Sept. 2, 1952 H. KIRKHAM 2,608,824

CONTROL VALVE

Filed Aug. 27, 1947 2 SHEETS—SHEET 1

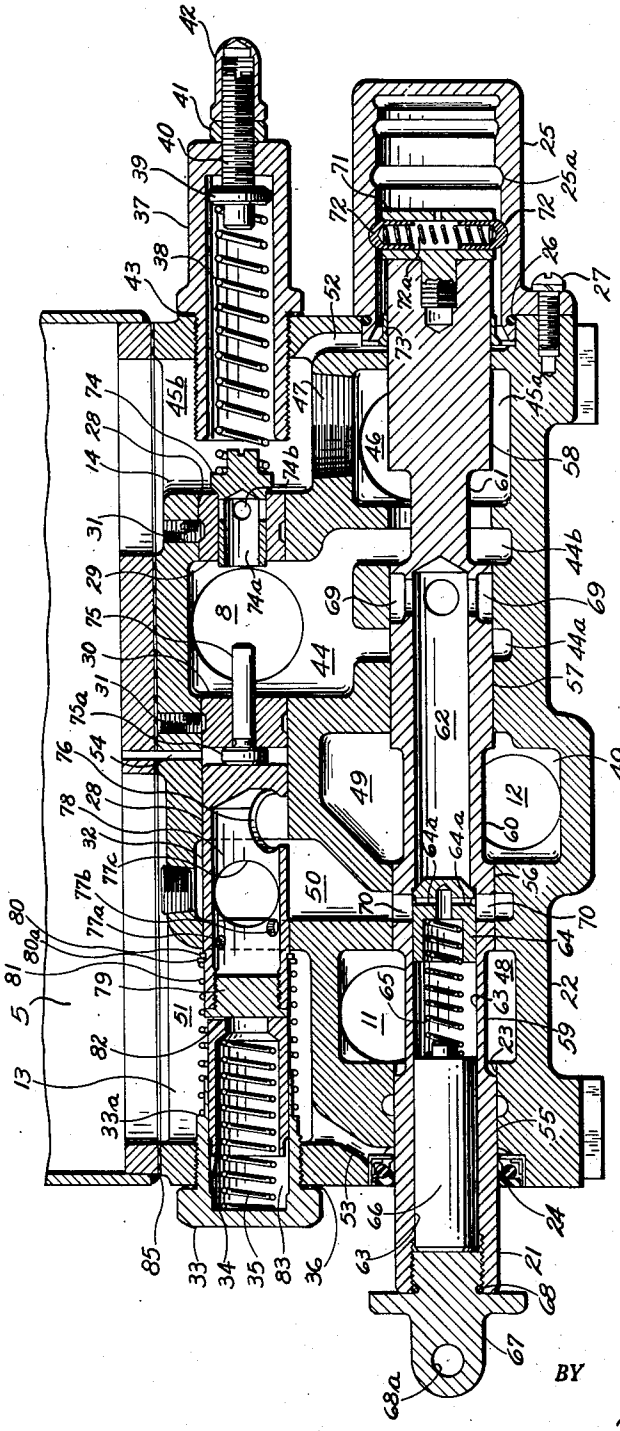


Fig. 1

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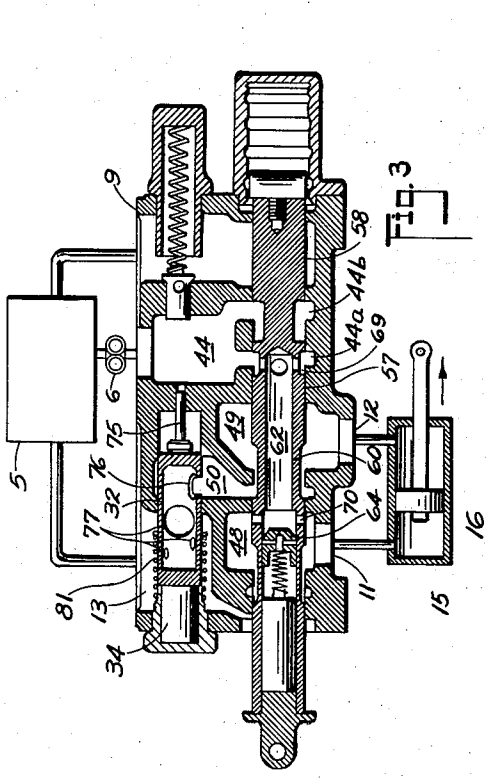


Fig. 3

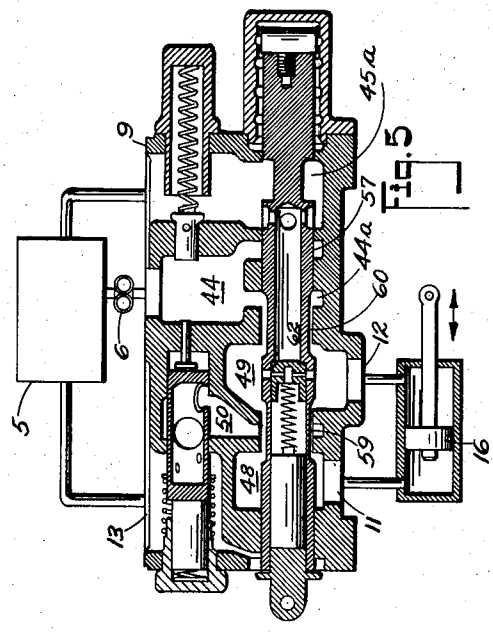


Fig. 5

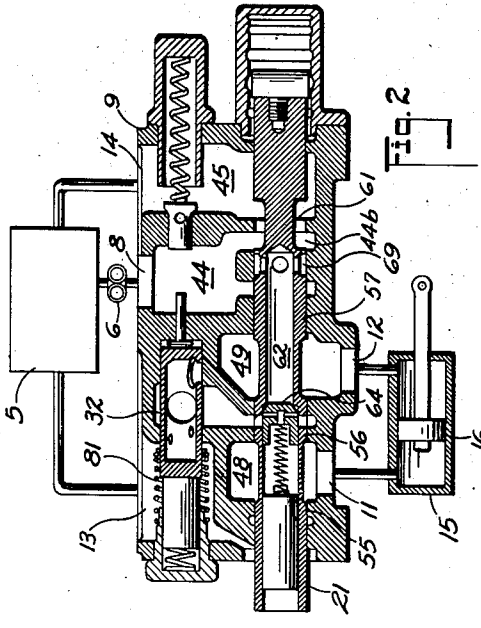


Fig. 2

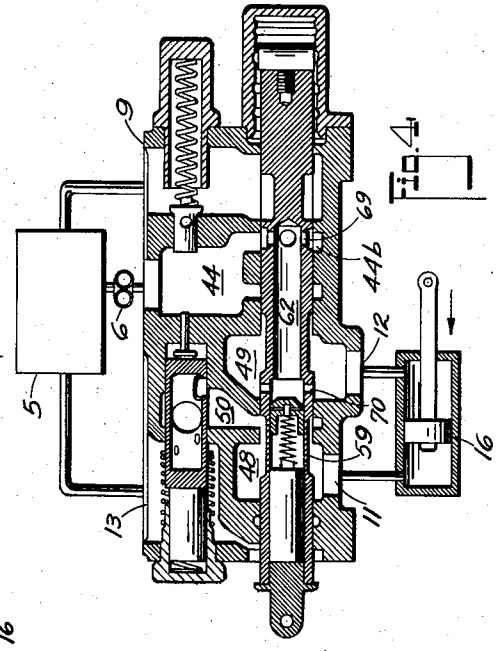


Fig. 4

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UNITED STATES PATENT OFFICE

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CONTROL VALVE

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Application August 27, 1947, Serial No. 770,882

14 Claims. (Cl. 60—52)

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This invention relates to hydraulic systems employing double-acting power cylinders and is particularly directed to improving the control of such cylinders. In its preferred form the invention is embodied in an improved control valve for hydraulic systems such as are used, for example, to control the position of the earth moving blade of a bulldozer.

For this purpose the double-acting cylinder is coupled to the blade, and is incorporated in a fluid system including also a reservoir, a pump, and a control valve. The control valve is manually settable to cause the cylinder to operate in any one of four ways: in the "raise" position of the valve the blade is elevated; in the "lower" position the blade is forced downward; in the "hold" position the blade is locked against movement; and in the "float" position of the valve the blade is left free to move up or down under the action of external forces.

This particular application of the improved control system will be explained herein. However, similar control phases are utilized in many applications of power cylinders, and the system of the invention is of general utility apart from bulldozers, hoists, and the like.

In the operation of double-acting hydraulic devices, conditions arise, dependent upon connected mechanical apparatus, necessitating extremely accurate control of the position of the ram piston, with means to prevent movement of the piston out of control of the operating liquid, as, for instance, under the effect of the external load. In the use of a bulldozer for grading, for example, it is important that the blade 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 by placing the valve in the lowering position, or, as is often done, by placing the valve in the "float" position. The great weight of the blade tends to withdraw the ram piston from the liquid following it and intended to regulate the rate of lowering on release of the liquid supporting the piston. The resulting erratic operation prevents the precise control of the blade necessary to accurate grading.

One factor contributing to the difficulty of control is the fact that in many installations the rate of delivery of the pump is variable, the pump usually being driven from the engine which provides motive power for the tractor. Thus, a system which might be entirely adequate under constant fluid delivery conditions may prove unsatisfactory when applied to a bulldozer.

If the external load forces the piston ahead of the supply of fluid behind it, creating a vacuum, control of the blade is lost until the pump has filled the cylinder. The present invention, by

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preventing such conditions, assures immediate response of the blade to its control in all situations.

The present invention is directed to securing a number of improvements in double-acting hydraulic systems, which may be briefly summarized as follows:

Smooth control of the power cylinder under all conditions of operation, and with widely varying rates of delivery of oil from the pump;

Elimination of erratic or jerky action of the power cylinder;

Control of the return flow from the cylinder to the reservoir in all phases of cylinder operation;

Maintenance of positive pressure on both faces of the piston at all times;

Immediate response of the cylinder to "raise" or "lower" settings following cylinder movement in "float" setting;

Elimination of flutter in the valve; and

Adaptability to tandem operation of valves.

These results are attained by the use of a new combination of elements in a hydraulic power system which cooperate in a novel way in the control of the system, as will be apparent from the description herein of a preferred embodiment of the invention. This new combination of parts includes one or more of the following subcombinations:

A manually settable valve and a flow control valve, the former being constructed to direct the flow from the pump and cylinder through the latter in all positions except "Hold";

Means for damping of the movement of the flow control valve, primarily the opening movements, thus preventing valve overtravel;

Provision for actuation of the flow control valve by relatively small hydraulic and elastic forces, and provision of a lightweight valve;

A flow control valve with a set of ports, graduated in size and staggered in position, to provide more sensitive control of small flow;

An exit chamber for the valve so constructed that it may readily be converted into two chambers, one for return of oil from a relief valve, and one for diversion of oil to a second control device.

Although, in its preferred form, the invention embodies all the characteristics and advantages stated above, it will be apparent to those skilled in the art that, in certain applications, certain of the parts and subcombinations may be omitted in the event that the installation is such as not to require them.

The invention may be better understood by reference to the drawings which accompany this specification and in which:

Fig. 1 is a longitudinal section of a control valve in accordance with the invention; and

Figs. 2 to 5 are diagrams of a hydraulic sys-

tem incorporating the said valve, illustrating different phases of operation thereof, with the valve shown somewhat schematically.

General description of the system

Before proceeding to the detailed description of the valve, which is essential to the understanding of the invention, a typical hydraulic power system incorporating the invention will be described generally with reference to Figs. 2 to 5. It should be understood that the valve is shown schematically in these figures. A suitable fluid, usually a light oil, is contained in a tank 5 (Fig. 2) from which it is continuously fed by the pump 6 into the inlet port 8 of the valve 9. The valve selectively controls the inflow and outflow of fluid through its ports 11 and 12 to the double-acting cylinder 15 in which the piston 16 is reciprocable. The valve also controls the return of fluid to the tank from its ports 13 and 14. The operation of the cylinder is controlled manually by setting a plunger 21 to any one of four positions.

In the "hold" position of the valve illustrated in Fig. 2, outlet ports 11 and 12 are closed, locking the fluid in both ends of the cylinder, and the pump discharge is returned to the tank through the port 14. In the "raise" position illustrated in Fig. 3, where work requiring hydraulic pressure is being done, fluid is circulated through the valve and out of port 11 into the left end of the cylinder. Fluid displaced from the right end of the cylinder passes through port 12, an automatic flow control valve 32 in the valve 9, and from the port 13 to the tank. In the "lower" position (Fig. 4), the operation is similar to that in "raise" except that port 12 is connected to the pump and port 11 through the flow control valve to the port 13. In the "float" position (Fig. 5), the two ends of the cylinder are coupled together and coupled to the pump, and are also coupled to the return port 13 through the flow control valve 32. The piston is thus free to move in the cylinder.

Valve construction

Considering now the preferred form of the valve in detail as shown in Fig. 1, the valve body or casing 22, which may be cast, is formed for mounting immediately beneath the tank 5, which may be secured to the valve in any conventional manner, a gasket 85 sealing the junction of the tank and valve. The return ports 13 and 14 open directly in register with corresponding apertures in the bottom of the tank 5.

A through bore 23 in the casing forms a cylinder for reciprocation of the valve operating plunger 21, which is dimensioned for a close fit therein.

The left end of the bore 23 is counterbored to receive a seal assembly 24, and the right end is similarly counterbored to receive a detent housing 25 fitted with a seal 26 and retained by screws 27. The outer surface of the plunger 21 is formed with four lands 55, 56, 57, and 58 separated by three sections of reduced diameter 59, 60, and 61. The valve is illustrated in the "hold" position, in which the reduced portions 59 and 60 of the valve plunger register with internal passages 48 and 49, respectively, which communicate with the external discharge ports 11 and 12, which, as previously described, are coupled to the operating cylinder 15.

In this position, the portion 61 registers with a branch 44*b* of the inlet chamber 44 into which the pump discharges through port 8, and with a chamber 45*a*. The plunger 21 is bored out to form passages 62 and 63, the passage 63 being of greater diameter than the passage 62. The inner end of the passage 62 is intersected by radial ports 69, and the inner end of the passage 63 by radial ports 70. A check valve member 64 held against the shoulder intermediate the bores 62 and 63 by a spring 65 permits the flow of oil from passage 62 into passage 63 but prevents return flow. Internal passages 64*a* in the valve member 64 provide an outlet for the chamber 63 to prevent trapping of fluid behind the check valve. The outer end of the compression spring 65 is guided by a plug 66 slipped into the bore 63 and held in place by a fitting 67 screwed into the tapped outer end of the bore and sealed by an O-ring 68 or an equivalent sealing ring. The fitting 67 serves as a plunger stop and in addition is formed with a transverse bore 68*a* for connection of a manual control lever to the plunger. The setting of the valve plunger to its correct positions and its retention therein are facilitated by a detent assembly 71 screwed into a tapped hole in the right hand end of the plunger 21 and mounting plungers 72 urged outwardly by a spring 72*a* into engagement in circumferential grooves 25*a* in the housing 25.

The inlet opening 8 in the upper portion of the valve communicates with the chamber 44 having two branches 44*a* and 44*b* terminating in enlargements of the bore 23. A bore 28 through the casing parallel to the bore 23 and intersecting the chamber 44 provides for the mounting of two automatic valves which form part of the system, a flow control valve and a relief valve. The seat for the relief valve is formed by a bushing 29 retained in the bore 28 by a set screw 31. The relief valve assembly comprises a hollow plunger 74 normally held against its seat in the bushing 29 by a compression spring 38. The spring is retained by a hollow threaded cap 37 in which is threaded the spring tension adjustment screw 40 the inner end of which abuts the spring guide 39. A lock nut 41 and cap nut 42 lock the adjusting screw and cover its exposed end. A gasket 43 is compressed under the flange of the cap 37. Whenever the pressure in the chamber 44 into which the pump discharges becomes excessive, the plunger 74 is forced to the right against the tension of the spring 38 and oil escapes through the central bore 74*a* and radial passages 74*b* of the plunger into the chamber 45*b* which discharges into the tank through the port 14. The operating pressure of the relief valve may be set in the obvious manner by adjusting the screw 40.

The flow control valve assembly which is mounted in the left end of the bore 28 is provided to control the flow of oil from the cylinder to the tank. This valve prevents return flow unless there is positive pressure in the chamber 44 and regulates the return flow to secure smooth action of the cylinder 15 and prevent drawing a vacuum in the cylinder. The valve comprises the flow control plunger 32 slidable in the bore 28 to regulate flow of oil from the chamber 50 which communicates with the valve operating plunger 21 to the chamber 51 from which the oil discharges into the reservoir through the outlet 13. The flow control valve plunger 32 is in the form of a hollow cup, a blind bore 78 therein being closed by a screwed-in plug 79. This plunger is formed with a thin wall and is relatively light in weight. The radial inlet passage 76 in the plunger 32 is always open to the chamber 50. Radial passages as indicated by 77*a*, 77*b*,

and 77c permit flow of oil from the interior of the plunger 32 to the chamber 51 when the plunger moves to the left from the position shown in Fig. 1. The ports 77 are staggered longitudinally of the plunger and are graduated in size. The passage 77c also serves to admit oil into the chamber 78 in the plunger 32 except in the case of extreme movement of the plunger to the left, in which case oil flows through the opening 76 which is unobstructed. The plunger 32 is urged to the left to open the ports 77 by the action of a pin 75 sliding in a bushing 30 fitted in the bore 28 and locked in position by a set screw 31. The body of the pin 75 projects into the chamber 44 and is thus urged to the left by the pressure of the fluid in the pump discharge line. The head 75a of the pin bears against the inner end of the plunger 32. The plunger is urged toward its closed position by a compression spring 81 engaging a washer 80a for which a snap ring 30 received in a groove in the plunger serves as an abutment. The spring 81 is retained against a shoulder 33a of a dashpot casing member 33 screwed into the tapped-out end of the bore 28. The dashpot casing 33 is formed with a hexagonal head under which the gasket 36 is compressed.

The casing 33 forms a part of a dashpot assembly described and claimed in my copending application Serial No. 752,689, filed June 5, 1947. In addition to the casing 33 the dashpot comprises a sleeve 34 closely fitting therein and urged outwardly of the casing by a compression spring 35. The face of the plunger 34 which normally bears against the cap 79 of the valve plunger 32 is formed with a radial groove 82 which forms a restricted passage for the escape of oil from the internal chamber 83 of the dashpot.

The dashpot is provided to stabilize the action of the plunger 32 and thus that of the power cylinder 15. The action of the dashpot is as follows: When the valve plunger 32 moves to the left to open the ports 77, movement can only take place by moving the dashpot sleeve 34 to the left, thus contracting the chamber 83 and forcing oil out through the small groove 82. If the pressure in the chamber 44 decreases, the spring 81 can close the ports 77 rapidly, the plunger simply moving away from the dashpot sleeve. When this occurs, oil can flow into the dashpot over the entire face, and the chamber 83 will fill rapidly, the sleeve 34 thus closely following the plunger 32 under the action of the spring 35. Rapid reversals of the plunger are thus prevented, since there can never be any substantial free travel of the plunger 32 to the left.

The entire face of the flow control valve plunger could be exposed to pressure in the inlet line. In the preferred construction shown herein only the relatively small area of the pin 75 is so exposed and thus lighter hydraulic thrust is exerted on the plunger. This feature makes possible the use of a relatively light plunger return spring 81.

A bleeder passage 54 through the valve casing and the bottom of the tank 5 prevents fluid blocking of movement of the plunger 32 and discharges any seepage past the pin 75. In some cases the passage 54 may advantageously be made small enough to act as a restricted orifice and thus slightly retard movement of the plunger 32 to the right.

A passage 53 drains off into the chamber 51 oil which may seep past the left end of the control plunger 21 and a passage 52 discharges fluid escaping around the right end of the plunger into the return chamber 45b. A collar 73 retained beneath the detent housing 25 serves as a stop to limit leftward movement of the operating plunger 21.

As previously stated, the oil circulated by the pump is diverted in the "hold" position of the valve into the chamber 45a and oil escaping past the relief valve 74 is discharged into the chamber 45b which communicates directly with the tank. The chambers 45a and 45b are normally in communication through a port 47. An auxiliary port 46 opening from the chamber 45a to the outside of the valve assembly is normally closed by a plug. With this arrangement the chambers 45a and 45b become in effect one chamber opening directly into the tank. In the event, however, that it is desired to operate more than one mechanism from the pump, the port 47 may be closed by a plug and the port 46 may be opened and connected by a conduit to a second valve or the like. With the valve in the "hold" position of Fig. 1, the oil from the pump then circulates through the chamber 44, around the relieved portion 61 of the valve operating plunger 21, through the chamber 45a and port 46 to the second control means (not shown).

Although the valve is shown herein in a form adapted for mounting directly on the bottom of the oil reservoir, it will be obvious to those skilled in the art that the valve may be very simply modified for installation apart from the tank. One convenient way of accomplishing this is to provide a cover for the valve fitting over the top thereof and in which a manifold is formed communicating with the ports 13, 14, and 54 of the valve. A threaded port for a common return line to the reservoir would be provided in such a cover.

Operation

Having now disclosed in detail the preferred structure of the valve, the operation of the system may best be understood by reference to Figs. 2 to 5 in which the structure of the valve is shown somewhat schematically and the four operating conditions of the system are shown. In Fig. 2, and in Fig. 1, the valve operating plunger 21 is in the "hold" position in which the piston 16 is hydraulically locked against movement in either direction. The chambers 48 and 49 which are connected to the ends of the cylinder are closed by the operating plunger 21, chamber 48 being closed by the lands 55 and 56 and the chamber 49 by the lands 56 and 57. The pump discharge into the chamber 44 flows through the branch 44b, around the groove 61 of the plunger into the return passages 45 and to the tank. The ports 69 of the operating plunger are blanked, being intermediate the passages 44a and 44b. There is thus no flow through the passage 62 of the plunger 21, and the flow control valve 32 is inactive. Since the pump output is discharged freely, there will be substantially no pressure in the chamber 44 and the valve 32 will be in closed position under the action of the spring 81.

If it is desired to raise the blade, the plunger 21 is moved to its extreme left position as shown in Fig. 3. In this position chamber 44b is closed by lands 57 and 58 of the plunger but radial ports 69 are aligned with chamber 44a, permitting the oil delivered by the pump to flow through the internal chamber 62 of the plunger, lift the check valve 64, and flow out through ports 70 which

are aligned with the chamber 48. From chamber 48 the oil flows through port 11 into the left hand end of cylinder 15, driving the piston to the right. Return flow from the right hand end of the cylinder enters the valve through port 12, and from passage 49 flows around undercut 60 of the plunger into passage 50. Since the cylinder 15 is doing work, a positive pressure will be maintained in the chamber 44 and the pin 75 will move the flow control valve 32 to its extreme left position, thus allowing unrestricted return flow. The chamber 50 is thus opened to the return port 13 through port 76, the chamber of the plunger 32 and ports 77. If, however, for any reason the normal load is reversed and the piston 16 is urged to the right by the mechanism to which it is coupled so that the clearance volume in the left hand end of cylinder 15 tends to increase more rapidly than it can be filled by the pump discharge, the pressure in the chamber 44 will immediately drop and the spring 81 will move the flow control valve to the right to restrict the outlet from the cylinder sufficiently to maintain a positive pressure in the chamber 44 and the left hand end of the cylinder. The flow control valve 32 will automatically arrive at a balanced position where it restricts the outflow from the cylinder sufficiently to maintain a positive pressure in the inflow line and prevent drawing of a vacuum in the cylinder.

With the valve set to the "lower" position illustrated in Fig. 4 the overall operation is very similar to that of the "raise" position. Chamber 45*a* is cut off from chamber 44*b* by the land 57 of the valve. Oil from the pump 6 flows into chamber 44 and from branch 44*b* through the ports 69, passage 62, and ports 70 into the chamber 49 from which it is discharged through port 12 to the right end of the cylinder 15. Discharge from the cylinder enters the valve through port 11 and proceeds from chamber 48 around the undercut 59 into the chamber 50 and thence to the tank through the flow control valve as previously described. The operation of the flow control valve in the "lower" position is identical with that in the "raise" position. Normally, during lowering, the cylinder is urged by the load, and the valve 32 automatically restricts the return flow to equal the rate of supply from the pump. If, however, the cylinder is doing work, as for instance, pushing a bulldozer blade into the ground, the increase of pressure in the chamber 44 opens the flow control valve fully, minimizing restriction in the return line from the cylinder.

Thus in both the "raise" and "lower" positions fluid is delivered from the pump into one or the other end of the cylinder to move the load positively if force is required to move it; and the return flow from the cylinder is automatically throttled to prevent the piston from running away from the pump if the load should be driving the piston positively. The opening of the flow control valve is retarded by the dashpot, preventing too great opening, with resulting oscillation of the valve and jerky action of the cylinder. If, however, the load or pump speed changes, the flow control valve can close rapidly, responding immediately to the changed conditions. Thus smooth action is secured in both directions, regardless of whether the load is positive or negative, and regardless of fluctuations in the load or in the rate of delivery from the pump.

In the "float" position of the valve illustrated in Fig. 5 the two ends of the cylinder are interconnected to permit free movement of the piston in either direction. Undercut 59 bridges chambers 48, 50, and 49 and undercut 60 interconnects chambers 44*a* and 49. Thus the pump, both ends of the cylinder, and the chamber 50 are in constant communication with each other. The piston is free to move in either direction and increases or decreases in the volume of the cylinder from the displacement of the piston rod are compensated for by flow of fluid from the pump or to the tank. It will be noted that the return passage 45*a* is closed by the land 57, and flow of oil to the tank in the "float" position is through the flow control valve 32. A positive pressure is maintained in the manner previously described, that is, valve 32 automatically throttles the return flow sufficiently to maintain the desired pressure in chamber 44, which pressure is conducted to both sides of the piston. Valve 32 is illustrated as open, but it may close if the entire pump discharge is being used to make up for the difference in volume of the two ends of the motor. If, for example, the piston 16 floats to the right, a greater volume of fluid will be required to fill the left end of the cylinder than is displaced from the right end because of the displacement of the piston rod at the right. Because of the positive pressure maintained in the system, the additional oil will be supplied from the pump and any tendency to draw a vacuum in the cylinder is prevented. In the event that the piston floats to the left, some fluid will be displaced from the cylinder and the flow control valve readily adjusts itself to handle this flow in addition to the pump displacement.

The prevention of voids in the cylinder or valve is highly beneficial to the operation of the system, insuring that the operating cylinder will always be immediately responsive to operation of the operating control plunger 21. With every part of the system always full of oil there is immediate response when the control is moved to any position since there can be no lag while a void is being filled by the pump.

In the normal operation of the system, the relief valve 74 remains closed. If, however, with the valve in the "raise" or "lower" position the piston reaches the end of its stroke or encounters a resistance greater than the system is designed to overcome, pressure will immediately build up in the chamber 44, lift the relief valve 74, and bypass the pump discharge into the chamber 45*b* (Fig. 1) and out through port 14.

Check valve 64 prevents backflow from either side of the hoist during the shifting of the plunger 21 from one operating position to another. It prevents reversal of flow from the cylinder in the event of a power failure or a break in the supply circuit when the valve is in the "raise" or "lower" position, and it also prevents flow from chamber 49 to chamber 45*a* when plunger 21 is in the "float" position.

The division of the passage through which return flow of oil takes place in the "hold" position into the two parts 45*a* and 45*b* connected by the threaded port 47 adds another valuable feature to the valve. With previously known valves it was practically impossible to operate a second control means in tandem with a first, especially when the first valve was mounted directly on the bottom of the supply tank. With the improved valve, such tandem operation is feasible without

interfering with the operation of the first or basic valve.

The description so far has been restricted to the single operation. In such installations port 47 is left open and an auxiliary return port 46 in the chamber 45a (Fig. 1) is plugged. For tandem operation the port 47 is closed by a plug and port 46 is connected to the second valve. With this organization the passage 45b functions as a by-pass to the tank only when the relief valve 74 is opened by excess pressure. In the "hold" position the pump discharge is fed from port 8 through chambers 44 and 44b, undercut 61, chamber 45a and port 46 to the second valve where it may be utilized in any desired manner. The second valve is supplied only when the first is in "hold." This may be desirable in many cases, and, moreover, this condition is not materially different from that which exists in the case of a conventional multi-plunger control valve wherein only one operating plunger is used at any one time. With this arrangement of the return passage 45a, 45b it is possible to use the same source of fluid supply to operate more than one set of mechanisms if desired and thus eliminate the need for a second supply source.

The hydraulic power system described herein as the preferred embodiment of my invention employs a double-acting ram which may be connected to a bulldozer blade or other device to be moved. The double-acting cylinder or ram is but one species of a class of reversible hydraulic motors, the direction of operation of which is determined by interchanging inlet and discharge connections, and thus controlling the direction of flow of fluid through the motor. This is commonly called "port-reversing." Some motors of this class are capable of unlimited operation in either direction and are thus superior to a ram for certain types of installation. In some port-reversing motors, fluid actually flows through the motor. In rams, flow into one end and out of the other end is analogous, although there is no actual flow through the motor. It will be apparent that the principles of this invention and the preferred form of valve embodying those principles disclosed herein may be employed with any motor of the port-reversing type.

The terms "raise" and "lower" as applied to the valve positions, while appropriate to certain installations, are arbitrary. These positions might equally well be denominated "right" and "left," "in" and "out," or "forward" and "reverse," the last named being perhaps the most general identification of these positions.

In the appended claims, reference to a motor is to be understood as applicable to hydraulic motors generally, and not as specific to cylinders or rams. The term pump is chosen merely for convenience and is intended to denominate any source of fluid under pressure for the operation of the motor. The term "reservoir" means any receiver for fluid under low pressure after employment in the motor.

In the claims, reference to valve positions by the terms "forward," "reverse," "hold," and "float," have the following meaning: "forward" means a position in which fluid is delivered from the pump to a first inlet of the motor and permitted to escape from the second inlet; "reverse" means a position in which fluid from the pump is directed to the second inlet of the motor and is allowed to return from the first inlet; "hold" means a position in which flow of fluid to or from either inlet of the motor is prevented; "float" means a position in which the two inlets are interconnected for free movement of the motor. In the case of a motor in which fluid flows through the motor, as distinguished from a ram, "forward" means a position in which fluid is circulated through the motor in one direction by the pump; "reverse" is the valve position in which fluid is circulated through the motor in the opposite direction by the pump; "hold" is the position in which circulation of fluid through the motor is prevented; and "float" is the position in which fluid is free to circulate through the motor in either direction.

The term "operating position" of the valve means any position causing or permitting movement of the motor such as the "forward," "reverse," and "float" positions as defined or equivalents.

Although the foregoing description is necessarily of a detailed character, in order that the invention may be completely set forth, it is to be understood that the specific terminology is not intended to be restrictive or confining, and that various rearrangements of parts and modifications of detail may be resorted to without departing from the scope or spirit of the invention as herein claimed.

I claim:

1. A hydraulic control device comprising a casing having an inlet port, two outlet ports, a return port, and two discharge chambers, formed therein; a flow control valve interposed between one discharge chamber and the return port; and a settable distributing valve formed to selectively interconnect the several ports and the discharge chambers as follows: to connect the inlet port selectively to either outlet port or both outlet ports; to connect either outlet port to the discharge chamber when the other outlet port is connected to the inlet port, and connect both outlet ports to said one discharge chamber when the inlet port is connected to both outlet ports and to simultaneously isolate the other discharge chamber; means responsive to pressure in the inlet port to open the flow control valve; damping means operative to retard opening movement of said valve during discharge flow of liquid past the same; and biasing means tending to close said valve.

2. A control device adapted to control the operation of a reversible motor in a system including the motor, a pump, and a reservoir: the said device comprising a casing formed with an inlet chamber adapted to be connected to the pump, first and second outlet chambers adapted to be connected to the inlets of the motor, a bypass chamber adapted to be connected to the reservoir, and a return chamber; a flow control valve interposed between the return chamber and the reservoir; and a distributing valve settable to three positions, a first position in which the outlet chambers are isolated and the inlet and bypass chambers are connected, a second position in which the inlet and first outlet chambers are connected and the second outlet and return chambers are connected, and a third position in which the inlet and second outlet chambers and first outlet and return chambers are connected; means responsive to pressure in the inlet chamber to open the flow control valve; damping means operative to retard opening movement of said valve during discharge flow of liquid past the same; and biasing means tending to close said valve and characterized by a closing force

which increases in direct relation to valve opening.

3. A control device adapted to control the operation of a reversible motor in a system including the motor, a pump, and a reservoir: the said device comprising a casing formed with an inlet chamber adapted to be connected to the pump, first and second outlet chambers adapted to be connected to the inlets of the motor, a bypass chamber adapted to be connected to the reservoir, and a return chamber; a flow control valve interposed between the return chamber and the reservoir; and a distributing valve settable to four positions, a first position in which the outlet chambers are isolated and the inlet and bypass chambers are connected, a second position in which the inlet and first outlet chambers are connected and the second outlet and return chambers are connected, a third position in which the inlet and second outlet chambers are connected and the first outlet and return chambers are connected, and a fourth position in which the inlet, outlet, and return chambers are connected and the by-pass chamber isolated from the inlet chamber; means responsive to pressure in the inlet chamber to open the flow control valve; damping means adapted to retard opening movement of the flow control valve; and spring means operative to bias the flow control valve to closed position.

4. A control device adapted to control the operation of a reversible motor in a system including the motor, a pump, and a reservoir: the said device comprising a casing formed with an inlet chamber adapted to be connected to the pump, first and second outlet chambers adapted to be connected to the inlets of the motor, a bypass chamber adapted to be connected to the reservoir, and a return chamber; a flow control valve interposed between the return chamber and the reservoir; and a distributing valve settable to four positions, a first position in which the outlet chambers are isolated and the inlet and bypass chambers are connected, a second position in which the inlet and first outlet chambers are connected and the second outlet and return chambers are connected, a third position in which the inlet and second outlet chambers are connected and the first outlet and return chambers are connected, and a fourth position in which the inlet, outlet, and return chambers are connected and the by-pass chamber isolated from the inlet chamber; means responsive to pressure in the inlet chamber to open the flow control valve; and means operative to close the flow control valve.

5. In a hydraulic control device, a body formed with an inlet chamber, a return chamber, and a discharge chamber intermediate the inlet and return chambers, and formed with a bore interconnecting the said chambers; a hollow piston closed at the ends so as to be balanced against fluid within the piston and formed with lateral openings into the void therein, and reciprocable in the said bore; the piston being slidable from a closed position in which the openings are without the return chamber to an open position in which at least one opening registers with the return chamber, at least one opening always registering with the discharge chamber; the hydrostatic effect of fluid in the inlet chamber urging the piston toward open position; means operative to urge the piston toward closed position; and a unidirectional damping device operative to retard movement of the piston toward open position during flow of discharge liquid through said one opening of said piston.

6. In a hydraulic control device, a body formed with an inlet chamber, a return chamber, and a discharge chamber intermediate the inlet and return chambers, and formed with a bore interconnecting the said return and discharge chambers; a hollow piston closed at the ends by means fixed to said piston, said piston being formed with lateral openings into the void therein, and reciprocable in the said bore; a passage between the inlet and discharge chambers; a plunger of less diameter than the piston slidable in the passage and engaging the piston; the piston being slidable from a closed position in which the openings are without the return chamber to an open position in which at least one opening registers with the return chamber, at least one opening always registering with the discharge chamber; the plunger urging the piston toward open position under the hydrostatic effect of fluid in the inlet chamber; means operative to bias the piston toward closed position; and a unidirectional damping device operative to retard movement of the piston toward its fully open position after said piston has reached a position wherein one opening therein communicates with said return chamber.

7. A hydraulic control device comprising a casing having an inlet port, two outlet ports, a return port, and two discharge chambers formed therein; a flow control valve interposed between one discharge chamber and the return port; and a settable distributing valve formed to selectively interconnect the several ports and the discharge chambers as follows: to connect the inlet port selectively to either outlet port or both outlet ports; to connect either outlet port to the discharge chamber when the other outlet port is connected to the inlet port, and connect both outlet ports to said one discharge chamber when the inlet port is connected to both outlet ports and to simultaneously isolate the other discharge chamber; means responsive to pressure in the inlet port to open the flow control valve, damping means operative to retard opening of the flow control valve during flow of discharge liquid past the flow control valve, and bias means tending to close the flow control valve, said valve being indifferent to the pressure of exhaust liquid.

8. A hydraulic control device comprising a casing formed with an inlet chamber, an outlet chamber, first and second motor chambers, a by-pass chamber and a return chamber; a flow control valve interposed between the return chamber and the outlet chamber; and a distributing valve settable to four positions, a first position in which the motor chambers are isolated and the inlet and by-pass chambers are connected; a second position in which the by-pass chamber is isolated, the inlet and first motor chambers are connected and the second motor and return chambers are connected; a third position in which the by-pass chamber is isolated, the inlet and second motor chambers are connected and the first motor and return chambers are connected; and a fourth position in which the by-pass chamber is isolated and the inlet, return and both motor chambers are simultaneously connected; means responsive to pressure in the inlet chamber to open the flow control valve; damping means to retard opening movement of the last named valve during flow of liquid past said valve; and means operative to

bias said flow control valve to closed position.

9. A control device comprising a casing having an inlet passage for connection to a source of liquid under pressure, a return passage for connection to a reservoir, and two outlet ports for connection to a reversible motor, a settable distributing valve in said casing formed to selectively establish communication between the inlet passage and one of said outlet ports and the return passage and the other of said outlet ports, a throttle valve in said return passage, means responsive to pressure in said inlet passage for opening said throttle valve, a spring for closing said throttle valve, piston and cylinder elements defining a liquid chamber, one of said elements being fixed in the casing and the other movable and spring extended into said return passage to engage the end of said throttle valve, and a port in said movable element leading into said chamber that is partially closed when the element engages said throttle valve to provide a restricted damping orifice.

10. In a hydraulic control device, a body formed with an inlet chamber, a return chamber, and a discharge chamber intermediate the inlet and return chambers, and formed with a bore interconnecting the said chambers; a piston reciprocable in said bore and formed with passage means to establish communication between said discharge and return chambers, said piston being balanced against the effects of fluid pressure within said discharge chamber, said piston being slidable from a closed position in which said passage means are entirely within the discharge chamber thereby blocking communication between the discharge and return chambers, to an open position in which at least a portion of said passage means is within the return chamber, at least a portion of said passage means being always within the discharge chamber; said piston having a portion exposed to the hydrostatic effect of fluid in the inlet chamber for urging the piston toward open position; and a unidirectional damping device operative to retard movement of the piston toward open position during flow of discharge liquid through said passage means.

11. In a hydraulic control device, a body formed with an inlet chamber, a return chamber, and a discharge chamber intermediate the inlet and return chambers, and formed with a bore interconnecting the said chambers; a piston reciprocable in said bore and formed with passage means to establish communication between said discharge and return chambers, said piston being balanced against the effects of fluid pressure within said discharge chamber, said piston being slidable from a closed position in which said passage means are entirely within the discharge chamber thereby blocking communication between the discharge and return chambers, to an open position in which at least a portion of said passage means is within the return chamber, at least a portion of said passage means being always within the discharge chamber; said piston having a portion exposed to the hydrostatic effect of fluid in the inlet chamber for urging the piston toward open position; means to bias the piston toward closed position; and a damping device to retard movement of the piston toward its fully open position after said piston has reached a position wherein said passageway establishes communication between said discharge and return chambers.

12. For use in a hydraulic system including a motor reversible by interchanging two ports as between inlet and discharge, a reservoir for liquid, and a continuously operating pump fed with liquid and serving to deliver liquid under pressure, a control valve mechanism comprising in combination, a flow control valve balanced so as to be indifferent to the pressure of liquid whose flow it controls, said valve having a discharge for connection with the reservoir and an inlet; biasing means continuously effective to urge said valve toward its closed position; pressure-responsive means, subject to the pressure of pump delivery, for urging said valve in its opening direction; one-way damping means continuously effective to retard opening movement of said flow control valve; and a maneuvering valve having connections, one for each motor port, a reservoir connection and a connection for the pump delivery, said valve having at least three functional positions, namely a hold position in which it closes both motor port connections and connects the pump delivery connection with the reservoir connection, and two relatively reverse motor-operating positions in which respectively it connects a selected one of said motor connections to pump delivery connection and the other to the inlet of said flow control valve.

13. For use in a hydraulic system including a motor reversible by interchanging two ports as between inlet and discharge, a reservoir for liquid, and a continuously operating pump fed with liquid and serving to deliver liquid under pressure, a control valve mechanism comprising in combination, a flow control valve balanced so as to be indifferent to the pressure of liquid whose flow it controls, said valve having a discharge for connection with the reservoir and an inlet; biasing means continuously effective to urge said valve toward its closed position; pressure-responsive means, subject to the pressure of pump delivery, for urging said valve in its opening direction; one-way damping means continuously effective to retard opening movement of said flow control valve; and a maneuvering valve having connections, one for each motor port, a reservoir connection and a connection for the pump delivery, said valve having at least three functional positions, namely a hold position in which it closes both motor port connections and connects the pump delivery connection with the reservoir connection, and two relatively reverse motor-operating positions in which respectively it establishes a one-way flow path from the pump delivery connection to a selected motor connection and connects the other motor connection to the inlet of said flow control valve.

14. For use in a hydraulic system including a motor reversible by interchanging two ports as between inlet and discharge, a reservoir for liquid, and a continuously operating pump fed with liquid and serving to deliver liquid under pressure, a control valve mechanism comprising in combination, a flow control valve having a discharge for connection with the reservoir and an inlet; means biasing said valve toward its closed position; pressure-responsive means, subject to the pressure of pump delivery, for urging said valve in its opening direction; one-way damping means serving to delay opening movement of said flow control valve; and a maneuvering valve having connections, one for each motor port, a reservoir connection and a connection for the pump delivery, said valve having at least four functional positions, namely a hold position in which it closes both motor port connections and connects the pump delivery connection with the

reservoir connection, two relatively reverse motor-operating positions in which respectively it connects a selected one of said motor connections to the pump delivery connection and the other to the inlet of the flow control valve, and a float position in which it closes the reservoir connection, and connects the pump delivery connection and both motor port connections together and to the inlet of the flow control valve.

HALL KIRKHAM.

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