Feb. 17, 1953 G. REUTER 2,628,731

HYDRAULICALLY-OPERATED TRACTOR SHOVEL

Filed Sept. 17, 1949 4 Sheets-Sheet 1

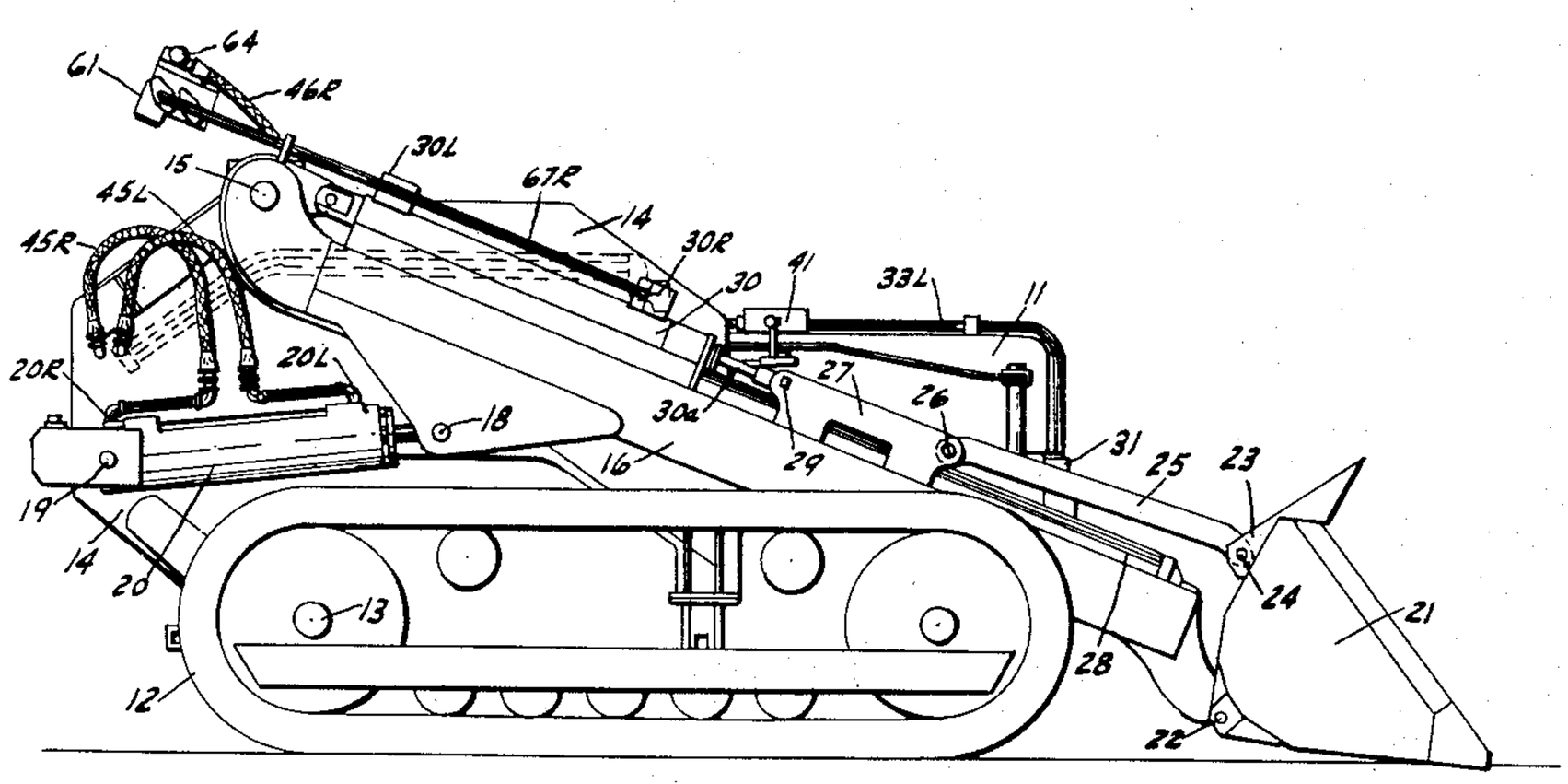

FIG. 1

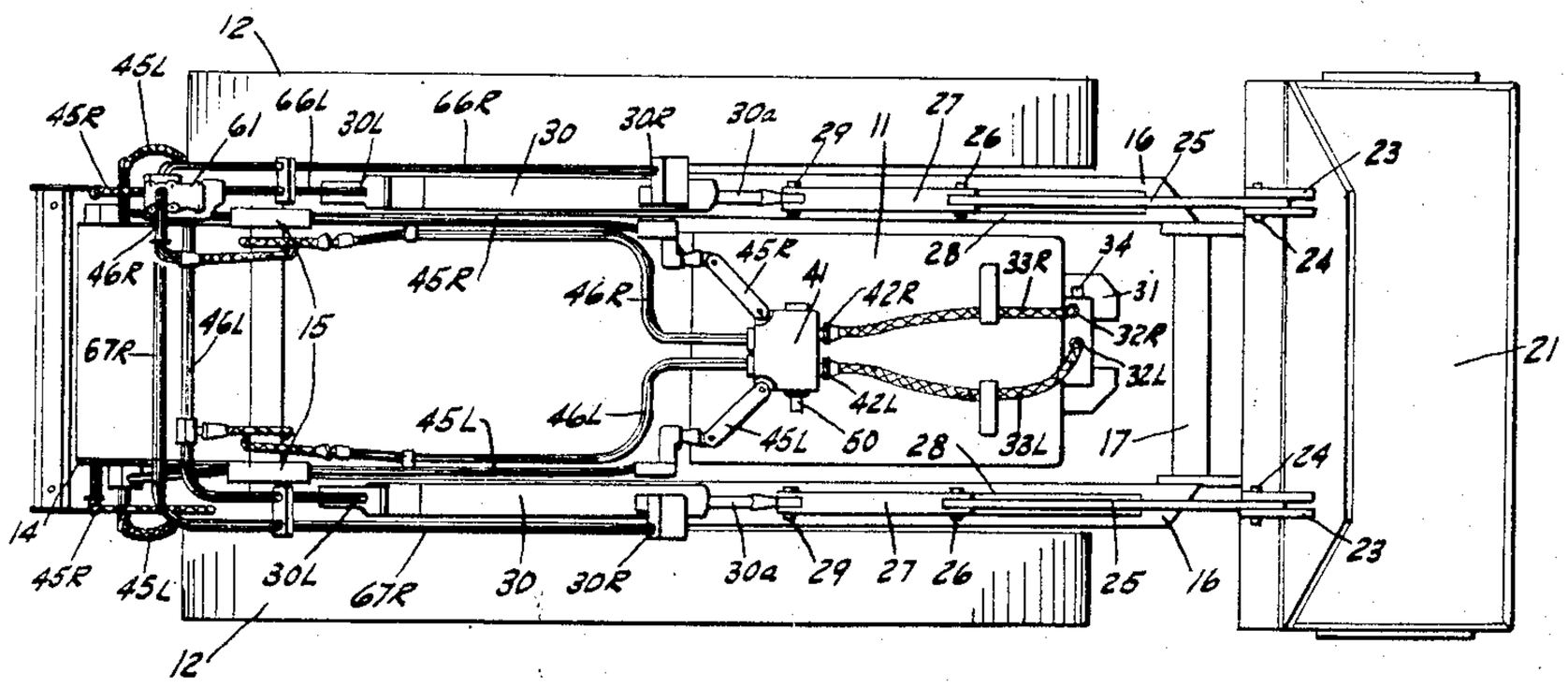

FIG. 2

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HYDRAULICALLY-OPERATED TRACTOR SHOVEL

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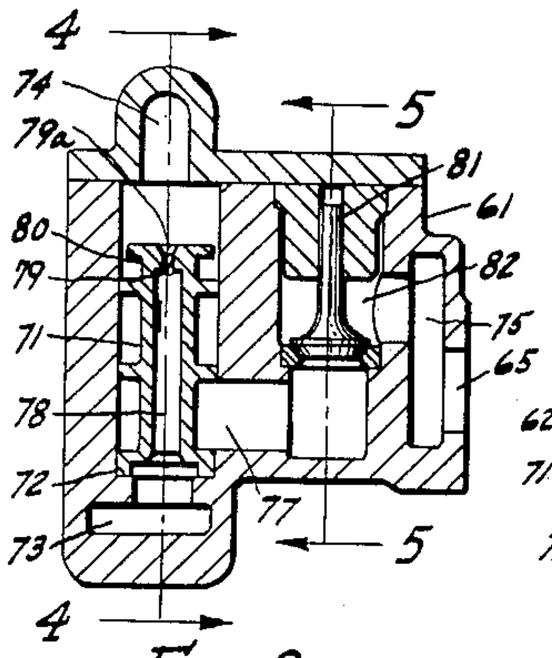

FIG 3

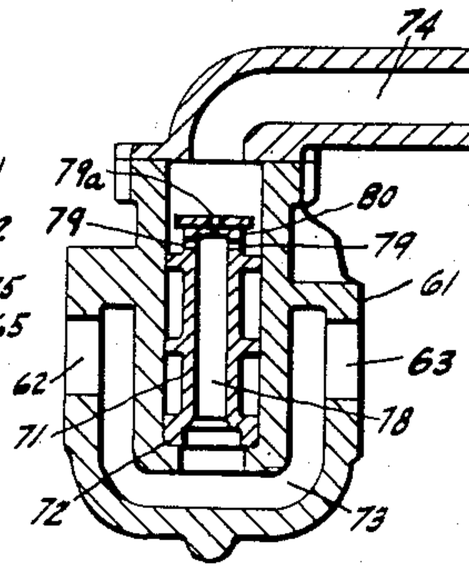

FIG 4

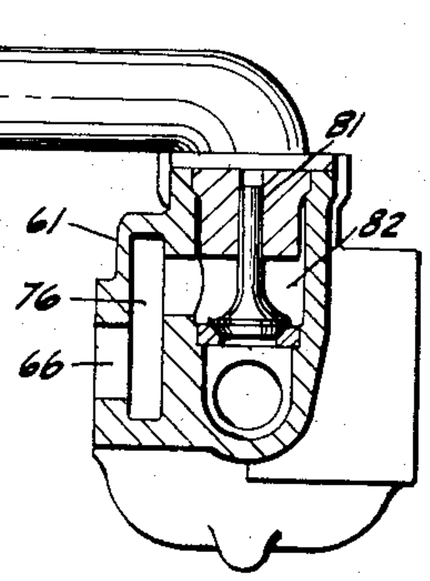

FIG 5

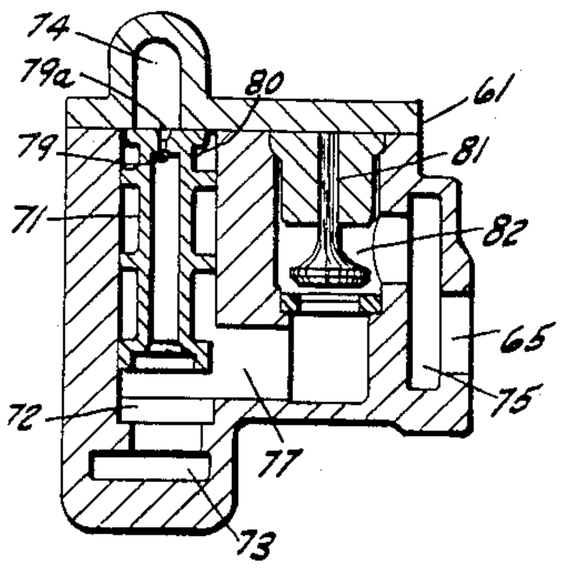

FIG 6

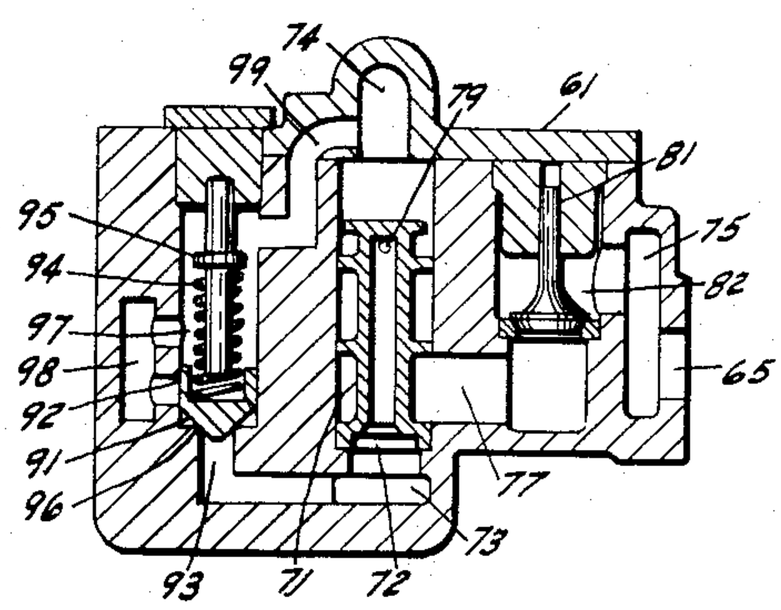

FIG 7

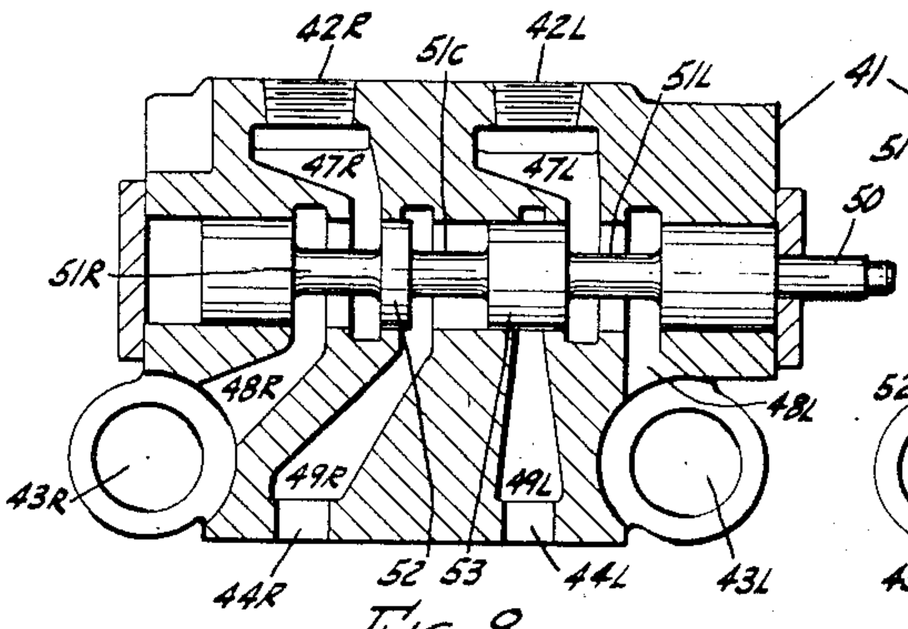

FIG 8

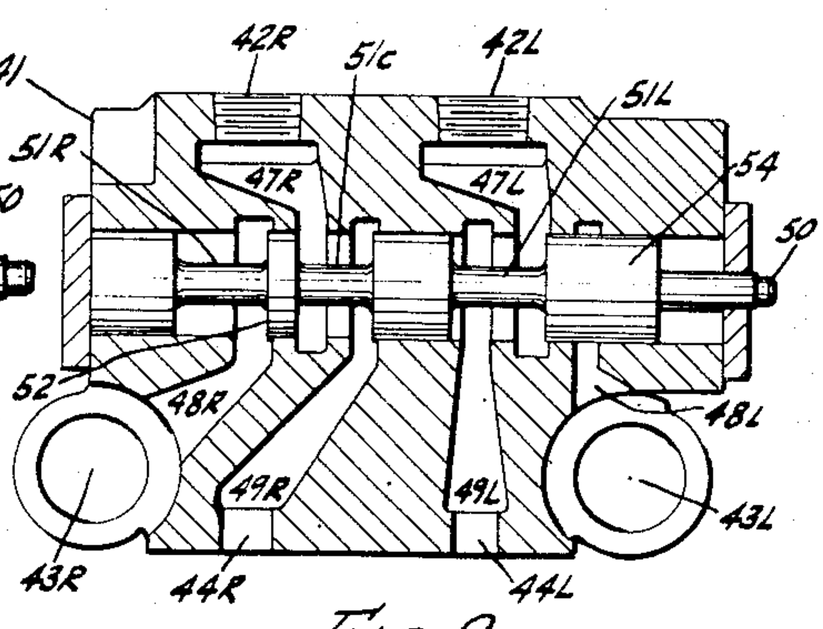

FIG 9

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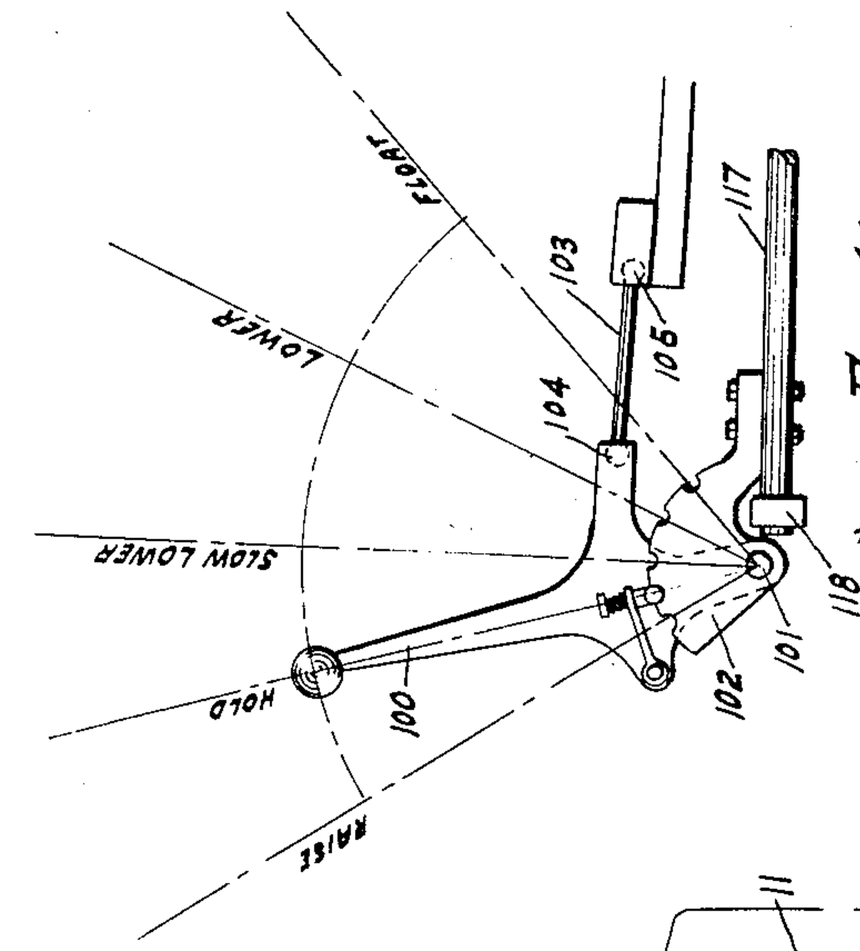

FIG. 11

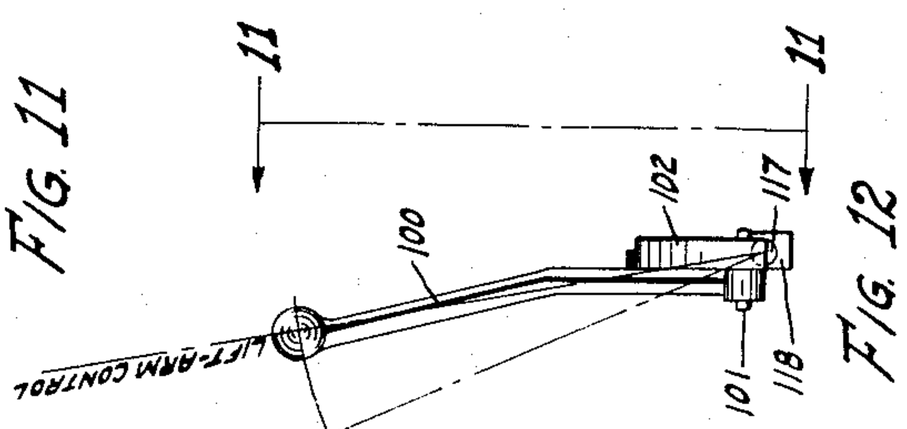

FIG. 12

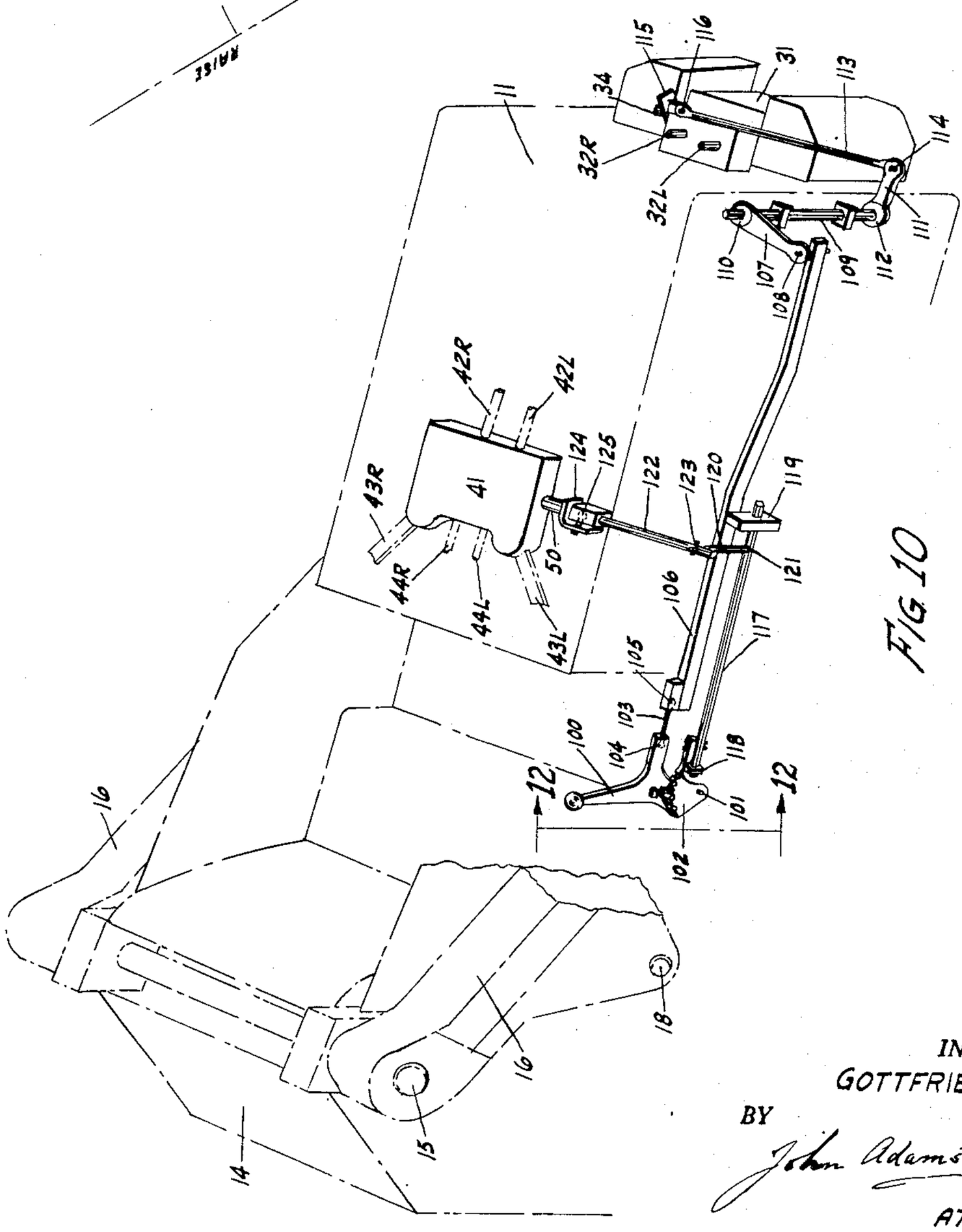

FIG. 10

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HYDRAULICALLY-OPERATED TRACTOR SHOVEL

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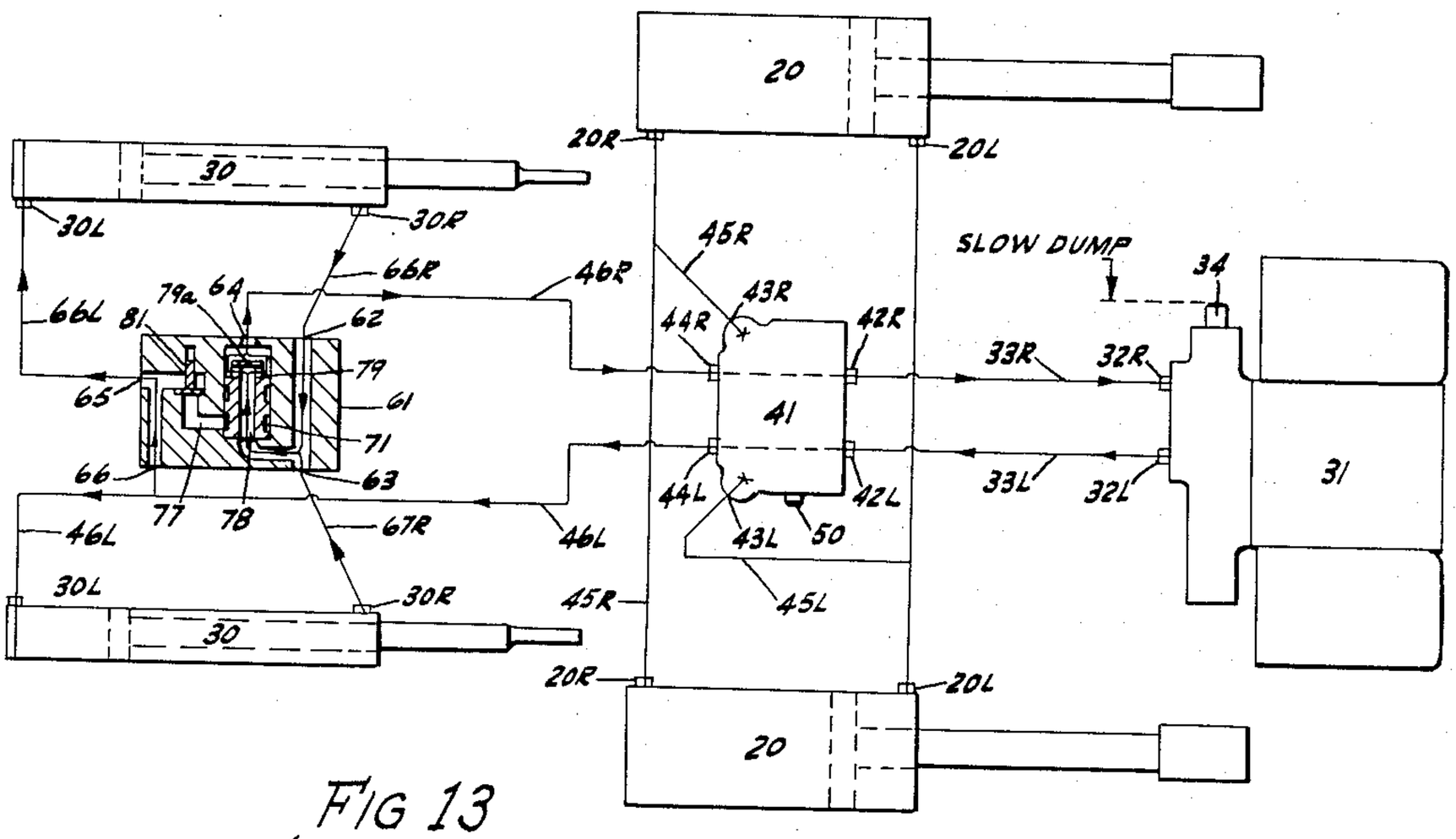

FIG 13
(SLOW DUMP)

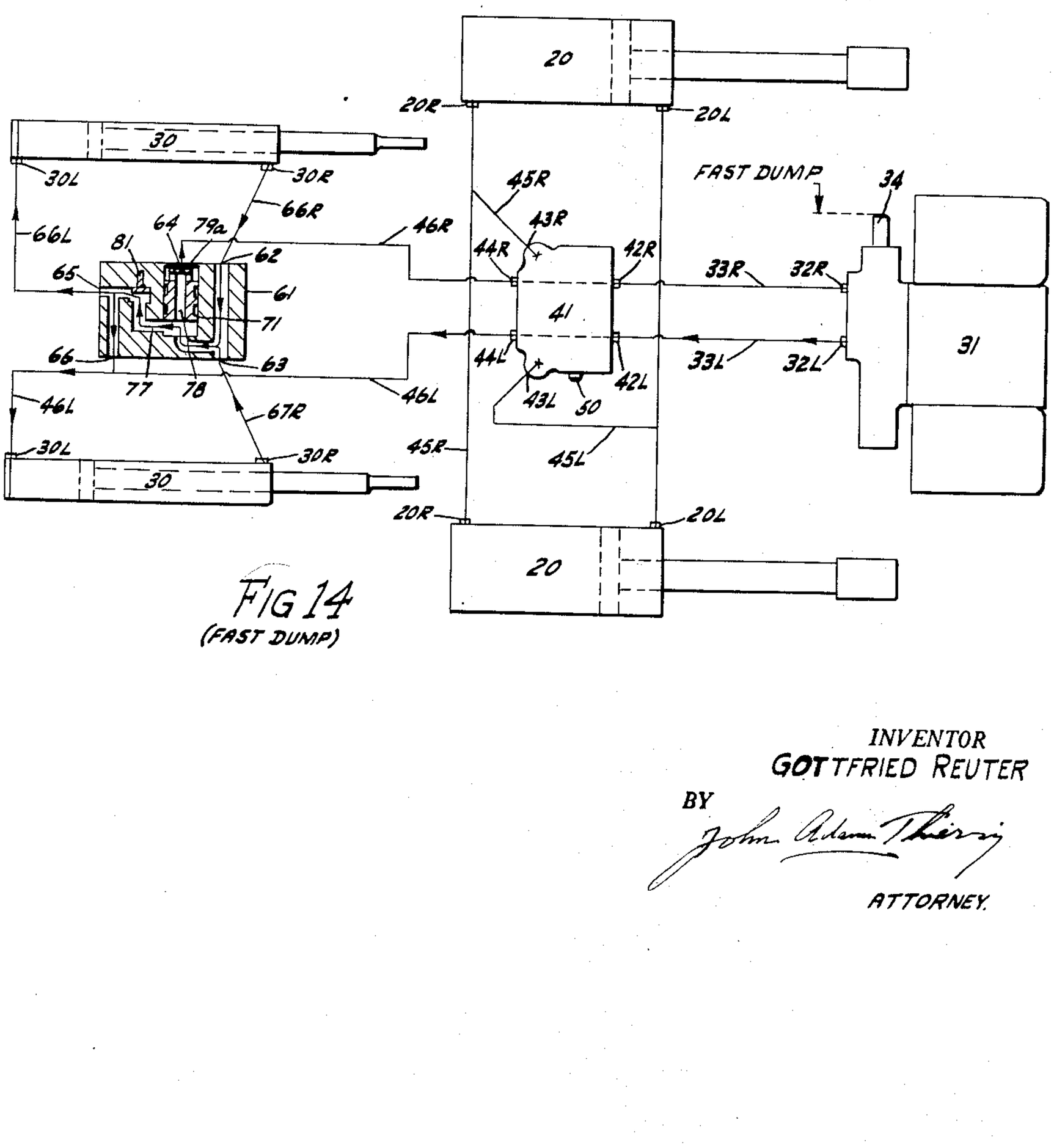

FIG 14
(FAST DUMP)

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Patented Feb. 17, 1953

2,628,731

UNITED STATES PATENT OFFICE

2,628,731

HYDRAULICALLY OPERATED TRACTOR SHOVEL

Gottfried Reuter, South Milwaukee, Wis., assignor to Bucyrus-Erie Company, South Milwaukee, Wis., a corporation of Delaware

Application September 17, 1949, Serial No. 116,391

4 Claims. (Cl. 214—140)

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This invention relates to new and useful improvements in tractor-mounted material-handling implements, more particularly to tractor shovels in which the horizontally-pivoted bucket is dumped and returned to normal carrying and digging position by an hydraulically-controlled mechanism.

In a machine of the type to which my invention is more particularly adapted, the implement is usually designed for attachment to a conventional tractor and consists of a transverse bucket, two arms pivoted on the tractor for pushing and lifting the bucket, and means to raise and lower the arms. The last-mentioned means usually consists of one or two hydraulic cylinders actuated by a pump driven by the engine of the tractor. The bottom of the bucket is usually concave toward the front in vertical cross-section, the ends being closed by flat plates. The bottom of the bucket is pivoted for dumping about a horizontal transverse axis on the front end of the lift arms, and the dumping and return movement of the bucket about this axis is usually effected by means of one or two double-acting hydraulic cylinders actuated by the pump and mounted on the lift arms.

The principal objects of the invention are to provide a material-handling implement in which:

(1) A very fast hydraulically-operated positive bucket dump is obtained without increasing normal pump capacity.

(2) The fast bucket dump utilizes the same fluid output from the pump and main control valve as is used for hydraulically lowering or raising the bucket lift arms at normal speed.

(3) The speed-force ratio at the bucket-dump piston is increased to produce the fast bucket dump without increasing speed of flow from the pump and main control valve.

(4) The increase of speed-force ratio at the bucket-dump piston occurs automatically responsive to a predetermined speed of return flow from the bucket-dump cylinder to the main control valve.

(5) Means is provided to render the means for changing the bucket-cylinder speed-force ratio inoperative automatically when the bucket is used in dumped or partially-dumped position to bulldoze backwards.

(6) Means is provided to prevent excess build-up of pressure in the bucket-dump control cylinder and its supply line after the end of the fast dump stroke without increasing dumping time.

In addition to the principal objects, above stated, a number of novel and useful details have

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been worked out, which will be readily evident as the description progresses.

The invention consists in the novel parts and in the combination and arrangement thereof, which are defined in the appended claims, and of which two embodiments are exemplified in the accompanying drawings, which are hereinafter particularly described and explained.

Throughout the description, the same reference number is applied to the same member or to similar members.

Figure 1 is a general side elevation of the tractor shovel embodying the invention, with control lever and linkage to the valve stems omitted (see Figures 10–12).

Figure 2 is a plan view of the same tractor shovel, also with control lever and linkage omitted.

Figure 3 is an enlarged vertical section of the short-circuit valve (for obtaining fast dump) showing the plungers of this valve in normal closed position.

Figure 4 is a similar section taken along the line 4—4 of Figure 3.

Figure 5 is a similar section taken along line 5—5 of Figure 3.

Figure 6 is similar to Figure 3, but shows the valve plungers raised in open position.

Figure 7 is an enlarged vertical section of a second embodiment of the short-circuit valve, showing all valve plungers in normal closed position.

Figure 8 is an enlarged horizontal section of the selector valve (for switching the hydraulic controls from the lift arms to the bucket or vice versa), showing the plunger of this valve in position for operation of the lift arms.

Figure 9 is similar to Figure 8, but with the plunger in position for operation of the bucket.

Figure 10 shows the control-lever linkage for controlling the selector valve and the main control valve of the hydraulic unit.

Figure 11 is an enlarged side view of the control lever showing its five fore-and-aft operating positions.

Figure 12 is a rear elevation of the control lever showing its two selector valve positions.

Figure 13 is a schematic diagram showing the hydraulic circuit for controlling the lift arms and the bucket and the direction of flow therein when the control lever is set in bucket-slow-dump position.

Figure 14 is similar to Figure 13, but shows the flow when the control lever is set in bucket fast-dump position.

Referring now to Figures 1 and 2, it is seen that 11 is a conventional tractor, mounted on creeping traction units 12, which are pivoted on propelling shaft 13 and have considerable freedom to oscillate independently about said shaft to conform to unevenness of the ground.

Pivoted to each side of cradle frame 14 on the tractor as at rearward point 15 is a forwardly-projecting lift arm 16. These arms are connected at their front end by cross-beam 17, and serve to support and impel bucket 21. They are raised and lowered by the following-described mechanism. To an intermediate point 18 on each arm 16 there is pivoted an hydraulic cylinder-piston assembly 20 which is also pivotally supported at a rearward and relatively-low point 19 on the cradle frame 14. The two cylinders are interconnected and their pistons are actuated by pressure fluid supplied from a conventional hydraulic unit 31 (hereinafter described) mounted at the front of the tractor. The bottom of bucket 21 is pivoted at 22 to the forward end of lift arms 16. Two pairs of ears 23 welded to the rear of bucket 21 are drilled for a pin connection at 24 to link arms 25 which are each pin-connected at their rear end 26 to a cross-head 27 grooved to slide on a T-shaped rail 28 welded to the top of each lift arm 16. The rear of each cross-head 26 is attached at 29 to piston rod 30*a* of bucket-dump control cylinder-piston assembly 30 mounted on each lift arm 16. Cylinder-piston assemblies 30 are double-acting, and pressure fluid therefor is supplied through selector valve 41 and short-circuit valve 61 from hydraulic unit 31 which will now be described.

At the front end of the tractor engine there is mounted a conventional hydraulic unit 31, which is driven by the tractor and comprises a hydraulic storage tank or tanks, a hydraulic pump, a control valve for the control of the flow to and from the pump, and various incidental conduits, relief valves, and one-way valves. Since this hydraulic unit is well known in the art and forms no part of my present invention, it is merely shown schematically in the figures. Suffice to say that the hydraulic unit has two fluid ports 32R and 32L which are connected (as hereinafter described) to the "raise" and "lower" ends respectively of the cylinder assemblies which the hydraulic unit controls. The plunger 34 of the control valve of the hydraulic unit has five positions to control the flow of fluid to and from the pump in five cases as follows:

(1) *"Raise" position.*—Fluid under pressure is delivered by the pump through the "raise" port 32R of the hydraulic unit to the "raise" end of the cylinders; return fluid from the "lower" end of the cylinders through the "lower" port 32L of the hydraulic unit into the pump intake and tank.

(2) *"Hold" position.*—Fluid under pressure is delivered by the pump to the tank and then back into the pump again without leaving the hydraulic unit. Fluid ports 32R and 32L of the hydraulic unit are blocked off. Hence the cylinder pistons are locked in position.

(3) *"Slow lower" position.*—Fluid is delivered by the pump to the tank and then back into the pump. But the fluid ports 32R and 32L of the hydraulic unit are not entirely blocked off, there being a slow flow of fluid, under pressure of the weight of the bucket, from the "raise" end of the cylinders, to the "raise" port 32R of the hydraulic unit, and thence through a bleeder in the control valve of the hydraulic unit to the tank and the pump intake. In this "slow lowering" position fluid is drawn into "lower" end of the cylinders from "lower" port 32L, to compensate for the fluid drawn out of the cylinder at its other end.

(4) *"Lower" position.*—Fluid under pressure is delivered by the pump through the "lower" port 32L of the hydraulic unit to the "lower" end of the cylinders; return fluid passing from the "raise" end of the cylinders through the "raise" port 32R of the hydraulic unit into the pump intake.

(5) *"Float" position.*—"Raise" and "lower" ports 32R and 32L of the hydraulic unit and hence the "raise" and "lower" ends of the cylinders intercommunicate and communicate, with flow permitted in either direction through the control valve and tank of the hydraulic unit. Hence the piston is free to "float" in its cylinder.

Turning now to the subject matter of the invention, the hydraulic circuit leading from the "raise" and "lower" ports 32R and 32L respectively of hydraulic unit 31 through selector valve 41 (hereinafter described) and short-circuit valve 61 (hereinafter described) to the "raise" and "lower" ends of the lift-arm cylinders 20 and bucket cylinders 30, will now be described.

Turning to Figures 8–9 and 13–14, it is seen that the selector valve 41, which is mounted for convenience above the tractor engine behind the hydraulic unit, has ports 42R and 42L located on its side adjacent the hydraulic unit and connected respectively to ports 32R and 32L of the hydraulic unit through conduits 33R and 33L (see Figure 2). On the other side of the selector valve there are two pairs of ports. The outer pair 43R and 43L are connected respectively to the "raise" and "lower" ends 20R and 20L of lift-arm cylinders 20 through conduits 45R and 45L. The inner pair 44R and 44L are connected respectively to the "raise" and "lower" ends 30R and 30L of bucket cylinders 30, through conduits 46R and 46L, short-circuit valve 61 (hereinafter described), and conduits 66R, 67R, and 66L.

There are six chambers in the selector valve, three for the "raise" side of the circuit and three for the "lower" (or "dump") side of the circuit. Ports 42R and 42L lead into chambers 47R and 47L respectively; ports 43R and 43L (to lift-arm cylinders) into chambers 48R and 48L respectively; and ports 44R and 44L (to bucket cylinders and short-circuit valve) into chambers 49R and 49L respectively.

Connection between these chambers is through annular recesses 51R, 51C, and 51L in plunger 50 which is shiftable along its longitudinal axis into one of two positions in its seat.

In the "lift-arm" control position (Figure 8) of plunger 50, chamber 47R is connected through annular recess 51R to chamber 48R and chamber 47L is connected through annular recess 51L to chamber 48L, connection to chambers 49R and 49L (to bucket cylinders 30) being blocked off by lands 52 and 53 respectively of plunger 50. Accordingly the lift arms alone are operable by the control valve of hydraulic unit 31, the bucket being locked in a "hold" position.

In the "bucket" control position (Figure 9) of plunger 50, chamber 47R is connected through annular recess 51C to chamber 49R, and chamber 47L is connected through annular recess 51L to chamber 49L; connection to chambers 48R and 48L (to lift-arm cylinders) being blocked off by lands 52 and 54 respectively of plunger 50. Accordingly the bucket alone is operable by the

control valve of the hydraulic unit **31**, the lift-arms being locked in a "hold" position.

Short-circuit valve **61** has five ports connected externally as follows (see Figures 2–5, 13 and 14): Port **62** is connected by conduit **66**R to the "raise" (bucket relatch) end **30**R of one of the bucket cylinders **30**. Port **63** is connected by conduit **67**R to the "raise" (bucket relatch) end **30**R of the other bucket cylinder. Port **64** is connected by conduit **46**R to the bucket "raise" (relatch) port **44**R of selector valve **41**. Port **65** is connected by conduit **66**L to the "lower" (bucket dump) end **30**L of one of the bucket cylinders. Port **66** is connected by conduit **46**L to the "lower" (bucket dump) end **30**L of the other bucket cylinder and also by the same conduit to "lower" (dump) port **44**L of selector valve **41**.

Short-circuit valve **61** (Figures 3–6) has a gravity-closing shuttle plunger **71** seated and shiftable vertically in vertical-cylindrical seat **72**, and a gravity-closing check-valve consisting of plunger **81** seated and shiftable vertically in vertical seat **82**. Seat **72** opens at its bottom end into passage **73** which interconnects ports **62** and **63**, at its top into passage **74** leading to port **64**, and at its lower side into passage **77** leading to the bottom end of seat **82** of check-valve **81**. Seat **82** opens at its sides into ports **65** and **66** through passages **75** and **76** respectively.

Both plungers **71** and **81** are normally held by gravity in lowered position (Figure 3), so that passage of fluid through passage **77** is blocked off.

Shuttle plunger **71** has a longitudinal bored passage **78** that opens at its lower end into passage **73** and at its upper end through radial holes **79** into external annular depression **80** which is open to the upper portion of seat **72**.

When shuttle plunger **71** is lifted into raised position, by fluid from ports **62—63** and passage **73** hitting the underside of the plunger, the head of the plunger covers and blocks off flow of fluid outwardly through bore **78**, radial holes **79**, passage **74** and port **64**, except for the small flow through relief hole **79***a* in the head of the plunger (this hole prevents excessive build-up of pressure in the "raise" and "lower" ends of the bucket cylinders); and at the same time passage **77** is uncovered and flow of fluid from ports **62—63** and passage **73** into passage **77** occurs with the result that one-way plunger **81** is raised by the fluid pressure on its underside and fluid flows on out through the interior of seat **82**, passages **75—76**, and ports **65—66**.

Turning now to Figure 7, we see a second embodiment of the short-circuit valve, in which the relief hole **79***a* in the head of shuttle-plunger **71** is replaced by a two-step relief valve connected in parallel with the shuttle valve and consisting of vertically-slidable plunger **91** having a conical bottom surface and a hollow stem **92** at its upper end for seating the lower end of load regulating spring **94** which is seated at its upper end against spring guide flange **95**. Plunger **91** is normally held by spring **94** seated on valve seat **96**. In this position plunger-stem **92** covers and blocks flow of fluid from passage **93** below plunger **91** into passage **98**, into chamber **97** above plunger **91** and thence into passages **99** and **74** which lead to port **64**. In this closed position plunger **91** has only a relatively-small effective pressure area (equal to the cross-section area of passage **93**), and accordingly a relatively-large pressure in passage **73—93** is required initially to open the valve by pushing plunger **91** up against spring **94**. Once the valve is open, however, the effective pressure area of plunger **91** is increased to its entire cross-section area, and accordingly only a relatively-low pressure of the bypassed fluid is required to keep plunger **91** open against spring **94**.

Turning now to Figures 10 to 12, it is seen that the valve plunger **34** of hydraulic unit **31** and selector valve plunger **50**, each of which is shiftable along its longitudinal axis, are actuated by a common hand control lever **100** mounted on the tractor beside the operator.

Fore-and-aft movement of control lever **100** about its pivot **101** on quadrant **102** shifts main control valve plunger **34** into its five operating positions of "raise," "hold," "slow lower," "lower," and "float" above described. To accomplish this, control-lever **100** is connected to plunger **34** by reach rod **103** universally connected at **104** to lever **100**, reach rod **106** universally connected at **105** to rod **103**, lever **107** pivotally connected at **108** to rod **106**, vertical lever shaft **109** rigidly connected at its upper end to the fulcrum **110** of lever **107** and mounted on the tractor to pivot about its axis, lever **111** rigidly connected at its fulcrum **112** to shaft **109**, transverse reach rod **113** pivotally connected at **114** to lever **111**, and anchor **115** pivotally connected at one end **116** to rod **113**, and rigidly connected at the other end to the plunger **34**. Notches are provided in quadrant **102** so that the control lever **100** can be held in each of its five operating positions.

Sideways movement of control lever **100** about the horizontal longitudinal axis of lever shaft **117** which is journalled on the side of the tractor at **118** and **119**, and upon which quadrant **102** is rigidly mounted, shifts the selector valve plunger **50** into its two operating positions of "lift-arm control" and "bucket control." To accomplish this, control lever **100** actuates plunger **50** through quadrant **102**, lever shaft **117**, lever **120** rigidly connected at **121** to shaft **117**, reach rod **122** pivoted at **123** to the end of lever **120**, and anchor **124** having universal connection **125** to rod **122**, and rigid connection to plunger **50**. Outward sideways movement of the control lever **100** throws the selector valve plunger **50** into "lift-arm control" position, and inward movement into "bucket-control" position.

Turning now to Figures 13 and 14, in which the circuit of the hydraulic system is represented schematically and fluid flow is represented by arrows for the cases of "slow dump" and "fast dump" respectively of the bucket, it is seen that for these as well as all other bucket-control cases, the selector valve plunger **50** is in "bucket-control" position so that ports **43**R and **43**L to the lift cylinders **20** are blocked off by the selector valve, which is open to allow passage of fluid from the hydraulic unit **31** to the bucket cylinders **30** through conduits **46**R and **46**L and short-circuit valve **61**.

When the operator now moves the control lever **100** forward from "hold" into "slow lower" position for slow dumping of the bucket (see Figures 11 and 13), this causes fluid to flow from the "lower" port **32**L of the hydraulic unit **31**, through ports **42**L and **44**L of the selector valve **41**, and thence through conduits **46**L and **66**L and ports **65—66** of short-circuit valve **61** to the rear "lower" (i. e., "dump") ends **30**L of bucket cylinders **30**, thereby causing the pistons of these cylinders to move forward and the fluid in the forward part of the cylinders to be expelled through "raise" (or "relatch") ports **30**R to ports **62—63** of the short-circuit valve **61**, and thence through

bore 78 and radial holes 79 (Figure 4) of shuttle plunger 71 out through port 64 and conduit 46R to port 44R of the selector valve, and thence through the selector valve to port 32R of the hydraulic unit 31. In this "slow dump" case the flow of fluid through shuttle-plunger 71 of the short-circuit valve 61 is not fast enough to lift the shuttle plunger from its seated position, so that a short-circuit through passage 77, valve seat 82, and ports 65—66 of the short-circuit valve to the "lower" (i. e., "dump") ends 30L of the bucket cylinders is blocked.

When, however, the operator puts the control lever 100 forward further into "lower" position for fast dumping of the bucket (see Figures 12 and 14), this causes the fluid to travel faster through the ports 62—63 of the short-circuit valve and to hit the underside of shuttle plunger 71 with such force that it instantly moves up, blocking all flow (except bleeding through relief hole 79*a*) through plunger 71 and port 64, and uncovering passage 77 so that the fluid expelled from the "raise" end 30R of the bucket cylinders is now short-circuited past check-valve plunger 81 and out through ports 65—66 back to the bucket cylinders through their "lower" i. e., "dump") end 30L. Thus a connection is established between the front and rear ends of the bucket cylinders and return flow to the hydraulic unit is eliminated except for the above-mentioned bleeding through hole 79*a* the function of which will be explained hereinafter. Therefore the fluid from the "lower" port 32L of the hydraulic unit will now serve merely to compensate for piston-rod displacement of the bucket cylinders 30, and accordingly movement of the pistons of these cylinders will be greatly accelerated producing a very fast dump, even faster than a gravity dump. This makes it possible for the operator to get rid of sticky material in his bucket and to speed up the digging operation and at the same time retain full control of his bucket.

It will be seen that when fluid at "lower" position speed is supplied by the hydraulic unit to the bucket cylinders, the short-circuit valve then automatically reduces the effective bucket-dump pressure area of the pistons of cylinders 30 to the cross-sectional area of their piston rods and thereby increases the speed-force ratio of the bucket cylinders. In this way it is possible to obtain a fast bucket dump with the relatively slow flow of fluid that is available from the hydraulic unit (and is normally sufficient for lowering or raising the lift-arms), and at the same time to have a common hydraulic unit and a common control lever for both the lift arms and the bucket, with analogous operating functions for each.

When the operator moves the control lever 100 back to "hold" position, flow through ports 32R and 32L of hydraulic unit 31 is blocked, and since plungers 71 and 81 of the short-circuit valve will then be in their normal gravity closed position, there will be no connection between ends 30L and ends 30R of the bucket cylinders 30 so that their pistons will be held stationary. If, however, the shuttle-plunger 71 is by chance stuck in its raised "short-circuit" position, and fluid in the "lower" end 30L of cylinders 30 is under pressure due to bulldozing backward with the bucket in dumped position, plunger 81 will block the short-circuit between the ends of the cylinder and thereby prevent a decrease in the effective pressure area of the piston and a corresponding excessive increase in fluid pressure in the cylinder.

When the operator moves the control lever 1 still further back to "raise" position for return ing the bucket to its normal carrying positio this causes fluid to flow from the "raise" port 3 of the hydraulic unit 31, through ports 42R a 44R of the selector valve 41, and thence throu conduit 46R, port 64 of short-circuit valve 6 radial holes 79 and bore 78 of plunger 71 whi is held by gravity and fluid pressure in its seat position (Figure 3), and thence out through por 62 and 63 through conduits 66R and 67R respe tively to the "raise" ports 30R of the buck cylinders 30, thereby causing the pistons of the cylinders to move rearwardly and the fluid in t rear chambers of the cylinders to be expell through the "lower" ports 30L, through condui 46L and 66L and ports 65—66 of the short-circu valve 61, and thence through ports 44L and 4 of the selector valve 41 to port 32L of hydrau unit 31. In this "bucket-return" case, both plun ers 71 and 81 are held by gravity and by flu pressure in their seated position so that shor circuit flow between the ports 30R and 3 through passage 77 is blocked.

Relief hole 79*a* in the head of shuttle plung 71 prevents excessive build-up of pressure in th shorted dump circuit. Hole 79*a* also serves t relieve pressure in the "lower" and "raise" end 30L and 30R of the cylinders 30 by returnin fluid to the "raise" port 32R of the hydraulic uni 31 when the end of the dumping stroke is reache In order, however, to develop less heat, if th operator should leave the control lever 100 i fast-dump position after dumping has been com pleted, it is desirable to return the fluid to th "raise" port 32R at as low pressure as possibl since then less engine horsepower is required Accordingly as an alternative to relief hole 79*a* a two-step relief valve may be connected in par allel with the shuttle valve. This alternativ embodiment is shown in Figure 7 and operate as follows. When and only when pressure i high, the plunger 91 will open, since the effective pressure area to open it when closed is small. Immediately after opening however, the effective pressure area is increased to the full cross-section area of the plunger, and accordingly pressure required to keep the plunger open is reduced, and so long as the plunger remains open any oil that is bypassed and returned to the "raise" port 32R of hydraulic unit 31 is returned at low pressure.

Having now described and illustrated two forms of the invention, it is to be understood that the invention is not to be limited to the specific form or arrangement of parts herein described and shown.

I claim:

1. In a tractor propelled material-handling apparatus the combination of: a main frame, a lifting and lowering frame attached to the main frame; a bucket rockingly supported by said lifting and lowering frame; means to raise and lower said lifting and lowering frame; a double-acting cylinder-piston assembly having one end supported by one of said frames and the other end pivotally connected to the bucket; hydraulic means to feed pressure fluid selectively into the chamber at one end of the cylinder of said assembly to rock the bucket into dumping position and into the chamber at the other end of the cylinder to restore the bucket to digging and carrying position; said hydraulic means including a fluid supply tank, a pump, piping and a control valve for the selective control of the flow

of such pressure fluid; and a normally-closed short-circuit valve connected between said chambers and adapted to open for a predetermined setting of said control valve of said hydraulic means to feed pressure fluid into the chamber at said one end of the cylinder to dump the bucket; said short-circuit valve being connected in the piping between said second-mentioned chamber and the main control valve in such a manner that when open it blocks substantially all return flow from said second-mentioned chamber to the main control valve and diverts it into the other end of the cylinder.

2. A material-handling apparatus according to claim 1, further characterized by the fact that in the circuit between said second-mentioned chamber and the main control valve, the short-circuit valve is in parallel with a normally-closed one-way valve that opens responsive to a predetermined fluid pressure in said second-mentioned chamber to permit a relief flow of fluid from said second-mentioned chamber to the main control valve, and remains open responsive to a pressure that is lower than said predetermined fluid pressure.

3. In a tractor-propelled material handling apparatus the combination of; a main frame, a lifting and lowering frame attached to the main frame; a bucket rockingly supported by said lifting and lowering frame; means to raise and lower said lifting and lowering frame; a double-acting cylinder-piston assembly having one end supported by one of said frames and the other end pivotally connected to the bucket; hydraulic means to feed pressure fluid selectively into the chamber at one end of the cylinder of said assembly to rock the bucket into dumping position and into the chamber at the other end of the cylinder to restore the bucket to digging and carrying position; said hydraulic means including a control valve for controlling the flow of such pressure fluid adapted to be set selectively to feed such pressure fluid into the first-mentioned chamber at one or the other of two predetermined speeds of flow; and a short-circuit valve connected between said chambers and between said second-mentioned chamber and the control valve in such a manner that, when the control valve is set to feed pressure fluid into said first-mentioned chamber at the lower of said predetermined speeds of flow, the short-circuit valve blocks flow between said chambers and provides an opening for return flow from the second-mentioned chamber to the control valve, and that, when the control valve is set to feed pressure fluid into said first-mentioned chamber at the higher of said predetermined speeds of flow, the short-circuit valve provides an opening for flow of pressure fluid from said second-mentioned chamber to said first-mentioned chamber and blocks substantially all return flow from said second-mentioned chamber to the control valve.

4. A material-handling apparatus according to claim 3, further characterized by the fact that in the circuit between said second-mentioned chamber and the main control valve, the short-circuit valve is in parallel with a normally-closed one-way valve that opens responsive to a predetermined fluid pressure in said second-mentioned chamber to permit a relief flow of fluid from said second-mentioned chamber to the main control valve, and remains open responsive to a pressure that is lower than said predetermined fluid pressure.

GOTTFRIED REUTER.

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