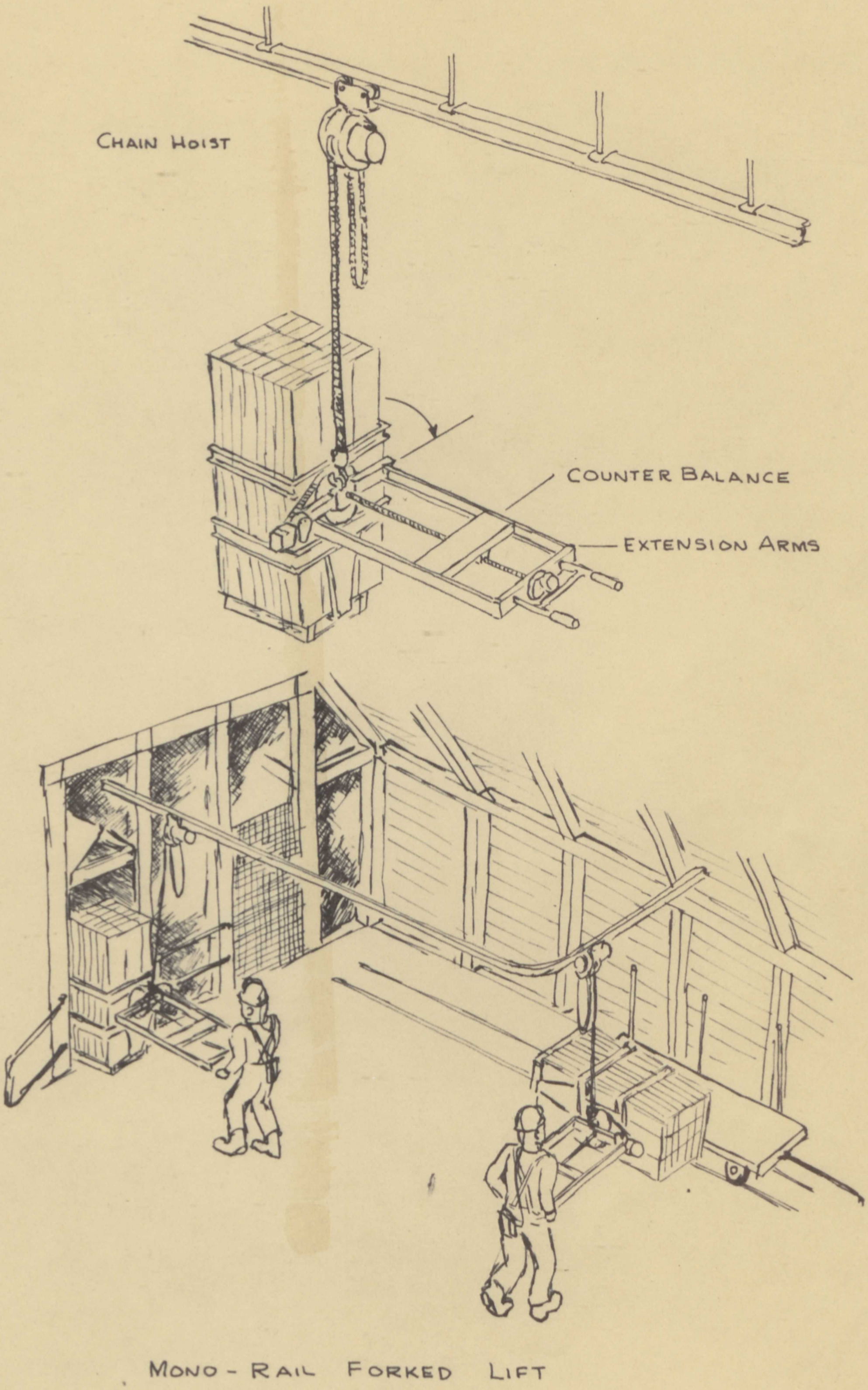
Handling timber through small shafts in narrow service cages often poses a problem to mine operators, wherever, of course, these conditions exist. Many mines have attacked this problem by standardizing timber sizes, and by delivering timber to the mine as banded bundles. Often the situation obtains where this bundle must be broken while the service cage is being loaded or unloaded. Whether intentional or not, bands are broken because of the inability of the cager to handle the bundle as a single unit.

Commonly, the timber bundle is handled on the surface by fork-lift truck. The fork-lift truck has not been adapted for underground use, and the bundle is usually broken for single-piece removal from the cage. The mono-rail forked lift is an adaptation of the rotary-lift mechanism of the fork truck to underground use at the shaft station.

The mono-rail forked lift consists of several forks mounted to counter-balancing extension arms. As illustrated in Plate 1, the entire unit is suspended and guided by an overhead mono-rail chain hoist. The fork assembly is connected through a gear train in such a manner that the forks and the load can be slowly rotated in a 90 degree arc. To allow adjustment of the balance of the lift and load, the counter balance is mounted to a feed screw.

For the removal of a bundle from a small cage, the lift is guided to place the forks around the load, the lower extension fork being placed under a pallet under the upright bundle. The lift and load are then tilted back by movement of the counter balance to a rear position. The operator then guides the balanced load from the cage. A turntable motor rotates the timber bundle 90 degrees to a horizontal position, after which the bundle is raised to a convenient height by the chain hoist, and guided by the overhead mono-rail to a spotted timber truck.

Plate 1 shows a sketch of the mono-rail forked lift and illustrates its use in shaft stations for handling bundled timber as a single unit. By eliminating the handling of individual timber pieces operators can save considerable time and labor, as well as prevent an accumulation of loose timber in the station area, and thus materially reduce a common hazard around shaft stations.



MONO - RAIL FORKED LIFT

PLATE 1.

G·L·W FEB., 1958

IN-THE-HOLE UNDERGROUND ROCK DRILL

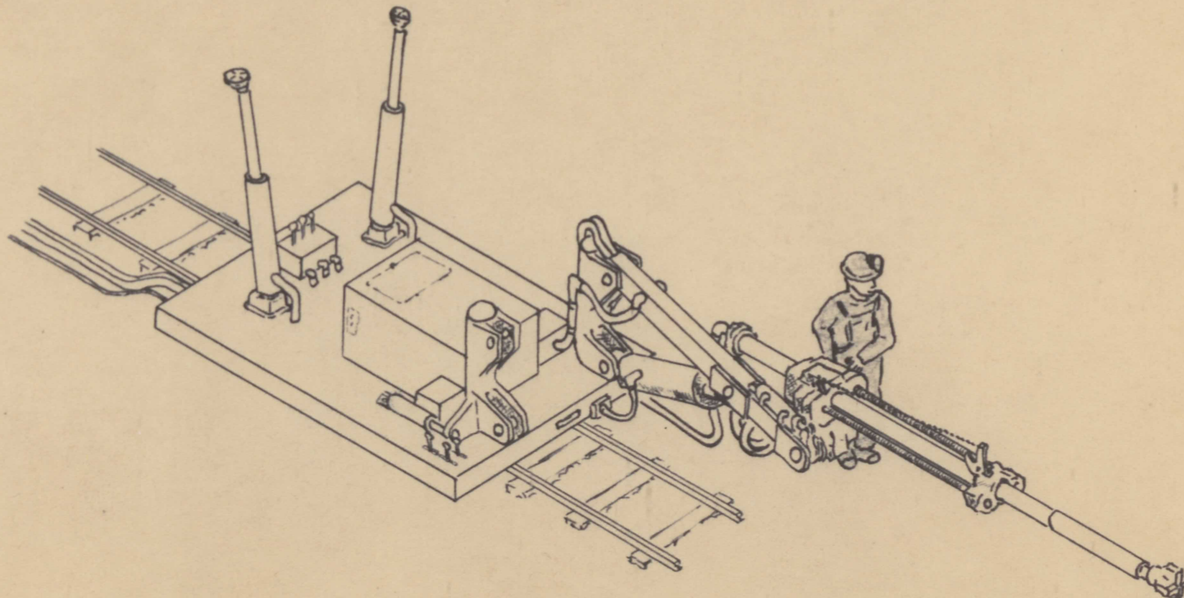
Numerous new techniques of rock drilling and rock breaking are being developed for more efficient advancement of underground shafts and level development.

The practice of using fewer and larger-diameter drill holes has not been widely applied as a means of speeding underground development. The absence of an efficient rock drill to drill large-diameter holes underground may be one reason for the lack of application on this method. One possible technique to advance a heading employs large drill holes around the periphery of the opening, which act as a free face, and prevent unnecessary shattering of the wall rock from the explosive placed in a few, large-diameter center holes.

The "in-the-hole rock drill" is proposed to provide a satisfactory large-bore drill for underground use in drifting and shaft sinking. This drill is shown in Plate 2 as it would be mounted on a track jumbo. Plate 3 illustrates the basic mechanism of the rotating and thrust elements. Percussive action is developed by the application of the commercial "in-the-hole" drill on a single-section drill stem. The continuous drill stem is advanced through the rotative transmission by two side screws that feed the drill stem in several cycled advances of the feed mechanism. Rotation to the drill stem is transmitted from the rotative transmission by a ball-bearing sleeve. The balls bear on the drill stem in splined grooves.

This proposed application of a large-diameter continuous drill stem eliminates steel handling and reduces nipping. Too, with the "in-the-hole" drill, normal percussion fatigue of the drill stem is eliminated. Other possible advantages of the drill are (1) the independent control of thrust and rotation and (2) positive pull out.

It is more difficult to assess the advantages of large-diameter drill holes in a drill pattern; however, large holes and fewer holes might be possible. Large-diameter explosive could be used, with resultant reduction of powder handling. The merit of a large-diameter drill hole pattern must be justified by experimentation.

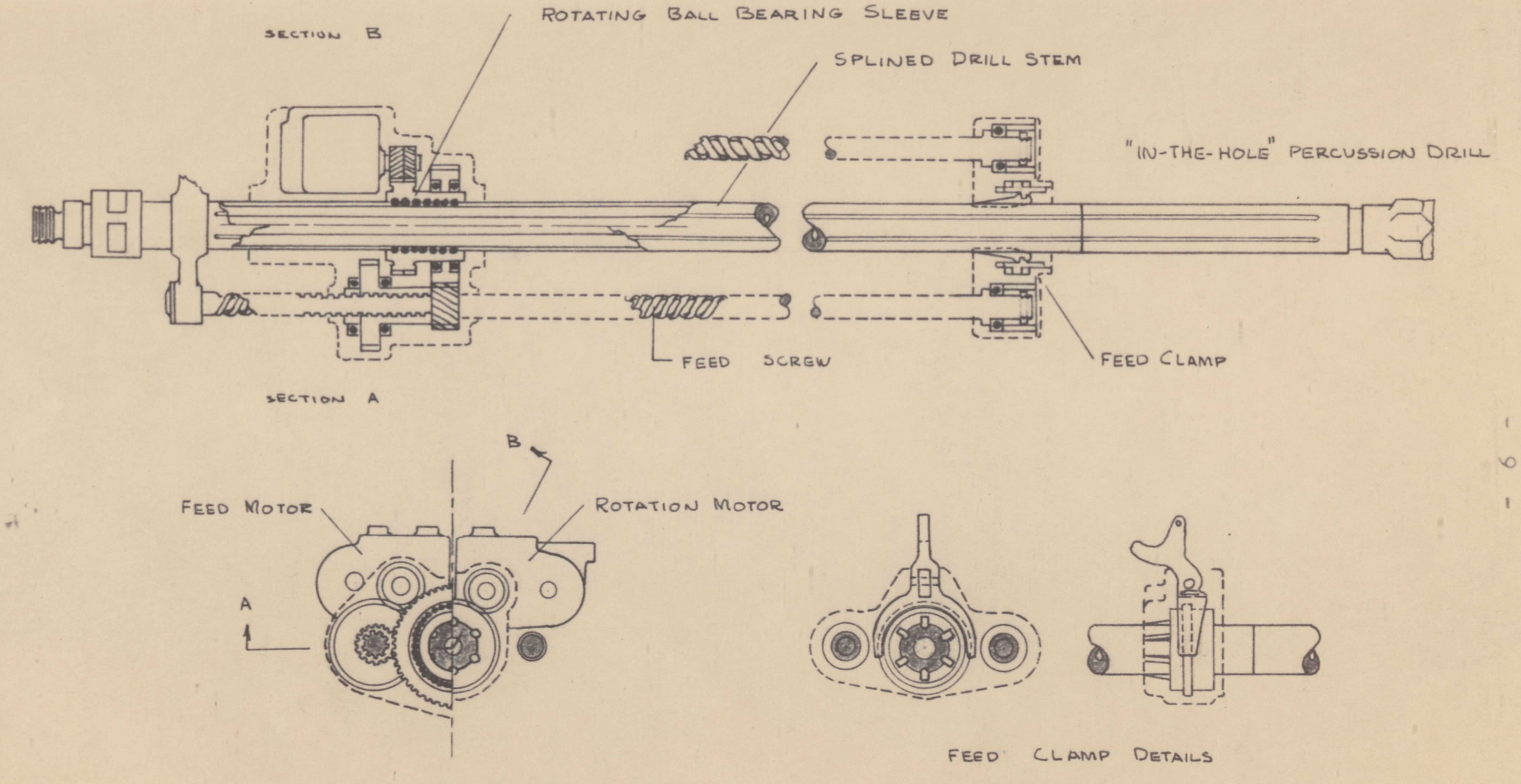


JUMBO MOUNTED "IN-THE-HOLE ROCK DRILL

PLATE 2

G.L.W

APRIL, 1958



IN-THE HOLE UNDERGROUND ROCK DRILL

PLATE 3.

G·L·W APRIL, 1958

MECHANICAL MUCKERS

Several students of Montana School of Mines have furnished the precedents for the development of the following two mucking principles. Basically, these ideas adapt continuous mucking to the mining cycle in underground metal-mine development.

Rotary Mucker

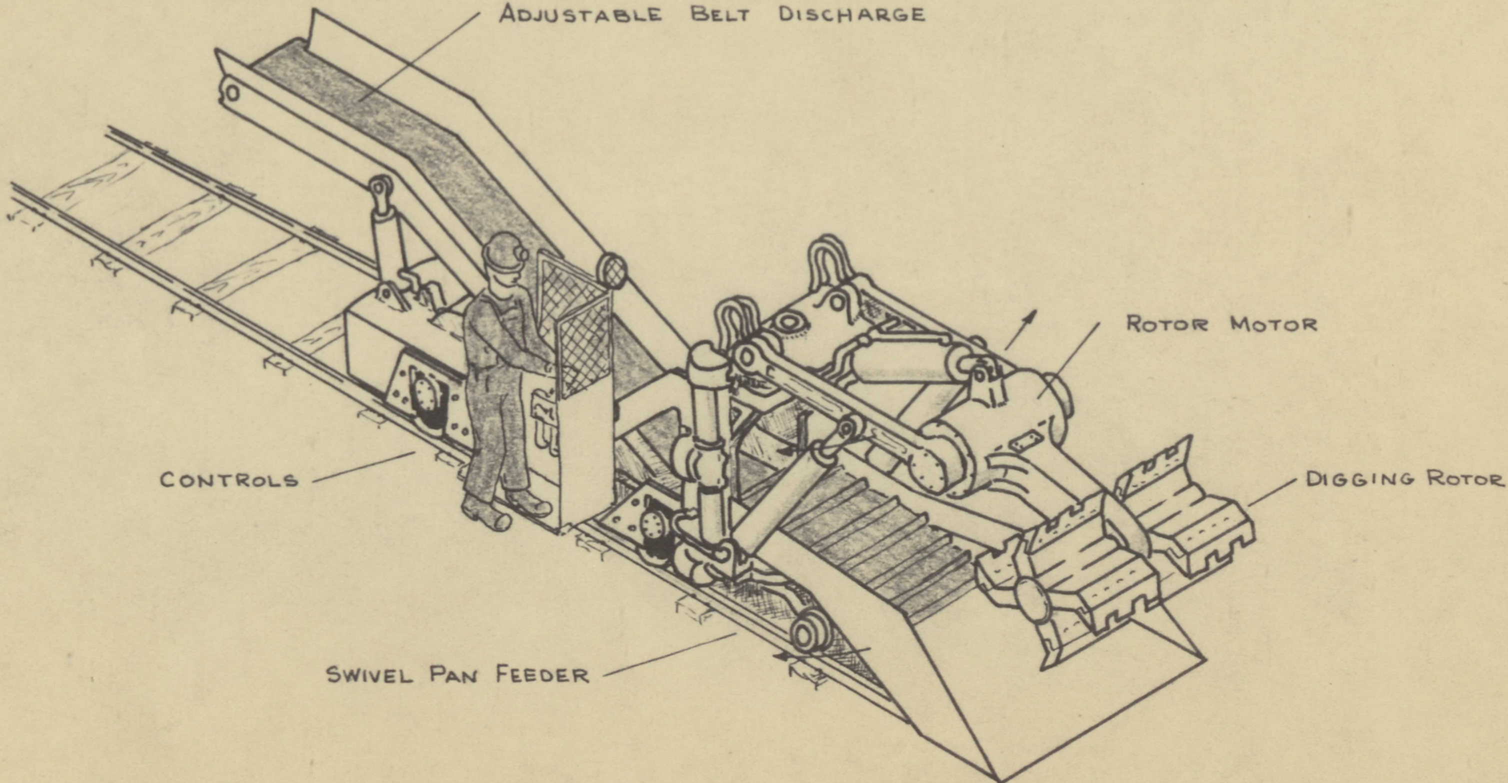
The rotary mucker, illustrated in Plate 4, consists of a heavy, forked rotor mounted on a flexible boom ahead of the traction frame. By a hydraulic motor in the boom, rotation is developed through a differential gear train. Throttling of the oil flow to the motor provides speed control of the rotor.

Hydraulic Boom Mucker

The hydraulic boom mucker, illustrated in Plate 5, is an adaptation of a principle developed by Moshe Sheinkin in a thesis submitted to the Mining Department of the Montana School of Mines. The hoe is mounted on a hydrolic extension cylinder and positioned by two smaller cylinders.

Common to both mucking machines are pivoted mountings of the booms, which permit operation on either side of the axis of the superstructure. This positioning of the boom of the rotary mucker is also followed by the swiveling of the pan feeder, in order to receive the muck for delivery to the discharge belt. Both machines having belt-discharge feeds, they are especially adapted to a continuous-type train loader. The application of crawler or track tractions could well be provided in either loader.

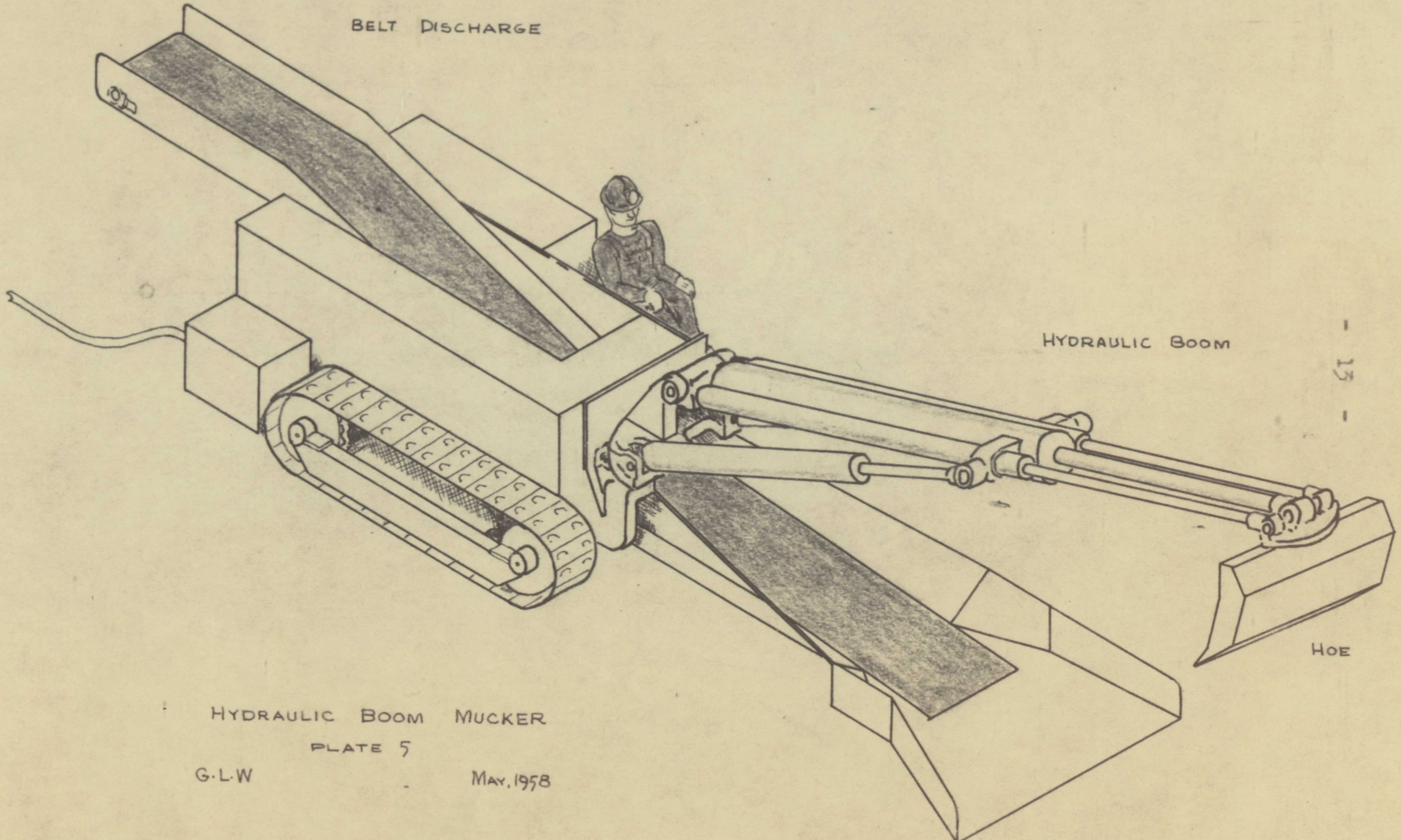
Another unique application of the hydraulic boom of the boom mucker is its use as a drill jumbo after completion of the mucking cycle. The hoe can be detached, then replaced by an offset bar for mounting one or more saddles, feed shells, and drifter-type rock drills. This application makes it unnecessary to remove the machine from the tunnel heading except during blasting operations.



ROTARY MUCKER

PLATE 4

G·L·W MAY, 1958



HYDRAULIC BOOM MUCKER

PLATE 5

G.L.W May, 1958

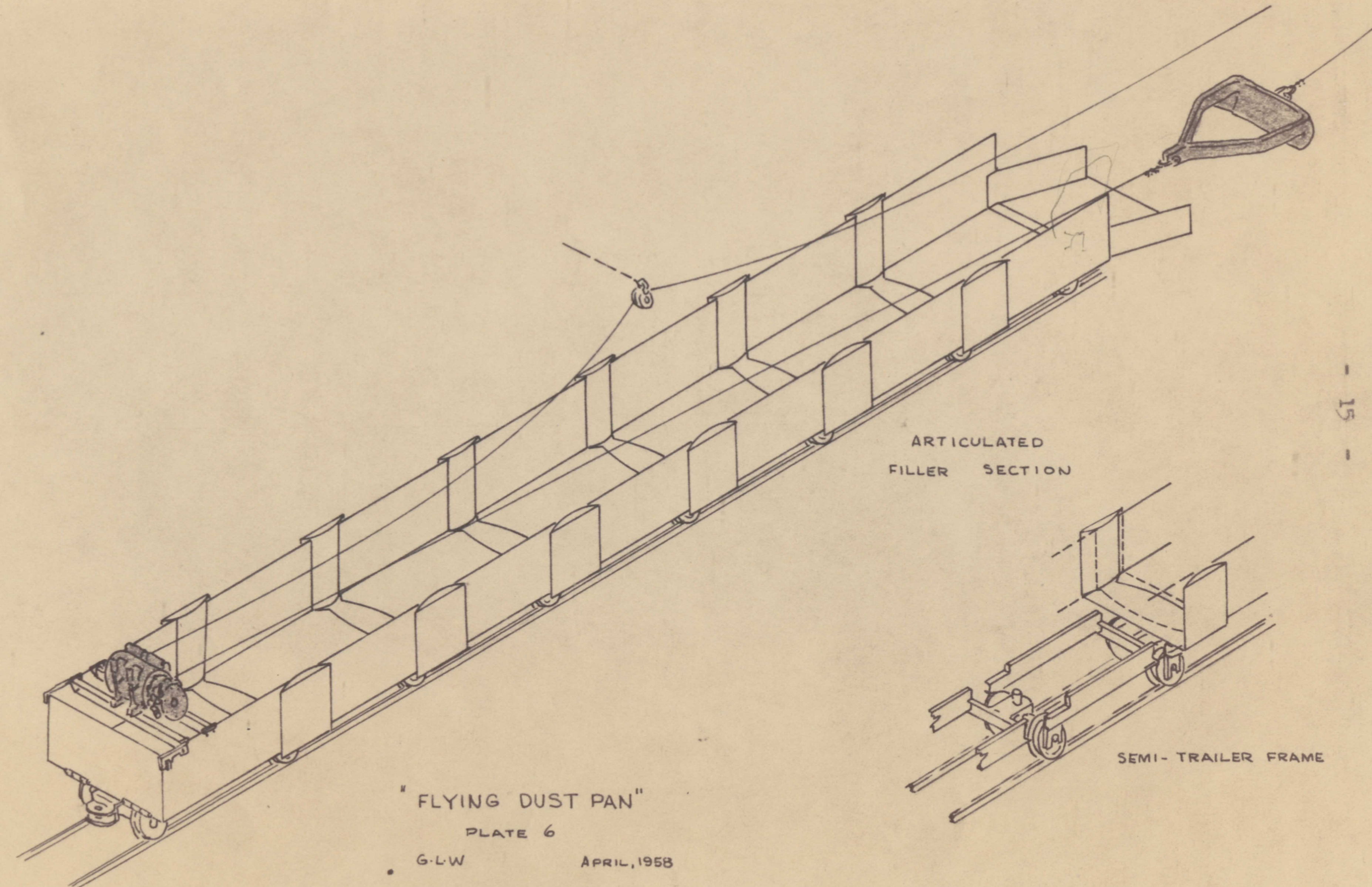
TRAIN LOADERS

This concluding section describes three types of train loaders, that is, loading devices as integral equipment of the transporting unit. The common feature of these trains is continuous handling without switching single cars, of the loaded rock from the heading. This advantage embraces an important step in the mechanization of the loading cycle in mine development and in the elimination of time-consuming work inherent in car switching at the tunnel face. It is strongly felt that the full potential of these trains can be fully utilized with the development and employment of continuous loading machines.

The problem of handling broken rock in a curved tunnel section must be considered in the design of any train which must be loaded from a tunnel face. While employed on curved track of varying radii, these trains are so designed to handle well all rock removal.

Flying Dust Pan

The first train illustrated in Plate 6 is a simple trough design loaded from the face by a scraper, which progressively stacks the broken rock in the cars toward the tunnel face as the round is mucked out. This train is particularily adapted to small drift cross sections, such as coyote holes and exploration developments. The design and fabrications of the "dust pan" are simple and permit easy



"FLYING DUST PAN"

PLATE 6

G·L·W APRIL, 1958

disassembly for removal to a new job site.

The train is low compared with its width, whose dimension permits use of a scraper approximately three fourths as wide as the tunnel section, and so overcomes the difficulty of cleaning the drift bottom by scraper loading. Furthermore, by employing scraper loading, drilling at the face can commence before mucking is completed. To allow the rock from each advance to be removed in one train trip, the required number of car sections is used in an operation.

The body sections, including only sides and flat bottom, are attached to a trailer type of frame; this suspension should provide good tramming characteristics over rough track and road beds. The articulated filler section is centered directly over the pivot between two cars. The axle is directly under the pivot permitting the train to follow a curve as a smooth, continuous trough. The bottom of the articulated filler section is formed as a slight elliptical dome, and thus provides a smooth and flexible joint between separate body sections.

An additional advantage of this train is its ability to transport long preassembled lengths of track and pipe. A long preassembled length of track can be loaded on the train, transported to the working face, then pulled on to a prepared road bed by the tail rope of the slusher.

Scrape unloading is utilized to maintain the simplicity of the train. It should be pointed out that this liability is offset by the time saving in the mucking operations at the working face.

Integral Piston Side Dump Car with Muck Pan

The above-named car represents a combination of mucking-pan muck distribution and a simple air-piston dump mechanism, as shown in Plate 7. During the mucking operation, a train of these cars presents a continuously bridged train for muck-pan rock distribution from the loader at the face. The bridging is simple, again incorporating slightly domed, elliptical bridge sections, connected by a special-patterned filler, an arrangement permitting mucking through curved track sections. The muck pan is operated by a double-drum slusher at the locomotive end of the train. To eliminate overhead guides, the pull back rope is returned through a series of rollers in the frames of the cars. The muck pan, a form of which is patented by an equipment manufacturer, is employed for efficient muck handling; it reduces the number of passes required for rock distribution to the cars.

Air cylinders, used on each car for quick dumping, may be actuated singly or simultaneously, dependent upon the valving of the air-distribution system employed. Upon retraction of the double-acting air piston, the center of gravity of the loaded car is offset to the outside of a pivot point, allowing the body to tip by gravity into the dump position. The side doors are released from their retaining latches, which are raised as the body is moved to dumping

INTEGRAL PISTON SIDE DUMP CAR
with MUCK PAN

PLATE 7

G·L·W

APRIL, 1958

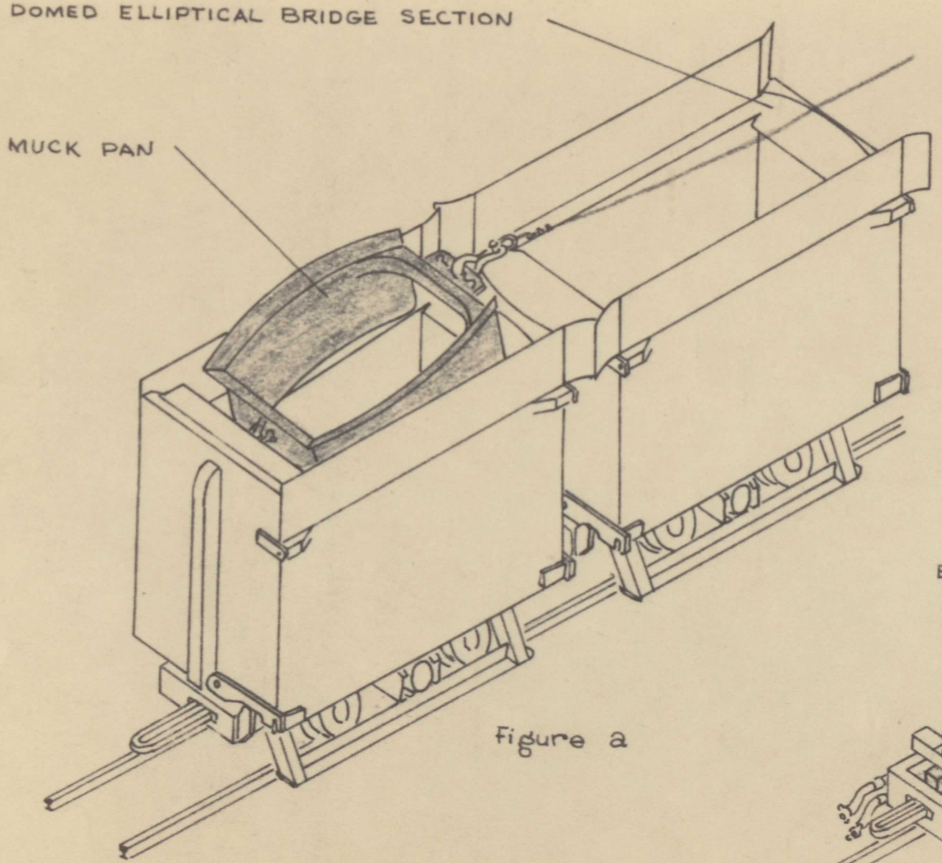
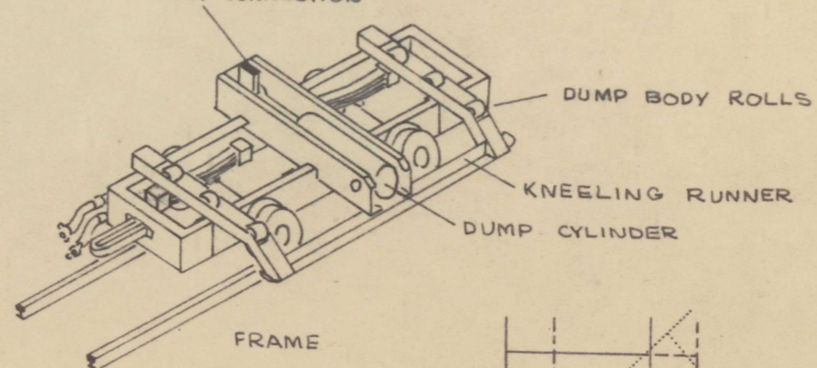


figure a



FRAME
figure b

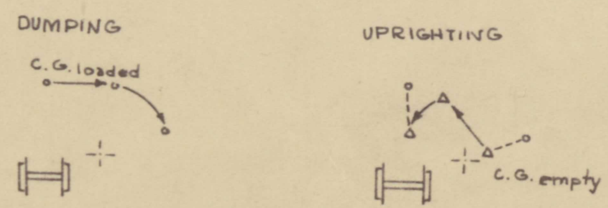
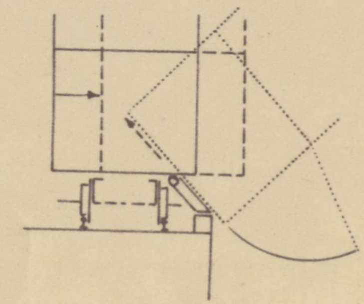


figure d.



DUMP POSITIONS
figure C.

position. The pivoted air cylinder follows the dumping arc of the body, where it is then in position to raise the body from the dumping position to sufficient height for the body upright. Figure d, Plate 7, shows approximately the position of the center of gravity of the loaded and empty car as it moves through the dumping positions. A kneeling runner stabilizes the car while it is dumping.

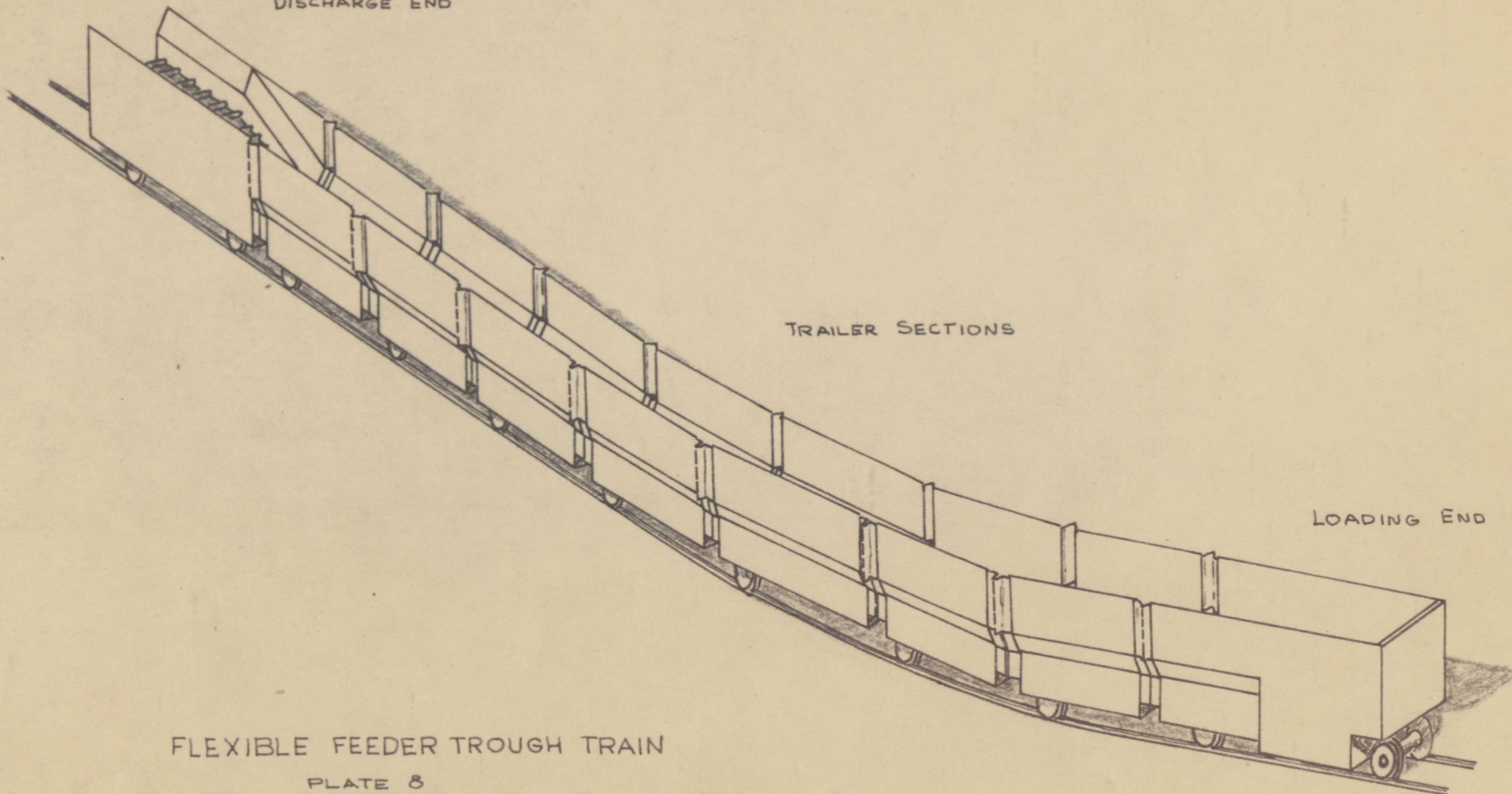
The extension of the car body and high dumping angle make this car particularily adaptable to building outside waste dumps. The air dump lends itself readily to slusher pocket dumping, where ore or rock distribution is important for utilization of storage volume. In some cases, the elimination of the dumping block used with Granby-type, side-dump cars reduces the drawbar pull for a given train length and permits longer trains to be pulled by the same trammer.

Flexible Feeder Trough Train

Plates 8 through 10 illustrate a somewhat more elaborate train loader, which is developed around a flexible belt similar to a belt being manufactured in Germany. The belt consists of a folded rubber fabric laminated to short metal plates. A central reinforcement between plate segments maintains the belt's shape and allows the web loops to flex around curves. The belt is guided through the train by the restraining sides of the car. Small-diameter rolls (illustrated) give the belt a free-rolling surface over which to move. Belt traction is furnished by a gear-reduction motor in the rear car (shown in Plate 10). Motor controls permit a variable speed adjustment of the belt drive, allowing the belt to be advanced at a rate corresponding to the mucking rate of the loader.

A packing device operated from the belt-tail sheave compacts the loose broken rock and permits full utilization of the car section for rock distribution and storage. This mechanism is shown in Plate 9. With the exception of the front-and rear-car sections containing the head-and tail-belt sheaves, the car segments are two-wheeled, semi-trailer cars bridged at the sides by preformed sliding plates and sprung, filler blocks. The vertical side plates are formed to accommodate the change in the train's axis as it passes a curve. The slide plates between double-wall car sides provide filler sections as the train negotiates a curved-track section.

This train design has dual application in development headings and in general tramming service. Since it is easily loaded from ore chutes at the end of a cross-cut, it eliminates the need for additional cross-cut length for empty-car handling or car switching. The one-point discharge makes rock dumping convenient under numerous situations. The broken rock is easily discharged at any location without installation of special dump blocks or other dumping equipment. By discharging the rock while it moves along a new track section, this train can perform quick, uniform track ballasting.



FLEXIBLE FEEDER TROUGH TRAIN

PLATE 8

G.L.W

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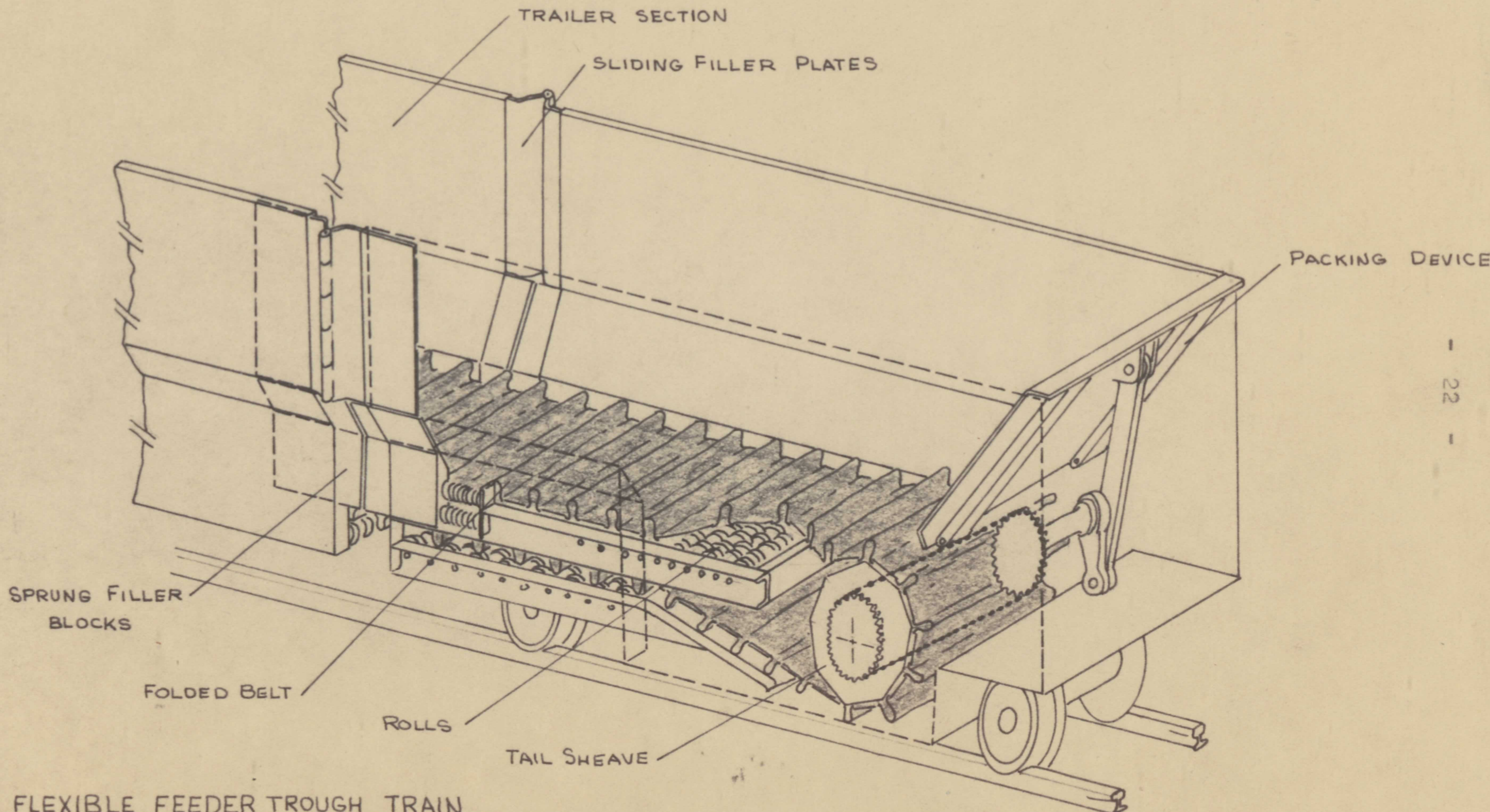
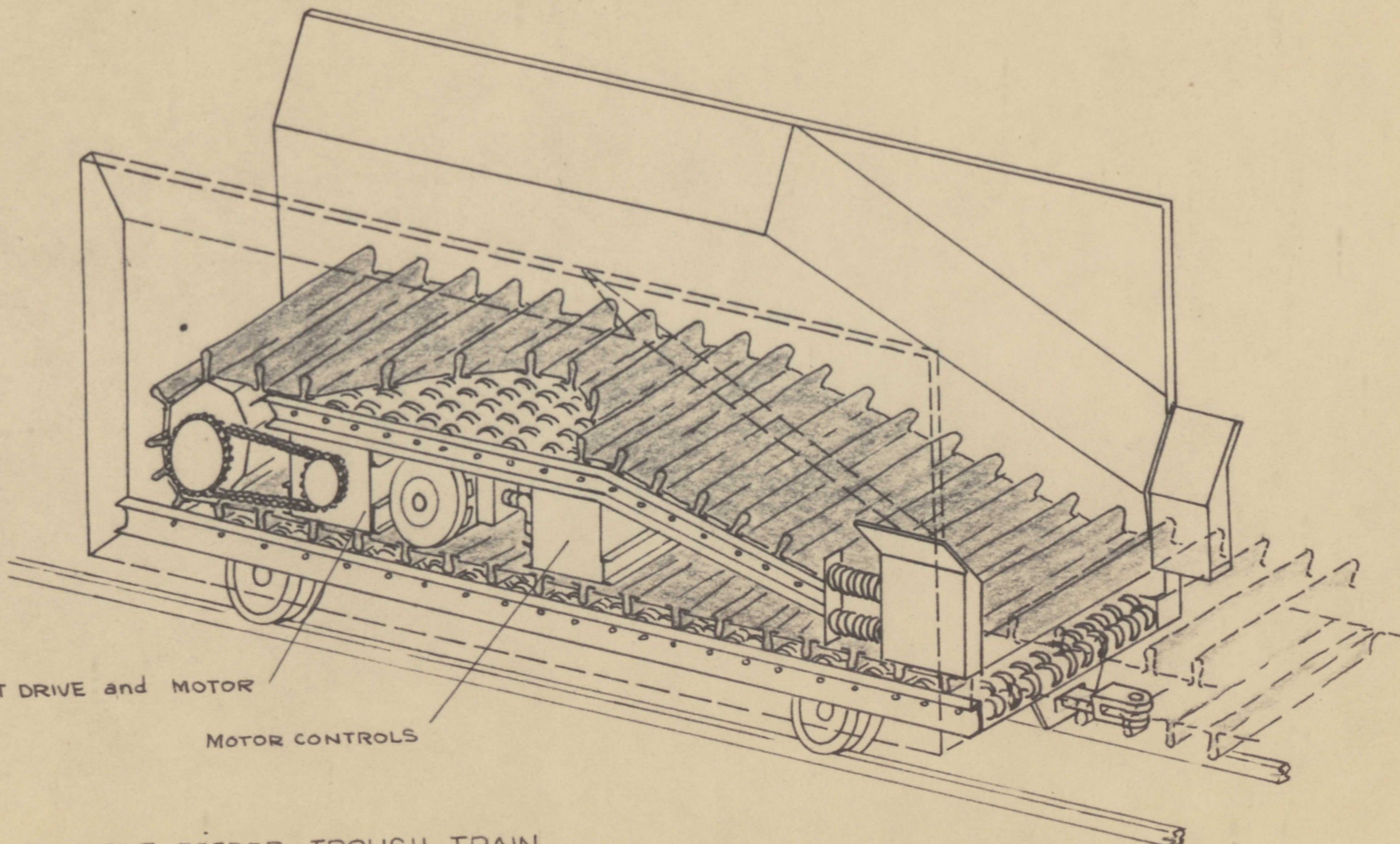


FLEXIBLE FEEDER TROUGH TRAIN
LOADER CAR
PLATE 9

G·L·W APRIL, 1958



FLEXIBLE FEEDER TROUGH TRAIN
DISCHARGE CAR
G·L·W PLATE 10 APRIL, 1958

CONCLUSION

This paper has tersely presented only a few of the many ideas developed through open discussion of the problems associated with mine mechanization. The practical application of these ideas will result through more demand of advanced methods of mining and development in the underground mining field.

The development and perfected application of any of these ideas demand considerable resources, both engineering and financial. It seems probably that, with the frequent appearance of new equipment for the mining industry, the future industrial workability of some of these ideas in some form is assured.