March 7, 1950 W. T. STEPHENS 2,499,425

CONTROL VALVE FOR DOUBLE-ACTING HYDRAULIC SYSTEMS

Original Filed Aug. 18, 1944 2 Sheets-Sheet 1

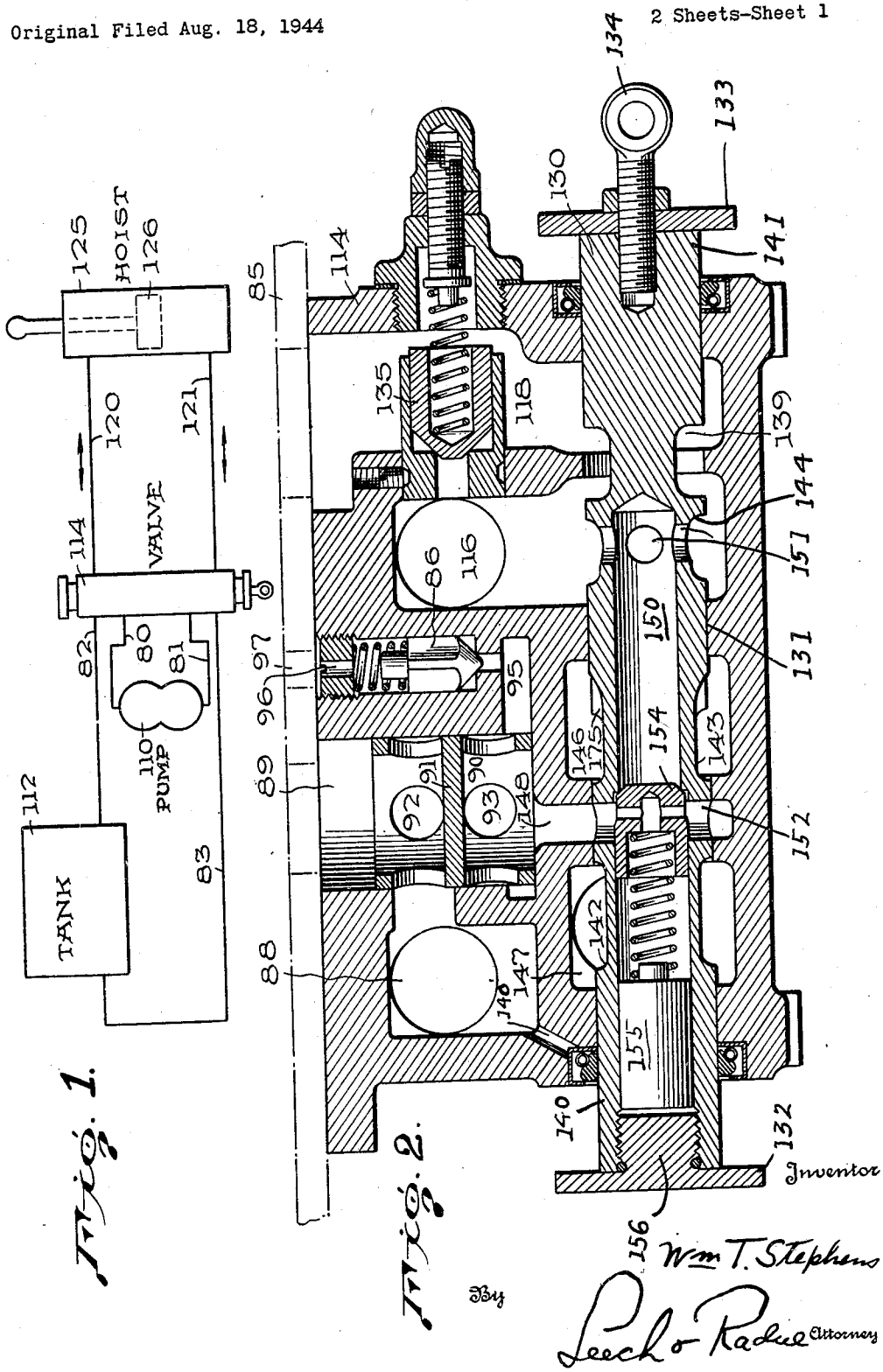

Fig. 1.

Fig. 2.

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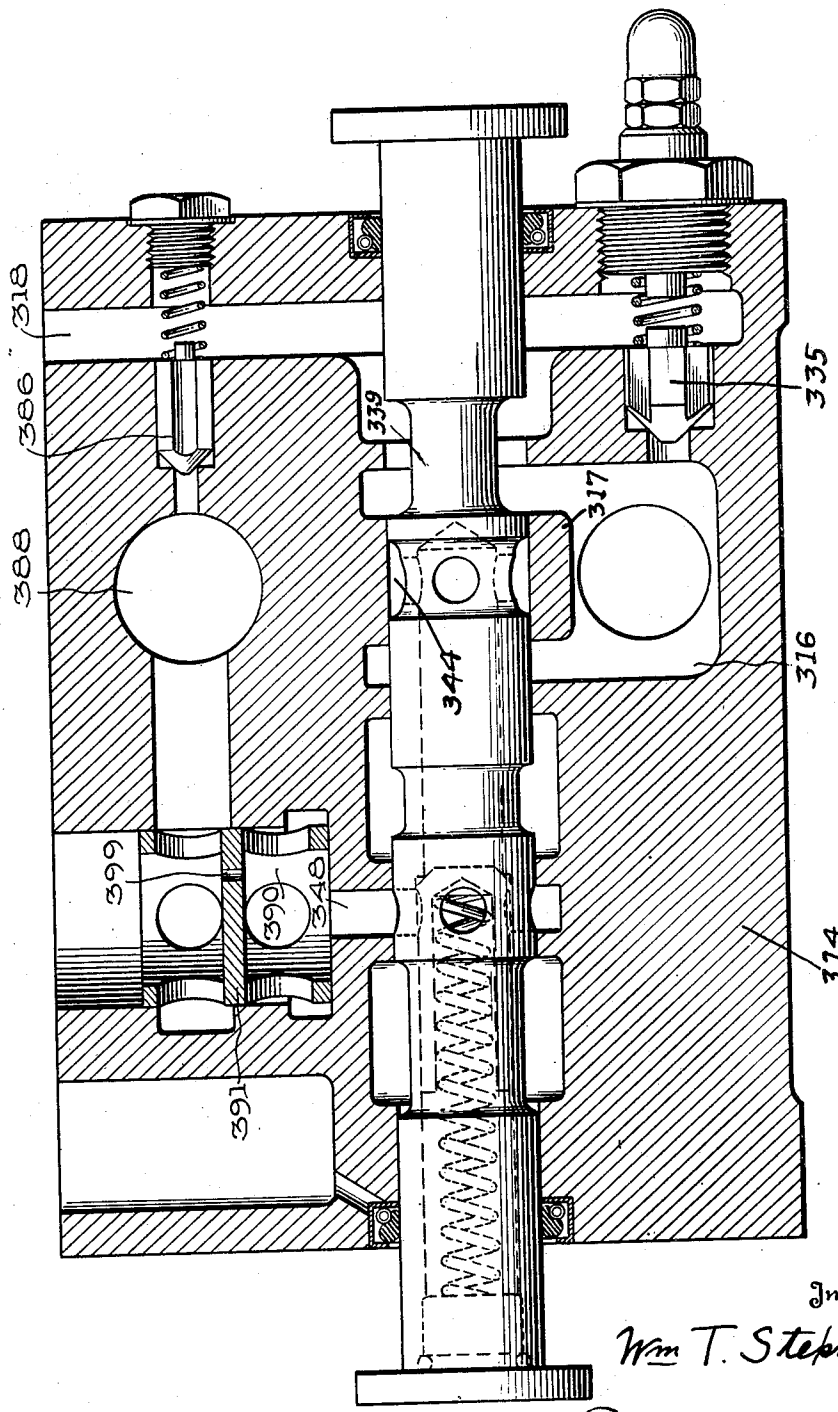

Fig. 3

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2,499,425

CONTROL VALVE FOR DOUBLE-ACTING HYDRAULIC SYSTEMS

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Original application August 18, 1944, Serial No. 550,078, now Patent No. 2,477,669, dated August 2, 1949. Divided and this application September 3, 1948, Serial No. 47,678

6 Claims. (Cl. 277—20)

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This invention relates to control valves for double acting hydraulic systems and more particularly to such valves equipped with automatic means to insure complete control of hydraulic rams or hoists on both raising and lowering operations.

It is a general object of the present invention to provide novel and improved control valves for double acting hydraulic systems.

More particularly it is an object of the present invention to provide hydraulic control valves for double acting hydraulic control systems of the closed type to insure against undesired movement of the hoist, on its lowering operation, due to the action of the load and independent of the rate of supply of the liquid causing the lowering operation.

As an important feature of the invention there is provided means for operating the system in the closed manner during movements of the hoist in either direction and for automatically converting to the open system at all other times.

A further important feature of the invention resides in the provision of a flow control valve for use with closed systems which not only provides for the automatic conversion to the open system when hoisting is not taking place, but which provides for an adequate supply of liquid to the pump inlet under all conditions and for relief of excess liquid in the case of differential volumes becoming available from the two ends of the hoist.

Among the essential features of the invention which contribute to its simplicity of construction and operation is the incorporation in the manual control valve of a single check valve automatically operable on both hoisting and lowering operations to insure against return of fluid from the hoist toward the pump.

Other features and objects of the invention include the simplicity of the valve housing structure, the arrangement and disposition of the main and auxiliary valve parts, the construction of the valve plungers, their ports and passages, and means providing for handling differential volumes of fluid from the two ends of the hoist when the control valve is in the float position.

Other and further objects and features of the invention will be more apparent to those skilled in the art upon a consideration of the accompanying drawings and the following specification wherein are disclosed several exemplary embodiments of the invention, it being understood that such changes, modifications and combinations of the several figures may be made as fall within

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the scope of the appended claims without departing from the spirit of the invention.

In said drawings:

Figure 1 is a schematic and diagrammatic representation of a hydraulic control system for the operation of a double acting hoist or ram by the so-called closed circuit system;

Figure 2 is a longitudinal central section through a control valve adapted for use with a system of the type illustrated in Figure 1; and

Figure 3 is a longitudinal central section through a control valve for use in a closed system of the type illustrated in Figure 1, the valve representing a simplification of the construction illustrated in Figure 2.

In the operation of double acting hydraulic devices such as rams, hoists and the like, conditions arise, dependent upon connected mechanical apparatus, necessitating extremely accurate control of the position of the piston, together with some means to prevent movement of the piston out of control of the hydraulic liquid as, for instance, under the operation or weight of the load when the latter is being lowered.

The present invention deals primarily with a valve intended for the control of the hydraulic cylinder or hoist used for the manipulation of the blade on a bulldozer or grader, but is not to be construed as so limited, since it is capable of use in a wide variety of fields. The description, however, for the sake of convenience, will refer to the preferred use of the apparatus.

In the operation of a bulldozer for grading or similar earth handling manipulations, it is desired that the blade may be raised, held, lowered or permitted to float, under the instant and accurate control of the operator. Difficulties have heretofore been experienced in equipment of this sort when attempts were made to lower the blade. Its considerable weight tends to withdraw the piston from the liquid following it and intended to regulate its rate of lowering on release of the liquid supporting the piston. This provides erratic operation and prevents the attainment of the fine grading which can be achieved with machines of this type provided with proper controls.

Heretofore two general systems have been used in an endeavor to overcome the above mentioned difficulty. The first of these is the use of the so-called "closed" system wherein the positive displacement pump for circulating the pressure liquid is connected to receive its supply of liquid from one end of the hoist cylinder while delivering to the opposite end. This prevents uncon-

trolled travel of the piston under the weight of the blade since liquid is withdrawn only as fast as delivered, but this system circulates such a small quantity of liquid that overheating is prevalent, particularly in the neutral or hold position, when fluid is merely circulated from the pump to the valve and back. The tank or reservoir serves only to provide reserve liquid and to take care of a differential in displacement at the two ends of the cylinder, one of which is occupied by a piston rod.

In the other or so-called "open" system, liquid is delivered from the high pressure side of the pump to operate the hoist on the lift stroke and fluid is returned to the tank from the opposite end of the hoist. The pump inlet is from the tank. Upon the lowering stroke some form or flow control valve is provided to limit the rate at which the liquid can be returned to the tank from the hoist in an endeavor to prevent the piston leaving the liquid in the upper side of the cylinder. Such flow control valves have not been wholly satisfactory because they were not constructed to regulate the rate of flow in accordance with the proper requirements. This system is not subject to serious overheating since the pump at all times takes its liquid from the large supply tank where cooling is adequate.

In accordance with the present invention improvements are made in the first system. In the system, operation when hoisting or lowering is in the normal closed system manner with the two ends of the hoist being connected to the two sides of the pump whereby overrunning is prevented. However, in the hold or neutral position, the system is converted automatically to an open one and the pump circulates liquid from and to the tank, thus preventing overheating during by far the longest periods of normal operation.

Material simplification of the valve housing structure is achieved by providing the check valve, which prevents return of high pressure liquid from the cylinder toward the pump, within a bore which is provided longitudinally of and in the valve plunger, which bore likewise permits the high pressure fluid to by-pass certain of the control grooves in the plunger surface between the lands thereon. This single check valve serves when supplying high pressure fluid to either end of the hoist.

Referring now to Figures 1 and 2 of the drawing, there is illustrated a "closed system" for hoist operation together with details of a valve for controlling the same. The system of Fig. 1 includes the positive displacement pump 110, the tank or reservoir 112, the valve 114 and the double acting hoist 125 housing piston 126 having piston rod 127 at one end. The pump is connected directly only to the valve by pipes 80 and 81 and the tank only to the valve as by conduits 82 and 83. Opposite ends of the hoist are connected to the valve by lines 120 and 121 respectively. It will be noted that the displacements at the two ends of the hoist cylinder are different and the valve provides means to compensate for this.

Fig. 2 illustrates in detail one form of valve for controlling the system of Fig. 1. Here the housing 114 is preferably unitary and for the sake of convenience and to reduce the amount of piping and the space occupied by the hydraulic equipment, is arranged to be mounted directly on the bottom wall 85 of the tank 112. For this purpose the housing top is flat. Corresponding

openings in the tank and housing meet to take the place of pipes 82 and 83 shown in Fig. 1. Obviously the valve, by suitable piping connections may be mounted independently of the tank.

The valve housing 114 contains chamber 88 for connection to the pump inlet by pipe 81 and chamber 116 for connection to the pump discharge or high pressure side of pipe 80. It also contains low pressure chambers 89 and 118 each passing through the upper surface of the housing for connection to the tank as shown. Chambers 146 and 147 are connected respectively by pipes 120 and 121 to the upper and lower ends of hoist 125.

Manual control of the operation of the hoist is effected by appropriate movement of the cylindrical valve plunger 130 arranged in and passing through bore 131 in the housing. The ends of the plunger are fitted with stop flanges 132 and 133, one of which is positioned by means of the manipulative eye 134. The valve is shown in the neutral or hold position, which locks the hoist plunger wherever it may be positioned at the time, serving thereby to hold the bulldozer blade in a fixed position against dislodgement.

The valve plunger bore 131 is intersected in sequence by hoisting chamber 147, discharge passage 148, lowering chamber 146, pump discharge chamber and tank return chamber 118 separated by appropriate walls. The plunger 130 is a cylindrical rod having a close fit in the bore by all portions of its surface not interrupted by ports or grooves. The full diameter portions are termed "lands" and there is one numbered 140 at the left end, one numbered 141 at the right end and three intermediate ones of various lengths. The surface of the plunger is provided with circumferential grooves 142, 143, 144 and 139 each of which has at least the function of spanning and thus connecting certain passages and chambers in the valve housing. The housing is equipped with a system relief valve 135 opening from pump discharge chamber 116 to tank connected chamber 118 and fitted with adjusting means as shown.

The main valve plunger is drilled from the left end to provide a central passage or bore 150 ported at 151 to the groove 144 and ported at 152 to the surface of the land intermediate grooves 142 and 143. A check valve 154 is spring pressed closed and prevents liquid movement from 152 toward 151 but not in the opposite direction. The spring chamber behind the valve is closed by plug 155 positioned by a screw portion 156 on flange 132. Proper venting of the plunger of the check valve, as shown, prevents fluid lock.

When the valve is moved to the left from the neutral position shown, the land 141 closes the port between passages 116 and 118 so that the pressure fluid from the pump is no longer returned to the tank. This high pressure fluid now enters ports 151 by way of groove 144, passes through passage 150, lifts check valve 152, flows out through ports 152 into passage 147 now registering therewith and passes to the underside of the piston of the hoist. Groove 143 has been moved to span passages 146 and 148 so that fluid returning from the upper side of the hoist by way of 146 is delivered into 148 to be returned to the tank.

When the plunger 30 is moved a portion of the permitted distance toward the right from the neutral position the land to the right of groove 144 closes off communication between 116 and 118 and high pressure fluid flows through check valve 154 to chamber 146 connected to the

upper side of the hoist. Groove 142 now spans hoist chamber 147 and passage 148 to discharge liquid from the under side of piston 126. In either of the hoist or lowering operations when the piston reaches the end of its stroke, continued delivery of fluid by the constantly driven pump lifts relief valve 135 and returns the liquid to the tank.

Since in the closed system the pump inlet is supplied from the discharge from the hoist, the discharge passage 148 is adapted to be connected to either of the hoist passages 146 or 147 and delivers in a manner to be later described to the low pressure outlet port 88 connected directly to the pump inlet. Control of the delivery of fluid to the pump must be such that this system operates as an open system when the control valve is in the neutral or hold position illustrated, for then the pump delivers high pressure to 116 through the groove 139 in the plunger into the low pressure discharge passage 118 back to the tank. The pump must then be able to take liquid from the tank for circulation to maintain adequate cooling during idling periods. For this purpose the low pressure chamber 89 forms an extension to the passage 148 and has its upper end open to the tank. Reciprocably mounted in this bore 89 is a valve member 90 comprising a close fitting cylindrical sleeve open at the ends and containing a central partition 91. Above the partition it is provided with lateral ports 92, below with corresponding lateral ports 93. The open bottom of this valve is arranged to receive return liquid from the hoist directly from the passage 148 in accordance with the position of the control valve.

With the flow control valve 90 in its lower position, as illustrated, fluid cannot escape through ports 93, which are closed off by walls of the bore in which the valve operates and the valve provides direct passage for liquid from the tank into the open upper end thereof and out through ports 92 into the low pressure passage 88 delivering to the pump. When the manual control valve plunger is set to move the hoist in either direction the discharge from the opposite end of the latter coming from passage 146 or 147 is delivered from the appropriate groove in the plunger into discharge passage 148 and flows into lower side of the flow control valve 90, building up a pressure therein sufficient to lift the valve against the very small pressure produced by the head of the liquid in the tank. Upward movement of the valve is limited by the underside of the tank wall and under these conditions the return fluid from the hoist discharges through ports 93 to 88 and supplies the pump.

If the control valve is set to the raise position the quantity of liquid being received from the upper portion of the hoist is less than that being delivered by the pump, because of the volume occupied by the piston rod. Under these conditions the pump inlet takes away liquid faster than it is being delivered through ports 93, thus reducing pressure on the underside of valve 90, permitting it to lower sufficiently to partially uncover ports 92, which provide make-up liquid direct from the tank to compensate for the differential volume on the two sides of the hoist piston.

On the reverse operation, i. e., lowering of the hoist, more fluid is being delivered beneath the now elevated flow control valve 90 than is being taken by the pump for delivery to the upper side of the hoist. This extra quantity of liquid builds up a pressure beneath valve 90 which acts on low pressure relief valve 86 through its passage 95, which is exposed when the skirt of the flow control valve is lifted. This permits adequate fluid relief to the tank through passages 96 and 97. The low pressure relief valve 86 is normally maintained closed by a light adjustable spring, as shown.

It will be seen that the flow control valve automatically provides compensation for the difference in volume of oil handled from the two sides of the hoist piston. It is also responsible for transferring the system from an open one when the control valve is in the neutral or hold position to a closed one when the hoist is being operated. The operation of the hoist by a closed system insures against the piston moving away from the body of oil which is attempting to lower the load, due to the latter trying to advance more rapidly, due to its weight, than the moving fluid. It is obvious that the tension on the spring controlling the low pressure relief valve 86 must be such that the hoist cannot fall of its own accord but must be forced down by the delivery of a lesser quantity of fluid to the upper side of the piston. A few pounds differential is adequate, which serves to relieve the pump of any substantial work during the lowering operation.

When the valve plunger 130 is pulled to its maximum position to the right, the "float" condition occurs, permitting the bulldozer blade to find its own level, and groove 144 spans passages 116 and 118 permitting the pump to freely deliver fluid to the tank. Groove 142 spans recesses 146, 147 and 148. This connects the hoist passages to each other so that the piston thereof is free to be moved under the action of its load in either direction. Since there is a differential in the volume of the two ends of the hoist cylinder the multiple longitudinal grooves 175 are provided at the right end of groove 143 and they serve to span passages 146 and 116. Oil may be taken from or delivered to this passage 116 in accordance with requirements from passage 146 which is now connected to the other hoist passage 148.

The valve of Fig. 3 is a modification in form with substantially the same performance of that of Fig. 2. The valve body 314 has its ports and passages somewhat differently arranged from those just described. The high pressure liquid from the pump is delivered into chamber 316 with parallel branch intersecting the plunger bore on opposite sides of a partition 317 which closes off groove 344 and ports 351 when the plunger is in neutral position.

Although the plunger has a slightly different arrangement of grooves it has the same number as on the plunger of Figure 2 and is equipped in an identical manner with a check valve.

In operation the neutral position of the valve provides the same performance as takes place in connection with Figure 2, fluid entering through 316, passing through groove 239 and back to the tank by way of 318 providing a free passage of liquid between the pump and the tank. A high pressure relief valve which may be similar or identical in construction to that disclosed at 135 in Figure 2 is provided at 335 in a corresponding position with respect to the high pressure inlet from the pump and discharges into passage 318 for returning liquid to the tank.

The operation of the main control plunger will be obvious from an inspection of Fig. 3 and the description of Fig. 2. The principal difference occurs in the float position where no provision is

made to connect the joined hoist ports to the inlet chamber 316. The slightly different position of the pump inlet chamber 388 provides a convenient arrangement for the low pressure relief valve 386, between it and the return passage 318. The flow control valve 390 is similar to that in Fig 2 and functions the same except for the provision of bleed port 399 through partition 391 which provides the compensation for volume differential on the two sides of the hoist piston. This bleeder port may be relied upon to take care of the excess liquid from the larger volumed side of the hoist during normal operation and the relief valve 386 omitted.

In all of the valves it will be noted that the packing at the right hand end of the main control valve has interposed between it and any source of high pressure fluid, a low pressure chamber which prevents putting this packing under any considerable pressure, and it is therefore insured against leakage. At the opposite end, however, the packing is closely adjacent the hoisting port, which at times is filled with high pressure liquid. Any seepage along the valve to the left hand packing is permitted to vent to the tank in Figure 2 through passage 140' connected to the pump inlet. A corresponding drain passage is provided in the construction of Fig. 3 to prevent high pressure liquid acting on the packings.

Each of the valves as just described provides for complete manual control of the hoist for operating a bulldozer or other device under all conditions of lifting and lowering and positively insures against the hoist taking control away from the operator on the lowering operation and dropping at an undesired speed. The system provides for full circulation of the oil between the pump and the tank in the neutral position of the valve where it remains for the largest portion of time during the operation of any hydraulically controlled earth-moving equipment. Adequate cooling is thereby insured.

This application is a division of my copending application Serial No. 550,078, filed August 18, 1944, now Patent Number 2,477,669 granted Aug. 2, 1949.

I claim:

1. A control valve for use in a hydraulic system composed of a double acting hoist, a tank and a positive displacement pump, comprising a valve housing having a bore, a reciprocable plunger movable in said bore to "raise," "hold," "lower" and "float" positions, said plunger having lands and intermediate grooves, a longitudinal bore in said plunger connecting spaced ports through the plunger, a check valve in said plunger bore between said ports, said housing having a plurality of passages intersecting said first bore for selective cooperation with said plunger grooves and ports, one of said passages being adapted for connection to the pump outlet, two of said passages being adapted respectively for connection to opposite ends of the hoist, a return fluid passage intermediate said hoist passages arranged to return fluid from the hoist for reuse by the pump, a pump inlet chamber, a connection between said chamber and the said return fluid passage, a valve in said connection adapted to be opened by fluid pressure in said return fluid passage, and a relief valve from said last mentioned passage to said tank operable when more liquid is returned than is required by the pump.

2. A control valve for use in a hydraulic system composed of a double acting hoist, a tank and a positive displacement pump, comprising a valve housing having a bore, a reciprocable plunger

movable in said bore to "raise," "hold," "lower" and "float" positions, said plunger having lands and intermediate grooves, a longitudinal bore in said plunger connecting spaced ports through the plunger, a check valve in said plunger bore between said ports, said housing having a plurality of passages intersecting said first bore for selective cooperation with said plunger grooves and ports, one of said passages being adapted for connection to the pump outlet, two of said passages being adapted respectively for connection to opposite ends of the hoist, a return fluid passage intermediate said hoist passages arranged to return fluid from the hoist for reuse by the pump, a pump inlet chamber, a connection between said chamber and the said return fluid passage, a valve in said connection adapted to be opened by fluid pressure in said return fluid passage, said connection also leading to said tank and a second portion on said valve regulating the flow between the tank and said chamber whereby the pump demands are satisfied from the return fluid augmented by that from the tank when necessary.

3. A control valve for use in a hydraulic system composed of a double acting hoist, a tank and a positive displacement pump, comprising a valve housing having a bore, a reciprocable plunger movable in said bore to "raise," "hold," "lower" and "float" positions, said plunger having lands and intermediate grooves, a longitudinal bore in said plunger connecting spaced ports through the plunger, a check valve in said plunger bore between said ports, said housing having a plurality of passages intersecting said first bore for selective cooperation with said plunger grooves and ports, one of said passages being adapted for connection to the pump outlet, two of said passages being adapted respectively for connection to opposite ends of the hoist, a return fluid passage intermediate said hoist passages arranged to return fluid from the hoist for reuse by the pump, a pump inlet chamber, a connection between said chamber and the said return fluid passage, a valve in said connection adapted to be opened by fluid pressure in said return fluid passage, said connection also leading to said tank, a second portion on said valve regulating the flow between the tank and said chamber whereby the pump demands are satisfied from the return fluid augmented by that from the tank when necessary, and means to waste return fluid to the tank when it is in excess of the pump demand.

4. A control valve for use in a hydraulic system composed of a double acting hoist, a tank and a positive displacement pump, comprising a valve housing having a bore, a reciprocable plunger movable in said bore to "raise," "hold," "lower" and "float" positions, said plunger having lands and intermediate grooves, a longitudinal bore in said plunger connecting spaced ports through the plunger, said housing having in the following order passages intersecting said first bore for selective cooperation with said plunger grooves and ports; first hoist passage, return fluid passage, second hoist passage, pump discharge passage and tank delivery passage; said lands in the neutral position of the plunger being positioned to isolate the hoist passages and one of said grooves being positioned to connect the pump discharge and tank delivery passages; one set of said ports being so positioned as to open selectively into the hoist passages when the plunger is moved from neutral, the other set of ports being arranged for positioning in the pump discharge passage; lands arranged to separate the pump discharge

and tank delivery passages when the first set of ports is positioned in either hoist passage; a bore communicating at one end with said tank, at the opposite end with said return fluid passage, a pump inlet chamber having a passage into said last mentioned bore and a valve element reciprocable in said last mentioned bore under the differential of tank and return liquid pressures and arranged to connect said last passage selectively to the tank and the return fluid passage.

5. The control valve as defined in claim 4 in which said valve element reciprocable in the bore between the tank and return fluid passage is arranged to connect the said pump inlet chamber simultaneously to the tank and return fluid passage to compensate for unequal displacements at the two ends of the hoist.

6. A control valve for a hydraulic system composed of double acting hoist, tank and constant running positive displacement pump, comprising a valve housing having a bore, a plunger reciprocable in said bore and having lands, circumferential grooves and longitudinally spaced ports, a longitudinal bore connecting said ports, said bore intersecting a single pump discharge chamber, a single liquid return chamber, a single tank chamber and a pair of hoist chambers, said plunger having a neutral position wherein a groove connects the pump discharge chamber to the tank chamber and two hoist positions wherein the last-mentioned chambers are isolated and the pump discharge chamber is connected through said ports and longitudinal bore to one of said hoist chambers, the unconnected hoist chamber being associated with the said liquid return chamber by one of said grooves, and a pump inlet chamber connected to said liquid return chamber.

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