May 22, 1956 D. M. SCHWARTZ ET AL 2,746,625

PIVOTED BUCKET LOADER

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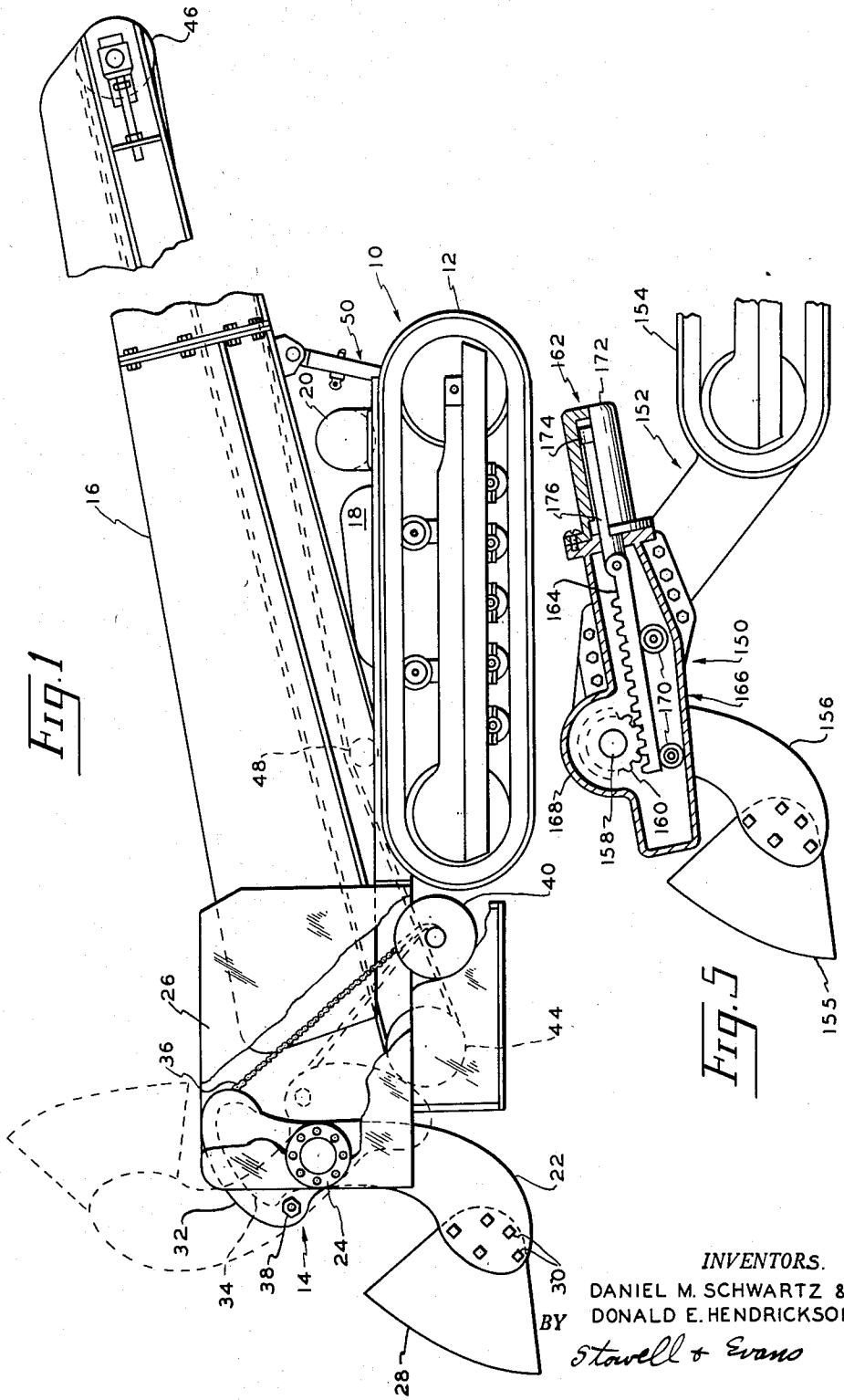


FIG. 1

FIG. 5

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PIVOTED BUCKET LOADER

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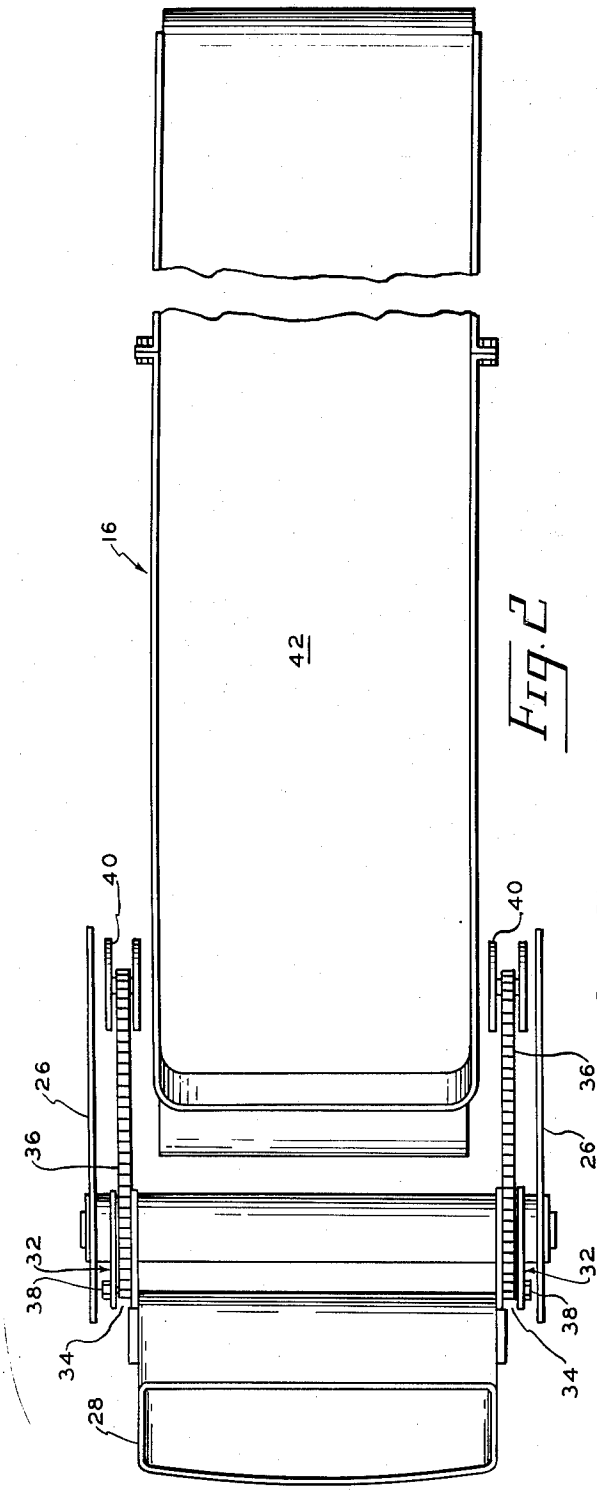


Fig. 2

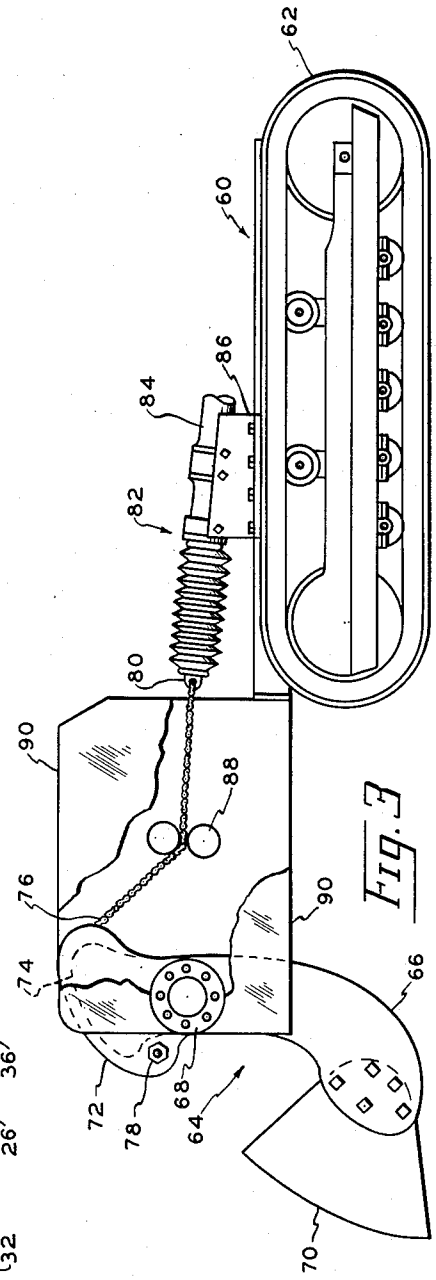


Fig. 3

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PIVOTED BUCKET LOADER

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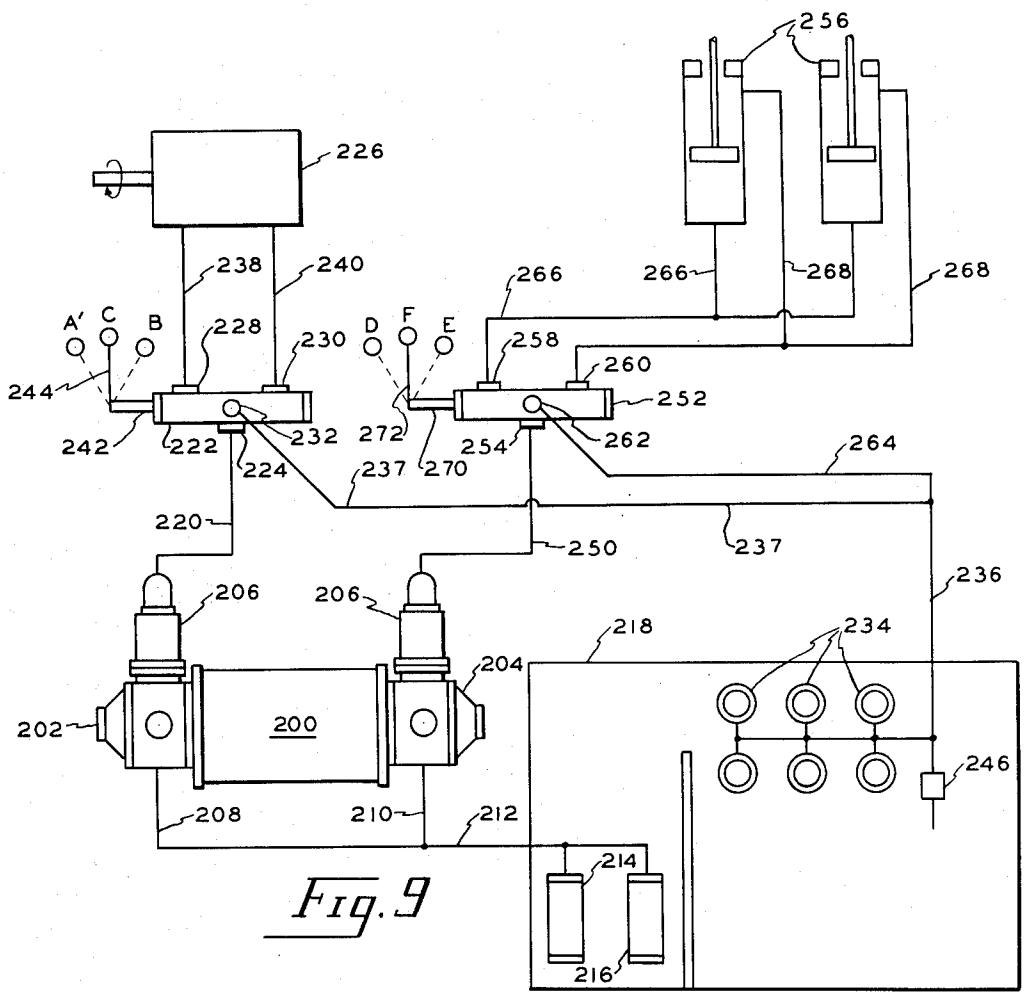


Fig. 9

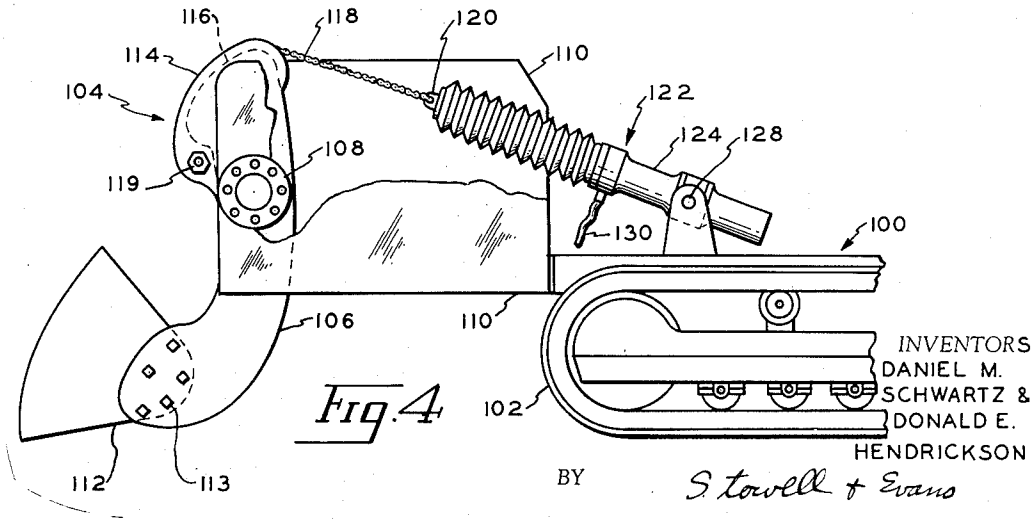


Fig. 4

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PIVOTED BUCKET LOADER

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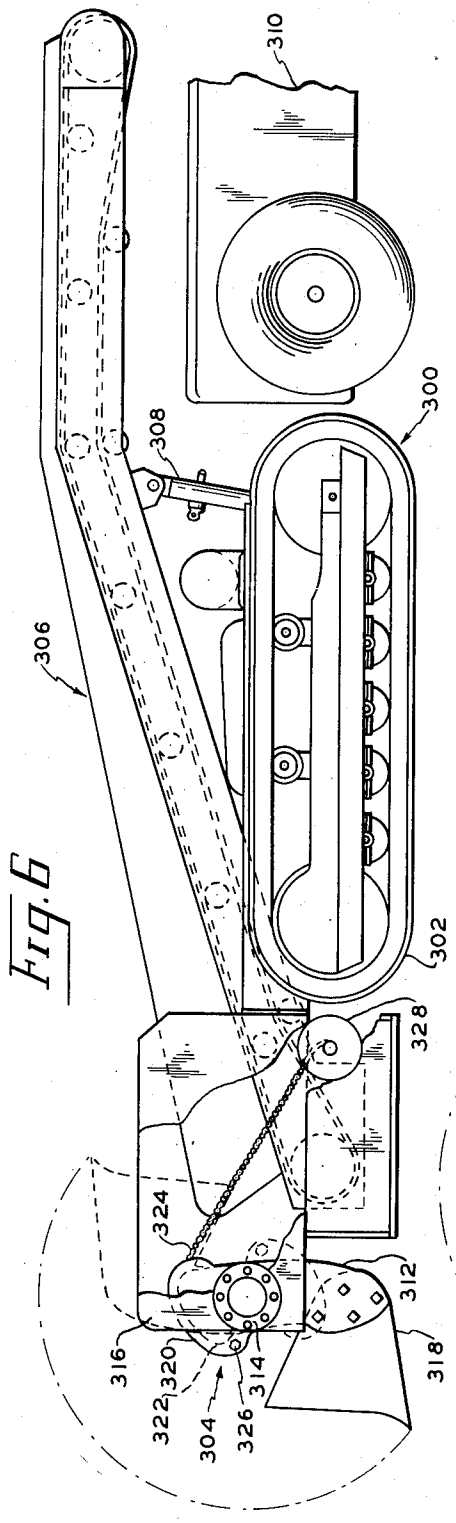


Fig. 6

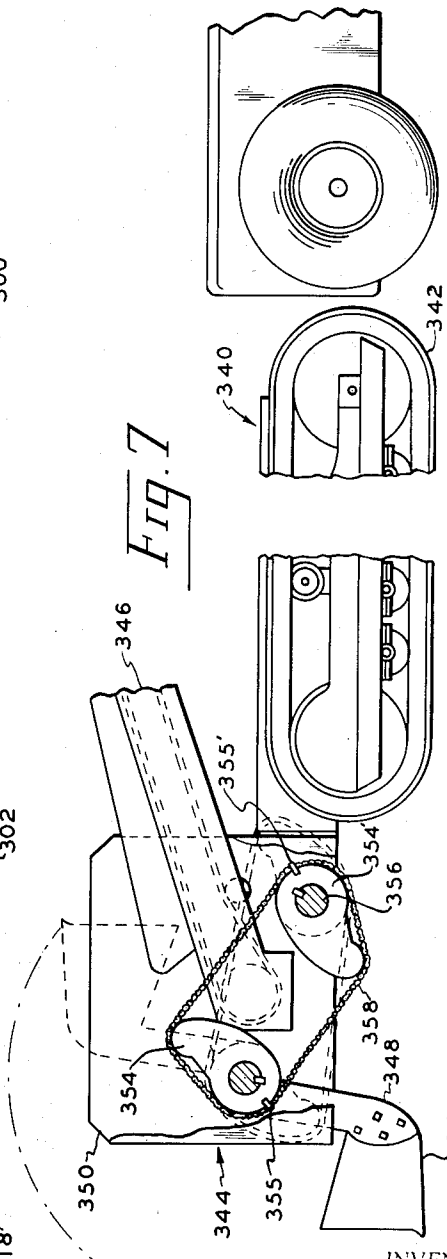


Fig. 7

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PIVOTED BUCKET LOADER

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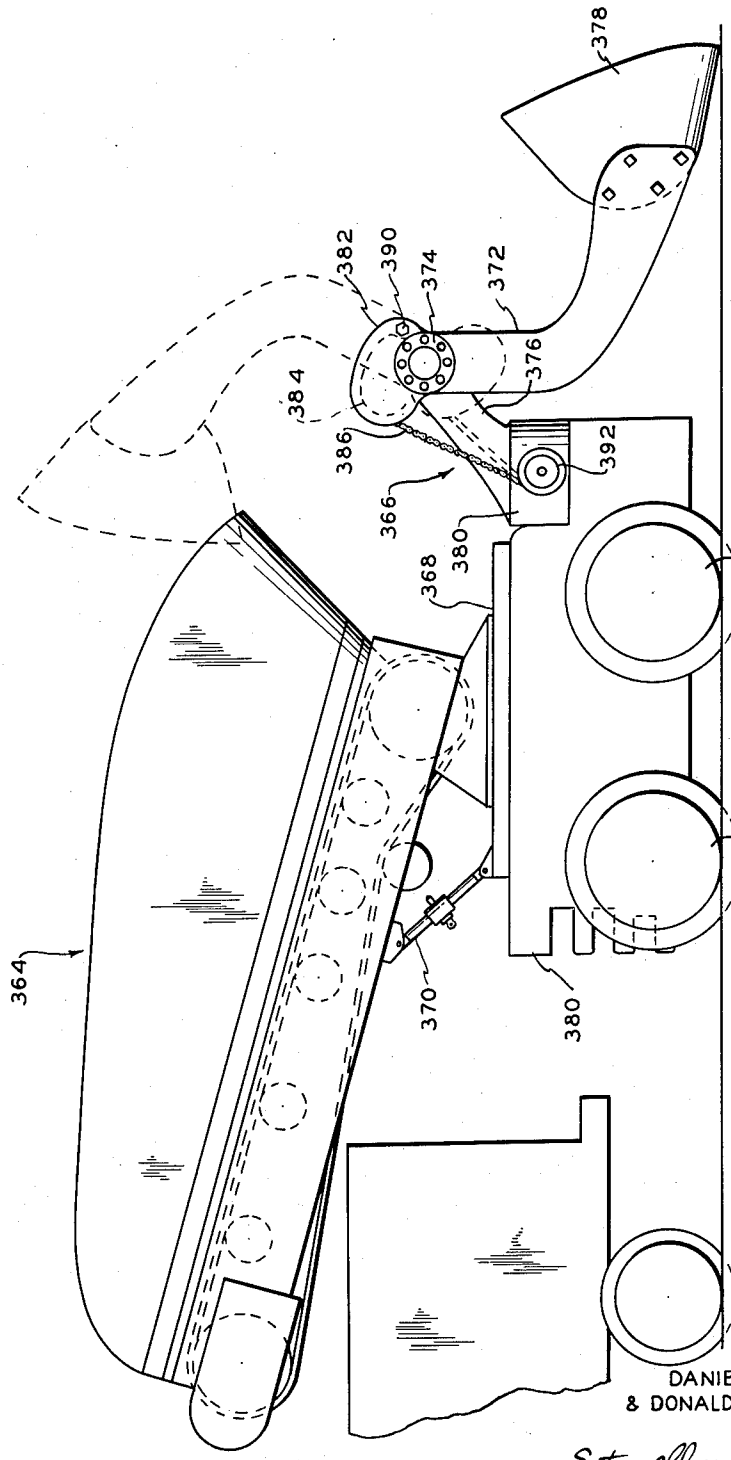


Fig. 8

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PIVOTED BUCKET LOADER

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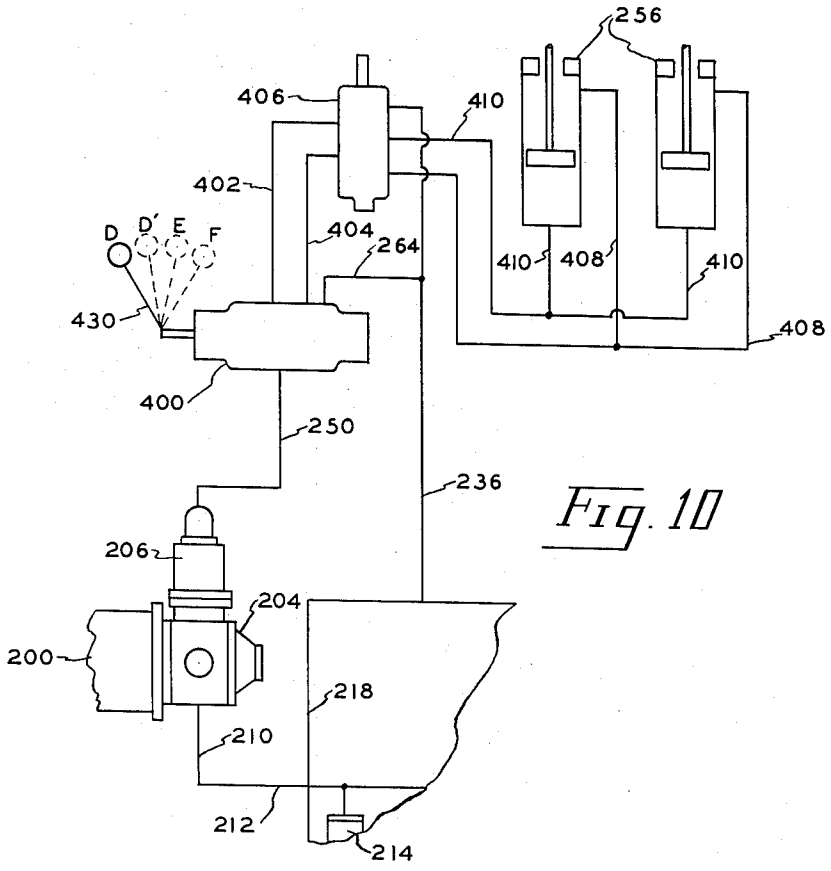


Fig. 10

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PIVOTED BUCKET LOADER

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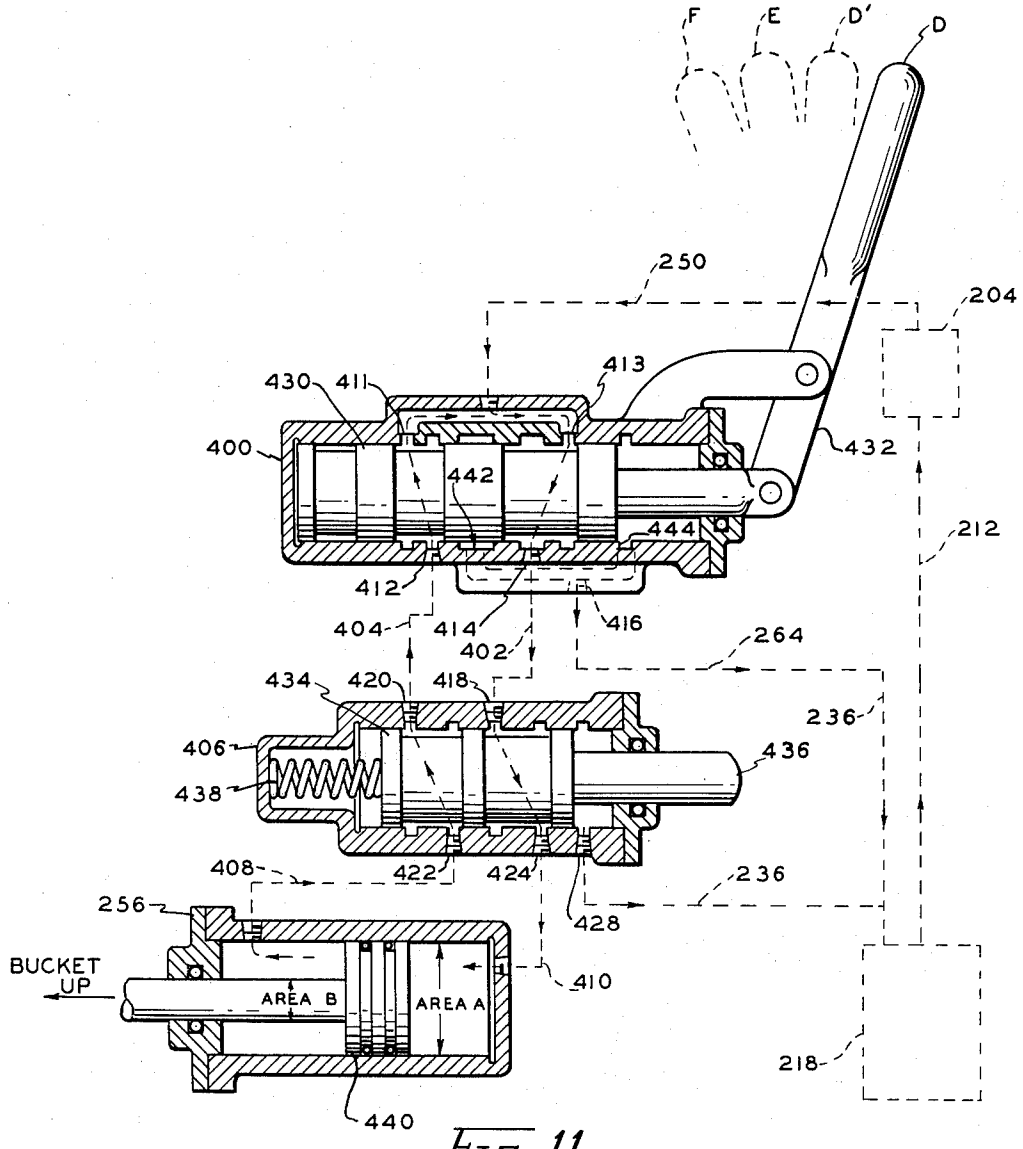


Fig. 11

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PIVOTED BUCKET LOADER

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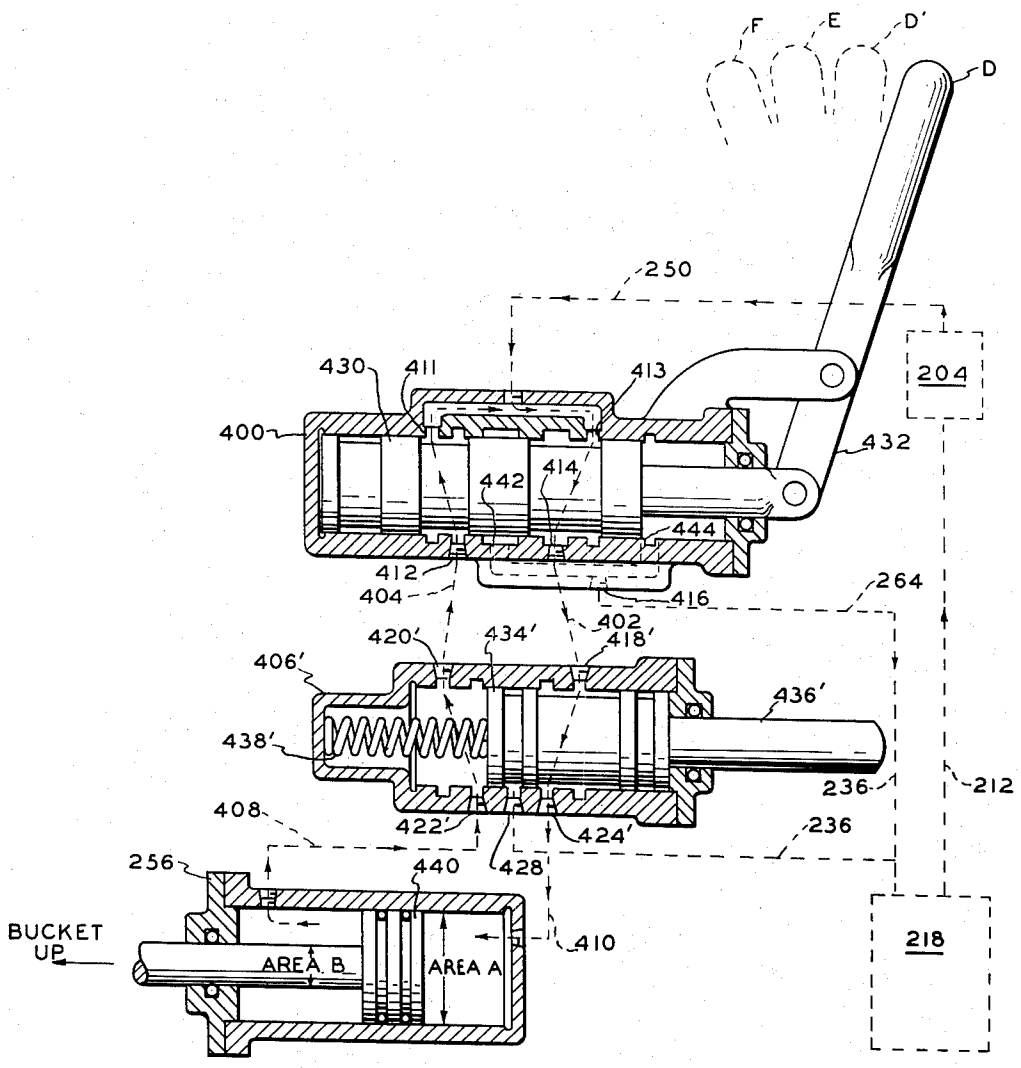


Fig. 12

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PIVOTED BUCKET LOADER

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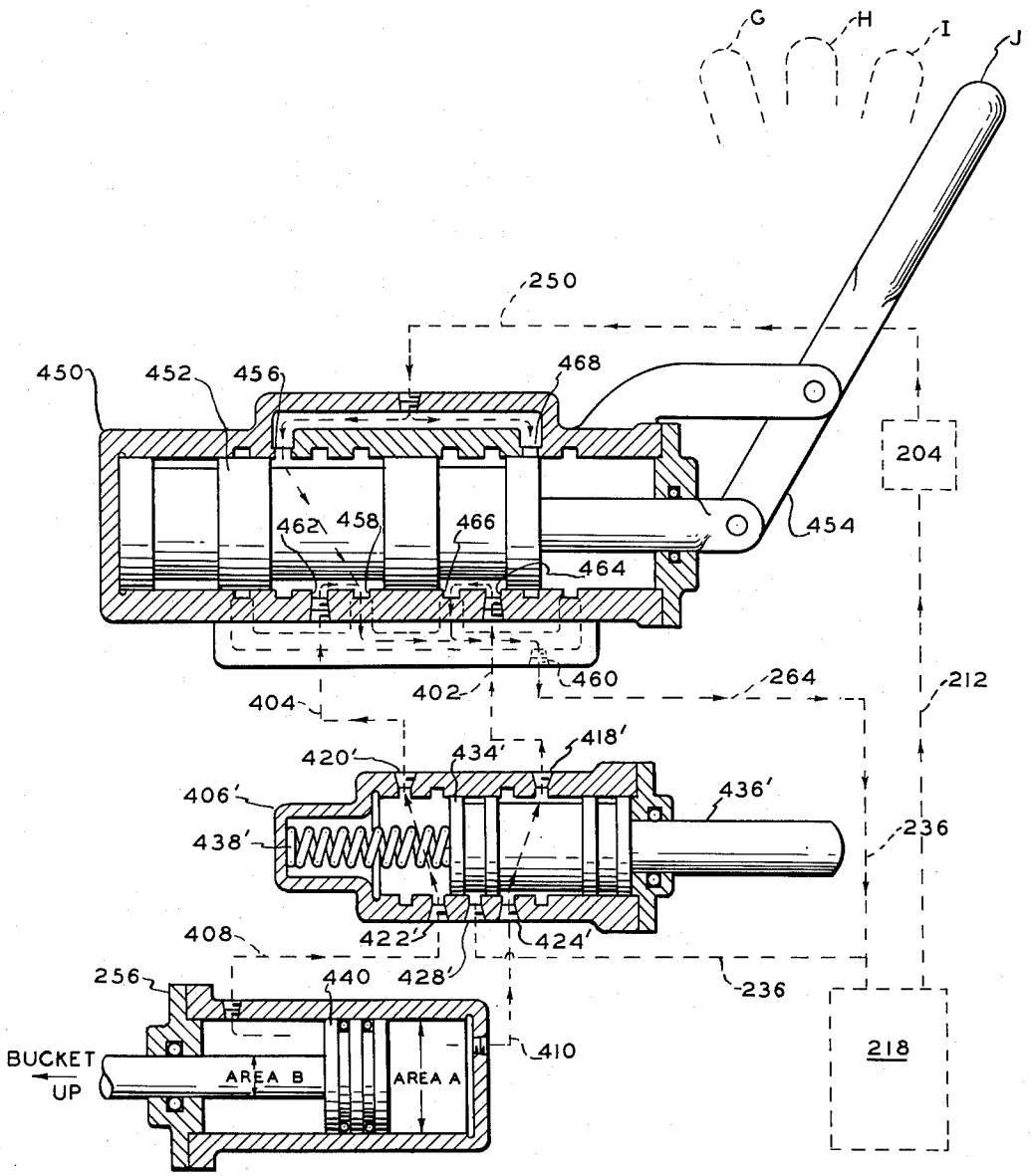


Fig. 13

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United States Patent Office 2,746,625
Patented May 22, 1956

2,746,625

PIVOTED BUCKET LOADER

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Application August 9, 1951, Serial No. 241,057

4 Claims. (Cl. 214—131)

This invention relates to a loading or excavating machine adapted to be used in mines and tunnels where, due to limited headroom and confined spaces, compactness, mobility and ease of control are essential features.

It is an object of the invention to provide an improved loading machine having a pivotally mounted arm adapted to carry an overhead shovel bucket.

Another object is to provide an improved device of the type described, having a variable torque drive.

A further object is to provide such a device having a variable torque responsive hydraulic motor or a variable torque transmission to the pivoted loader arm or both.

Another object of the invention is to provide an improved loading machine having a pivotally mounted loader arm, and a conveyor adapted to receive the mucked material.

Broadly, the invention comprises a loading machine having a pivotally mounted shovel arm, and variable torque drive means for the arm including one or more variable torque transmission elements or a torque responsive drive motor or both the torque responsive motor and one or more variable torque transmission elements.

These and other objects and advantages of the invention will appear more fully in connection with the illustrative embodiments of the invention shown in the accompanying drawings, in which:

Fig. 1 is a fragmentary left side elevation of a pivoted bucket loader embodying the principle of the invention in combination with a mobile conveyor;

Fig. 2 is a top plan view of the machine shown in Fig. 1;

Figs. 3, 4, 5, 6, 7, and 8 are fragmentary side elevations of modified embodiments of the invention showing details of the bucket arm pivoting means; and

Fig. 9 is a diagrammatic representation of a hydraulic system of the pivoted bucket loader of the invention.

Fig. 10 is a diagrammatic representation of a portion of the hydraulic system shown in Fig. 9, with modified bucket assembly control members;

Fig. 11 is an enlarged detailed section of the hydraulic control members shown in Fig. 10; and

Figs. 12 and 13 are modified embodiments of the hydraulic control members shown in Fig. 11 of the drawings.

With reference to the illustrative embodiments of the invention and in particular to Figs. 1 and 2, there is shown an excavating apparatus embodying the principles of the invention which generally comprises a main frame or body **10**, mounted on crawler or self-laying track units **12**.

The main frame **10** carries a pivoted loading bucket assembly **14** secured to the forward end of the machine, and adapted to load material into a conveyor **16** pivotally secured to the frame **10**.

The prime mover, and the bucket, conveyor and traction motors, generally designated **18** and **20**, respectively, are housed beneath the endless belt conveyor and between the self-laying track units of the loader.

The bucket assembly **14** comprises a pair of bucket pivoting arms **22** pivotally mounted in bearings **24** journaled in the side frames **26** of the machine. Between the pivot arms **22**, and at their lower ends, a muck bucket **28** is rigidly secured, for example, by welding or by bolts **30** as shown in the drawings.

The upper ends of pivot arms **22** have cam-shaped outer faces **32** provided with grooves or channels **34**. These channels conform to the outer cam surfaces of the arms and are adapted to receive flexible draft members. In the drawings these draft members are shown as flat cable chains **36** which are highly effective for riding in cam grooves and winding on chain reels. One end of the draft members are secured to the forward portion of the cam surfaces by retaining bolts, **38**, while the other ends are secured to the reels **40**. As shown in the drawings the cam faces **32** of the pivot arms **22** are shaped to provide the largest effective radius from the center of bearing **24** to the point of tangency of chain **36** when the bucket is in the digging position, the effective radius decreasing to a minimum as the bucket approaches the discharge position.

The reels **40**, as more clearly shown in Fig. 1 of the drawings, are positioned below the bucket arm pivot bearings **24**. When the chains are wound upon the reels, the chains ride in the cam grooves **34** throughout the digging-discharge cycle, providing an effective variable ratio drive for the loader. Further, as the chains wrap around the reels, the effective diameter of the reels increases, giving higher speeds to the bucket during the discharge portion of the digging-discharge cycle, thus providing an additional variable ratio drive for the loader.

It will thus be seen that when the bucket is in the digging position of the digging-discharge cycle, the effective diameter of the chain reel is at a minimum, and at the discharge portion of the cycle the effective diameter of the reel is at its maximum. Therefore, the minimum effective diameter of the chain reel combines with the maximum effective radius of the cam, providing the maximum effective torque at the bucket during the digging portion of the digging-discharge cycle, and in the discharge portion of the cycle high speed is obtained by the combination of the maximum effective diameter of the chain reel with the minimum effective radius of the cam.

The bucket in an advantageous form of the invention is adapted to discharge on to the lower end of an endless belt conveyor **16**.

The conveyor belt **42** has a driven pulley **44**, tension pulley **46** and guide pulleys **48**. The forward end of the conveyor is pivotally mounted on the main frame **10** of the machine, while the rearward portion of the conveyor is supported by a power jack assembly **50**, enabling the operator to raise or lower the discharge end of the conveyor. This provides an extremely versatile loader as the discharge height of the conveyor may be lowered in shafts and tunnels having low clearances or the conveyor may be adjusted to the most efficient height for various shuttle cars used to receive the conveyor discharge.

With reference to Figs. 3 and 4 of the illustrative embodiments of the invention, fluid pressure operated cylinders are shown as the means for raising and lowering the cam head pivot arms of the loader, through flexible draft members.

Referring particularly to Fig. 3, there is shown an excavating apparatus which generally comprises a main frame or body **60**, mounted on self-laying track units **62**.

The frame **60** carries a pivoted loading bucket assembly **64** similar in construction to the device shown in Figs. 1 and 2 of the drawings. The assembly comprises a pair of bucket arms **66**, support bearings **68** and muck bucket

70. The cam-shaped head 72 of the device is provided with channels 74 which conform to the outer cam surfaces 72. The cam faces 72 of the pivot arms 66, are shaped to provide the largest effective radius from the center of bearing 68 to the point of tangency of chain 76 when the bucket is in the digging position, the effective radius decreasing to a minimum as the bucket approaches the discharge position. A pair of flexible draft members 76 are secured at one end to the forward portion of the cam surfaces by retaining bolts 78, while the other ends are secured to piston rods 80 of fluid pressure operated piston assemblies 82. The cylinders 84 of each piston assembly are rigidly secured to the main frame of the mobile carriage by brackets 86. A pair of guide pulleys 88 between which the flexible draft members are adapted to run are carried by the side frames 90 of the loading machine. Guide pulleys 88 are provided to reduce lateral thrust upon the piston assembly 82, as the flexible draft members are pulled or released by the reciprocating piston rods 80, during the digging-discharge cycle.

The guide pulleys 88 may be eliminated in constructions where the piston assemblies are pivotally mounted on the loading machine as shown in Fig. 4 of the drawings. In this form of the invention, there is shown an excavating apparatus generally comprising a main frame or body 100, having crawler or self-laying track units 102.

The main frame 100 carries a pivoted loading bucket assembly 104 secured to the forward end of the machine. The bucket assembly 104 comprises a pair of bucket pivoting arms 106 pivotally mounted in bearings 108 journaled in the side frames 110 of the machine. Between the pivot arms 106 and at their lower ends, a muck bucket 112 is rigidly secured, by bolts 113.

The upper ends of pivot arms 106 have cam-shaped outer faces 114 provided with grooves or channels 116.

These channels conform to the curvature of the cam surfaces 114 and are adapted to receive flexible draft members shown in Fig. 4 as chains 118. The cam faces 114 of the pivot arms 106 are shaped to provide the largest effective radius from the center of bearing 108, to the point of tangency of chain 18 when the bucket is in the digging position, the effective radius decreasing to a minimum as the bucket approaches the discharge position. One end of the chains 118 are secured to the forward portion of each of the cam surfaces of the pivot arm by retaining bolts 119, while the other ends are each secured to the ends of piston rods 120 of the fluid pressure operated piston assemblies 122. Each piston assembly of the bucket drive mechanism comprises an outer cylinder 124 pivotally mounted on the carriage by brackets 128. Flexible fluid pressure lines 130 connect the cylinder to a suitable fluid pressure system.

With the cylinders 124 adapted to pivot about bearings 132, it will be seen that as piston rods 120 are forced into the cylinders, the pivot arms 106 are rotated clockwise about bearings 108 and the bucket is raised to the discharge position. During the rotation of the pivot arms, the forward ends of the fluid pressure cylinders pivot downwardly so that chains 118 pull around the cam surfaces of the pivot arms, eliminating the need for guide pulleys to prevent lateral thrust upon the piston assemblies assuring that the maximum mechanical advantage of the cam surfaces are utilized throughout the digging-discharge cycle of the loading apparatus.

Fig. 5 of the illustrative embodiments of the invention shows a modified form of the invention having a rack and pinion assembly 150 for actuating the bucket of the loading machine. In this form of the invention, a supporting frame 152 secured to the forward end of a suitable mobile carriage indicated by numeral 154, is adapted to carry the shovel bucket 155 and the bucket actuating mechanism 150. A bucket 155 is secured to the lower ends of a pair of bucket pivoting arms 156.

A shaft 158 secured to the other ends of pivot arms 156 is journaled in bearings carried in the frames 152. Keyed to the outboard ends of shaft 158 are pinion gears 160. Gears 160 are driven by the fluid pressure operated piston assemblies 162 through rack gears 164. The entire drive assemblies are mounted in housings 166 bolted to the support frames 152.

The housings 166 for each drive assembly are in two sections designated 168 and 172, respectively. Within section 168, the rack and pinion section, are journaled the rack supporting idler wheels 170. Within section 172, the piston section, which is secured to the rearward portion of section 168, a piston 174 and piston rod 176 are reciprocally mounted.

The main frames 60, 100 and 152 of the pivoted bucket loaders shown in Figs. 3, 4 and 5 of the drawings are adapted to support an endless belt conveyor as shown in Figs. 1 and 2 of the drawings, whereby the material mucked by the bucket may be conveniently discharged into shuttle cars, or be transported out of the mine or tunnel on a conveyor assembly.

In excavating operations where the headroom is particularly limited the excavating apparatus shown in Figs. 6 and 7 are particularly advantageous.

Referring particularly to Fig. 6, there is shown a low headroom loader which generally comprises a main frame or body 300 mounted on self-laying track units 302.

The frame 300 carries a pivoted loading bucket assembly 304 similar in construction to the device shown in Figs. 1 and 2 of the drawing, in combination with a low headroom endless belt conveyor 306 adapted to receive and transport material discharged by the shovel bucket.

The forward end of the conveyor is pivotally mounted on the main frame of the machine, while the rearward portion of the conveyor is supported by a power jack assembly 308, enabling the loader operator to raise or lower the discharge end of the conveyor. The discharge portion of the conveyor is angularly positioned with respect to the receiving end whereby the maximum height of the conveyor is reached forward of the discharge end. As is clearly shown in Fig. 6 of the drawings, this form of construction substantially facilitates excavating in low headroom tunnels, and mines by permitting the receiving end of the conveyor to be substantially at ground height, followed by a high rate of inclination to lift the mucked material to loading heights in a relative short distance, followed by a transporting section that is approximately parallel with the base line of the loading machine.

The discharge end of the conveyor may load directly into a shuttle car such as 310 or onto a conveyor system to be transported out of the mine or tunnel.

The bucket assembly 304 comprises a pair of bucket pivoting arms 312 pivotally mounted in bearings 314 journaled in the side frames 316 of the machine. Between the pivot arms 312, and at their lower ends, a muck bucket 318 is rigidly secured.

The upper ends of pivot arms 312 have cam-shaped outer faces 320 provided with grooves or channels 322. These channels conform to the outer cam surfaces of the arms and are adapted to receive flexible draft members, for example, flat cable chains 324 which are highly effective for riding in cam grooves and winding on chain reels. One end of the cable chains are secured to the forward portion of the cam surfaces at 326, while the other ends are secured to chain reels 328. The cam faces 320 are shaped to provide the largest effective radius from the center of bearing 314 to the point of tangency of chain 324 when the muck bucket is in the digging position, the effective radius decreasing to a minimum as the bucket approaches the discharge position.

The reels 328 are positioned below the bucket arm pivot bearings 314 whereby when the chains 324 are wound upon the reels, the chains ride in the cam grooves 322 throughout the digging-discharge cycle, providing an effective variable ratio drive for the loader. Further,

as the chains wrap around the reels, their effective diameter increases, giving higher speeds to the bucket during the discharge portion of the digging-discharge cycle, thus providing an additional variable ratio drive for the loader.

As the bucket is pivoted from the digging position to the discharge position, the tip of the bucket lip describes a circular arc about its pivotal mounting. It is the radius of this arc measured from the center of the pivotal mounting in combination with the endless belt conveyor which determines the minimum permissible headroom for the particular loading machine. It will be seen that since the variable torque drive of the loader is provided by the cam head **320**, large booms and pivot arms are not required to obtain the necessary digging torque for the loader of the invention and it is therefore possible to provide a loader which will operate in tunnels, the head-room of which is exceptionally now.

With reference to Fig. 7 of the drawings, there is shown a modified form of the low headroom excavating machine shown in Fig. 6 of the drawings providing a double cam drive device for the pivoted bucket assembly. In this form of the invention the advantages of the variable torque drive providing a low speed high torque digging portion and a high speed low torque discharge portion is augmented by the provision of a positive bucket return drive, thereby permitting the bucket to operate on steep embankments and in inclined mine tunnels and the like. This form of the invention has the further advantage over the form of the loader shown in Fig. 6 in that the discharge position of the bucket may be beyond the center of gravity of the mucking assembly, thus obtaining the full advantage of the low headroom features of this invention by permitting the discharge lip of the bucket to curve over into the conveyor hopper.

In the drawing, **340** is the main frame or body of the excavating machine which is advantageously mounted on self-laying track units **342**. The frame **340** carries a pivoted loading bucket assembly **344** at its forward end and a low headroom endless belt conveyor **346**, only a portion of which is shown in the drawing of similar construction to conveyor **306** described in reference to Fig. 6, is pivotally mounted on the body of the machine.

The bucket assembly **344** comprises a pair of bucket pivoting arms **348** journaled in the side frames **350** of the excavating machine. Between the pivot arms **348** and at their lower ends a muck bucket **352** is rigidly secured. The upper ends of pivot arms **348** have cam-shaped outer faces **354**. Complementary cams **354'** are keyed to the extremities of a driven shaft **356** journaled in a lower portion of the loading assembly side frames **350**. The outer surfaces of cams **354** and **354'** are adapted to receive endless flexible draft members **358** secured to the cams at **355** and **355'**, respectively. The flexible draft members are shown in the drawing as flat cable chains which are highly effective for riding on cam surfaces. The cam surfaces are shaped to provide a digging-discharge cycle having a high torque, low speed portion at the beginning of the digging operation which gradually develops into a high speed, low torque portion at the end of the discharge cycle. The cam faces of cams **354** and **354'** and their relative positions with respect to each other are selected to provide the largest effective radii from the center of the pivotal mounting of the pivot arms **348** to the point of tangency of chains **358** with cams **354**, and the smallest effective radii from the center of the shaft **356** to the point of tangency of chains **358** with cams **354'** when the bucket is in the digging position; the effective radii of cams **354** decreasing to a minimum and the effective radii of cams **354'** increasing to a maximum as the bucket approaches the discharge position, thus providing a very effective variable ratio drive for the excavating machine.

The relative positions of cams **354** and **354'** as shown in Fig. 7 of the drawings provide a low speed high torque zone during the digging portion of the digging-discharge cycle and a high speed low torque zone during the discharge portion of the cycle.

It will be seen that similar advantages are obtainable in this form of the invention when the driver cams **354'** are replaced by circular sprocket wheels adapted to engage with the endless chains **358**, the variable ratio drive being provided solely by the driven cams **354** attached to the bucket pivoting arms **348**, while the sprocket wheels provide positive holding or driving of the shovel bucket throughout the digging-discharge cycle of operation.

While in the preferred form of the invention shaft **356** which carries the driver cams **354'** is adapted to be driven in the bucket-up and bucket-down directions to provide a positive bucket return, in an alternate form of the invention the shaft **356** is driven in the bucket-up direction only. In this modification of the invention a brake assembly is provided on the shaft **356** whereby the shovel bucket may be held in any position of its digging-discharge cycle. Further, the brake assembly prevents the shovel bucket from riding up when scraping or bulldozing is performed with the loader of the invention.

In Fig. 8 of the drawings there is shown a further modification of the excavating machine of the invention. In this form of the invention the conveyor and the pivoted shovel bucket assembly can be pivoted in a horizontal plane for curve loading and cleaning up around muck piles. This form of the invention is particularly advantageous when the loader is adapted to travel on rails or tracks.

The excavating machine shown in Fig. 8 generally comprises a main frame **360** mounted on flanged wheels **362**. The main frame carries an endless belt conveyor **364** and a pivoted loading bucket assembly **366**.

The conveyor is pivotally secured to a power operated turn table **368** and is provided with an adjustable support **370** which connects the rearward portion of the turn table **368** and the bottom of the conveyor. Thus it will be seen that the conveyor may be pivoted in both the horizontal and vertical planes. The vertical adjustment enables the loader operator to raise or lower the discharge end of the conveyor for direct loading into shuttle cars or conveyor systems of various heights, while the horizontal adjustment permits loading on curved sections of track.

The bucket assembly **366** generally comprises a pair of bucket pivoting arms **372** pivotally mounted in bearings **374** journaled in the upper end of the support frame **376**, the lower end of which is secured to a power operated turn table **380**. Between the pivot arms **372** and at their lower ends a muck bucket **378** is secured.

The upper ends of pivot arms **372** have cam-shaped outer faces **382** provided with grooves or channels **384**. These channels conform to the outer cam surfaces of the arms and are adapted to receive flexible draft members, for example, flat cable chains **386**. One end of the cable chains are secured to the forward portion of the cam surfaces at **390**, and the other ends are secured to reels **392** driven through the turn table **380**. The cam faces **382** are shaped to provide the largest effective radius from the center of bearing **374** to the point of tangency of chain **386** when the bucket **378** is in the digging position, the effective radius decreasing to a minimum as the bucket approaches the discharge position.

The reels **392** are positioned below the bucket arm pivot bearings **374**, whereby when the chains **386** are wound upon the reels the chains ride in the cam grooves **384** throughout the digging-discharge cycle, providing an effective variable ratio drive for the excavating machine. Further, as the chains wrap around the reels, their effective diameter increases giving higher speeds at lower torque to the bucket during the discharge portion of the digging-discharge cycle, thus providing an additional variable ratio drive for the loader. It is evident that while

the specific embodiment of this form of the invention is shown mounted on flanged wheels, other forms of traction devices may be advantageously adapted to the machine, and that the conveyor or the bucket assembly may alone be adapted for pivotal movement in a horizontal plane.

With referenue to Fig. 9 of the drawings, diagrammatically representing an advantageous form of hydraulic power system for the pivoted bucket loader, **200** is the prime mover which may be, for example, an electric motor or an internal combustion engine. Variable delivery pumps **202** and **204** of any well-known type, such as the radial piston or radial vane types, having individual flow control members **206** of the fluid pressure type, are driven by prime mover **200**. In the preferred form of the invention, variable delivery pumps **202** and **204** are the pressure responsive type wherein at high pressure the volume delivered by the pumps is a minimum, and at low pressure the volume rises to a maximum.

The suction side of the pumps are connected by conduits **208** and **210**, respectively, to a common supply line **212** leading from a pair of fluid filters **214** and **216** secured to the main reservoir **218** for hydraulic fluid.

The delivery side of pump **202** is connected by conduit **220** to the loader drive control valve **222**, at valve port **224**. The traction control valve **222** distributes the pressure fluid to reversible traction motor **226** through valve ports **228** and **230**, and from port **232** to the fluid reservoir **218** through filter cartridges **234** and return lines **236** and **237**.

Conduits **238** and **240** are the pressure supply or return lines for traction motor **226** and are connected to valve ports **228** and **230**.

The valve **222** is provided with a valve spool **242** and control lever **244**. The spool has three positions designated "A," "B" and "C"—forward, reverse and neutral, respectively. In the drawings, the spool is in the neutral position and fluid pressure enters the valve through port **224** and is directed to the reservoir return line **237**, through port **232**. The spool ports to the traction motor are blocked while the spool is in the neutral position preventing fluid flow in motor conduits **238** and **240**, thus providing a hydraulic brake for the loader.

When the spool is placed in position "A," the forward drive position, fluid pressure is directed to motor **226** through conduit **238** and returned to the valve through conduit **240** and valve port **230**. From port **232**, the return pressure fluid is directed to return lines **237** and **236** to the reservoir.

To reverse the direction of the traction motor, the control lever is placed in position "B." The motor then receives fluid pressure from conduit **220**, valve ports **224** and **230** and conduit **240** and exhausts to the fluid reservoir after returning to the valve **222** through return lines **237** and **236**.

A relief valve **246**, provided in the return lines ahead of the filter cartridges **234**, is adapted to shunt the return pressure fluid directly into the fluid reservoir if the filter cartridges become clogged or overloaded.

The delivery side of pump **204** is connected by means of conduit **250** to the bucket control valve **252** through valve port **254**. This valve distributes the pressure fluid to bucket pivoting arm motors, shown in the drawings as fluid pressure cylinders **256**, through valve ports **258** and **260**, and from port **262** to the fluid reservoir **218** through filters **234** and return lines **236** and **264**.

Conduits **266** and **268** are the pressure supply or return lines for the cylinders **256**, and are connected to valve ports **258** and **260**, respectively.

The valve **224** is provided with a spool **270** and control lever **272**, the spool having three positions designated "D," "E" and "F," the bucket up, down, and neutral positions, respectively. In the drawing, this valve is shown in the neutral position so that fluid pressure enters the valve through port **254** and is directed to the reservoir return line **264**, through port **262**. The spool ports to the bucket actuating cylinders are blocked when the valve is in the neutral position preventing fluid flow in conduits **266** and **268**, thus providing a hydraulic brake for the bucket assembly.

When the control lever is placed in position "D," fluid pressure is directed to the forward end of the cylinders **256** through conduit **268** and returned to the valve through conduit **266** and valve port **258**. From port **258**, the return pressure fluid is directed to return lines **264** and **236** to the reservoir, and the bucket is raised to the dumping position.

To lower the bucket arm, the control lever **272** is placed in position "E." The cylinders then receive fluid pressure from conduit **250**, valve ports **254**, and **258** and conduit **266** to the rearward end of the cylinders, and exhausts from the forward ends to the fluid reservoir after returning to the valve **252** through return lines **264** and **236**.

In Figs. 10 and 11 of the drawings, there is shown a portion of the hydraulic power system shown in Fig. 9, with like parts having identical reference numerals, in conjunction with a modified bucket control valve and an automatic bucket reversing valve. This form of the invention is particularly advantageous when employed in conjunction with the form of the loaders shown in Figs. 3, 4 and 5.

The prime mover **200** drives the variable delivery pump **204** having a flow control member **206** of the fluid pressure type. Pump **204**, in the preferred form of the invention, is of the pressure responsive type wherein at high pressure the volume delivered by the pumps is at a minimum and at low pressure the volume rises to a maximum.

The suction side of pump **204** is connected by conduits **210** and **212** to the main fluid reservoir **218** through fluid filter **214**, while the delivery side of the pump and flow control member **206** is connected by means of conduit **250** to the bucket control valve generally designated **400**. This valve distributes the pressure fluid to the reversing valve **406** through valve ports **412** and **414**, and from port **416** to the fluid reservoir **218** through return lines **264** and **236**.

Conduits **402** and **404** are the pressure supply or return lines for the reversing valve **406** and are connected to valve ports **418** and **420**, respectively.

Pressure and/or return lines **408** and **410** connect ports **422** and **424** of the bucket reversing valve **406** with the forward and rearward ports of the fluid pressure cylinders **256**, respectively. Valve **406** is also connected to the return line **236** through valve port **428**.

The bucket manual control valve **400** is provided with a spool **430** and spool control lever **432**, the spool having four positions designated "D," "D'," "E" and "F," generally the bucket up low torque, bucket up high torque, bucket down and neutral positions, respectively. In the drawings Figs. 10 and 11, this valve is shown in position "D," bucket up low torque.

The reversing valve **406** is provided with a spool **434** and control rod **436** therefor which are normally biased by coil spring **438** toward the forward end so that valve ports **418**, **420**, **422** and **424** are in the open position. When the bucket reaches the dumping position, the bucket pivoting arm, for example, contacts rod **436** and the spool **434** is moved inwardly compressing spring **438**. In the drawings Figs. 10 and 11, the bucket has not reached the dumping position and the spool of the reversing valve has not been actuated by the bucket arm.

With the manual control and reversing valves positioned as shown, pressure fluid from conduit **250** is connected to both ends of the cylinder **256**. However, since the effective areas of the piston **440** are A and A minus B, the piston will move toward the head of the cylinder and there will be an effective force lifting the bucket equal to area B times the pressure of the fluid. The volume of the fluid displaced by the piston movement is directed to the other side of the piston through the reversing valve

406 and manual control valve 400. When the bucket reaches the dumping position and the reversing valve spool 434 is pushed inwardly by the bucket arm, fluid pressure entering port 418 of the reversing valve is directed to conduit 408 and the head of the piston 440 through valve port 422, while conduit 410 at the rear of the fluid actuated cylinder directs fluid pressure displaced by piston 440 to the reservoir 218 through port 428 of the reversing valve and return line 236. Thus the bucket is driven momentarily downwardly until spool 434 is returned to its forward position by spring 438 and the bucket again driven into the dumping position. This procedure continues as long as the control handle 432 is maintained in the bucket up position, affording an effective means for discharging sticky material from the bucket, and prevents damage to the loader and its hydraulic system by automatically reversing the direction of the bucket when it reaches its maximum upward position.

After the mucked material has been discharged from the bucket, the bucket is driven downwardly by putting control handle 432 in position "E." When control handle 432 is in position "E," fluid pressure from conduit 250 is directed to the forward port of the fluid pressure cylinders 256 through ports 411 and 412 of the valve 400, conduit 404 to port 420 of valve 406, and to conduit 408 through port 422. The rearward end of the cylinders 256 are vented to the reservoir through conduit 410, valve ports 424 and 418 of valve 406, conduit 402 and valve ports 414, 442 and 416 of valve 400 to return lines 264 and 236. The bucket is thus driven downwardly with an effective force equal to pressure times area A minus area B of the piston 440.

During the initial digging portion of the digging discharge cycle of the excavating machine, the control handle 432 is placed in position "D'," that is bucket up high torque. In this position the effective force lifting the bucket is area A of piston 440 times the pressure. Fluid pressure from conduit 250 is directed to the rearward ports of the fluid pressure cylinders 256 through ports 413 and 414 of control valve 400, conduit 402 to the reversing valve 406, through ports 418 and 424 of the valve to conduit 410. The forward portion of the cylinder is vented to the fluid reservoir through conduit 408 and ports 422 and 420 of valve 406, conduit 404, ports 412, 442 and 416 of valve 400 to return lines 264 and 236. After the bucket has completed the initial digging portion of the digging-discharge cycle the control valve 400 is manually placed in position "D," bucket up low torque position, as shown in the drawings; however, it will be evident that the change over from high torque to the low torque position may be automatic and timed with any position or sequence of bucket movement.

When it is desired to stop the bucket during any portion of its digging-discharge cycle the control handle of valve 400 is placed in the "E" or neutral position, in which case both ports 412 and 414 of the control valve 400 are blocked, preventing the flow of pressure fluid to or from the bucket actuating motor. When ports 412 and 414 are blocked pressure fluid from conduit 250 is vented into the reservoir through ports 444 and 416 of valve 400 to return lines 264 and 236.

With reference to Fig. 12 of the drawings, there is shown a modified form of the automatic direction reversing valve in a hydraulic system as shown in Fig. 11 with like parts having identical reference numerals. In this form of the invention when the bucket has reached the dumping position, the pressure fluid to the fluid actuated cylinder is cut off, and both ends of the cylinder are vented to the fluid reservoir allowing the bucket to float free and move downwardly by gravity.

The automatic direction reversing valve 406' is provided with a movable spool 434' and a control rod 436' which are normally biased by coil spring 438' toward the forward end of the valve so that ports 418', 424', 420' and 422' connecting pressure and/or relief conduits 402 and 410, and 404 with 408, respectively, are in the open position.

With the manual control valve in the "D" position, bucket up low torque, and the valve 406' positioned as shown, pressure fluid from conduit 250 is connected to both ends of the cylinder 256. However, since the effective areas of the piston 440 are A and A minus B, the piston will move toward the head of the cylinder and there will be an effective force lifting the bucket equal to area B times the pressure of the fluid. The volume of the fluid displaced by the piston movement is directed to the other side of the piston through the reversing valve 406' and manual control valve 400. When the bucket reaches the dumping position and the reversing valve spool 434' is pushed inwardly by the bucket arm, fluid presure entering the reversing valve ports 418' and 420' is blocked by the spool and both conduits 408 and 410 are vented to the reservoir 218 through return line 236, valve port 428' and ports 422' and 424', respectively, thus the bucket is free to move momentarily downwardly until spool 434' is driven into its forward and normal position by spring 438', and the bucket again driven into the dumping position. This cycle would be repeated as long as the main control valve 400 remains in the bucket up position. It is thus seen that the automatic reversing valve cuts off the power to bucket assembly and prevents the bucket arm from being driven positively into the bucket stop relieving the resulting strain on the bucket assembly and the transmission of the excavator.

After the mucked material has been discharged, the operator may stop further movement of the bucket assembly by placing the control handle in the neutral position, or drive the bucket downwardly by placing the control handle in position "E" which directs fluid pressure from conduit 250 to the forward port of the fluid pressure cylinders 256.

On excavators where it is advantageous to allow the bucket to return to the digging position by gravity, a four way valve 450 such as shown in Fig. 13 is substituted for the manual control valve 400 described in reference to Figs. 10 through 12. In Fig. 13 of the drawing, manual control valve 450 is shown in conjunction with the fluid pressure transmission described with reference to Fig. 12, and like parts are given identical reference numerals.

The manual control valve 450 is provided with a spool 452 and a control lever 454, the spool having four positions designated, with reference to the control handle, "G," "H," "I," and "J," bucket down, neutral, bucket up and bucked free floating, respectively. In the drawing the valve is shown in position "J" providing a free floating piston.

With the annual control valve in position "J" as shown in Fig. 13, pressure fluid from conduit 250 is directed to the main reservoir through valve ports 456, 458 and 460 and return lines 264 and 236. Both ends of the fluid pressure operated cylinder 256 are also vented to the reservoir 218 providing a free floating piston enabling the bucket to return by gravity to the digging position. The forward end of the cylinder is vented to the reservoir through conduit 408 ports 422' and 420' of the automatic reversing valve 406', conduit 404 and ports 462, 458 and 460 of control valve 450 to return lines 264 and 236. The rearward end of the cylinder is vented to the reservoir through conduit 410, ports 424' and 418' of valve 406', conduit 402 and ports 464, 466 and 460 of control valve 450 to return lines 264 and 236.

After the bucket has returned to the digging position, the digging cycle is commenced by placing the control handle in position "I," the bucket up position. In this position pressure fluid is directed to the non-piston rod side of cylinder 256 from pressure conduit 250 through ports 468 and 464 of the control valve, conduit 402, ports 418' and 424' of the reversing valve 406' to conduit 410. The forward port of the cylinder is vented to the reservoir through conduit 408, ports 422' and 420' of valve 406',

conduit 404, and ports 462, 458 and 460 of control valve 450 to return line 264 and 236. When the bucket reaches the dumping position, spool 434' of the reversing valve is driven into its rearward position by contact of the bucket arm with control rod 436', both ends of the fluid pressure cylinder 256 then being automatically vented to the reservoir through the reversing valve as hereinbefore described with reference to Fig. 12 of the illustrative embodiment of the invention.

After the material in the bucket is discharged, the operator may place the control handle in position "J" enabling the bucket to return by gravity to the digging position, or in position "G," whereby pressure fluid from conduit 250 through valve ports 456 and 462 of the control valve, ports 420' and 422' of the reversing valve and conduit 408 to the piston rod end of the cylinder 256, drives the bucket downwardly to the digging position.

From the foregoing description of the hydraulic systems of the invention it will be evident that various modifications may be made in the form and the type of the control members, for example, while the systems shown in Figs. 9 through 13 are described with reference to a variable delivery pump, constant delivery pumps may be employed and the control valves shown in Figs. 10 through 13 may be used in a fluid pressure system without the automatic reversing valves 406 and 406'.

In the form of the invention shown in Figs. 1, 2, 6, 7 and 8 of the drawings wherein a cable drum or driver cam is utilized to raise and lower the bucket pivoting arms, the fluid pressure cylinders 256, shown in Figs. 9 through 13 of the drawings, would be replaced by a fluid pressure operated motor or a pair of motors shown as at 226.

It will be seen that with the torque responsive motor above described, coupled with the variable torque transmission, characterized by a power demand cycle including a high torque, low speed portion during the digging operation, and a low torque high speed portion during the dumping operation, the power demand is maintained within the maximum power output of the prime mover. The hydraulic systems further provide a power transmission which is responsive to the torque demands of the traction and bucket motors to maintain power requirements at a minimum.

The utility of the variable torque transmission is thus increased by providing the loader with the torque responsive motor.

From the foregoing description of the invention, it will be seen that an improved loading machine having a pivoted loader arm adapted to carry an overhead shovel bucket is provided, which is especially adaptable for use in mines and tunnels, due to its compactness and ease of control. Further by the provision of the improved hydraulic system having a single prime mover adapted to supply power to a plurality of fluid pressure operable motors, each having an individual power-torque demand, great savings in space, cost of construction and maintenance are attained.

We claim:

1. A material handling machine comprising a main frame and a power source, an arm pivotally mounted adjacent the forward end of said main frame, a shovel bucket carried at one end of said arm, a cam surface provided at the other end of said arm, said cam surface shaped to provide a continuous torque-speed ratio from a high torque low speed zone in the shovel digging position to a low torque high speed zone in the shovel dumping position, means connecting said cam surface to the power source for actuating the shovel arm through the digging-discharge cycle, said means including flexible draft means contacting the cam surface of said pivotally mounted arm and pulling means connected to said flexible draft means, and a torque responsive pump means for transmitting power from the power source to said pulling means.

2. The invention defined in claim 1 wherein said pulling means connected to the flexible draft means comprises a motor driven reel.

3. The invention defined in claim 1 wherein said pulling means connected to the flexible draft means comprises a piston rod, said piston rod being connected to a piston reciprocally mounted in a fluid pressure operated cylinder.

4. The invention defined in claim 1 wherein the cylinder is pivotally mounted on said main frame.

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