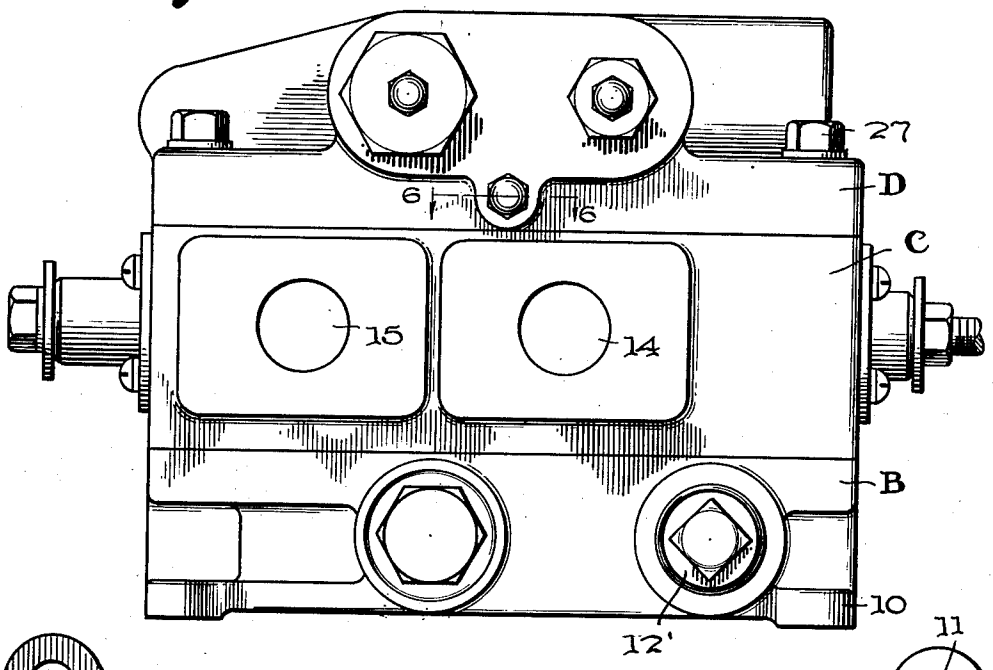
July 22, 1952 H. KIRKHAM 2,604,327

CONTROL VALVE WITH FLOW CONTROL

Filed April 17, 1946 3 Sheets-Sheet 1

Fig. 1.



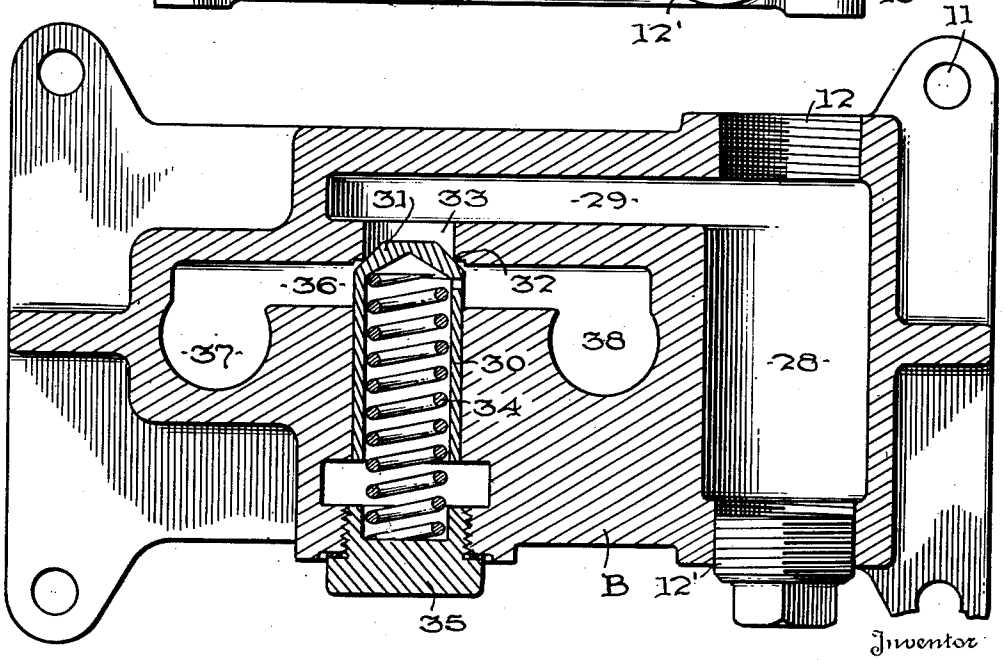


Fig. 5.

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July 22, 1952 H. KIRKHAM 2,604,327

CONTROL VALVE WITH FLOW CONTROL

Filed April 17, 1946 3 Sheets-Sheet 2

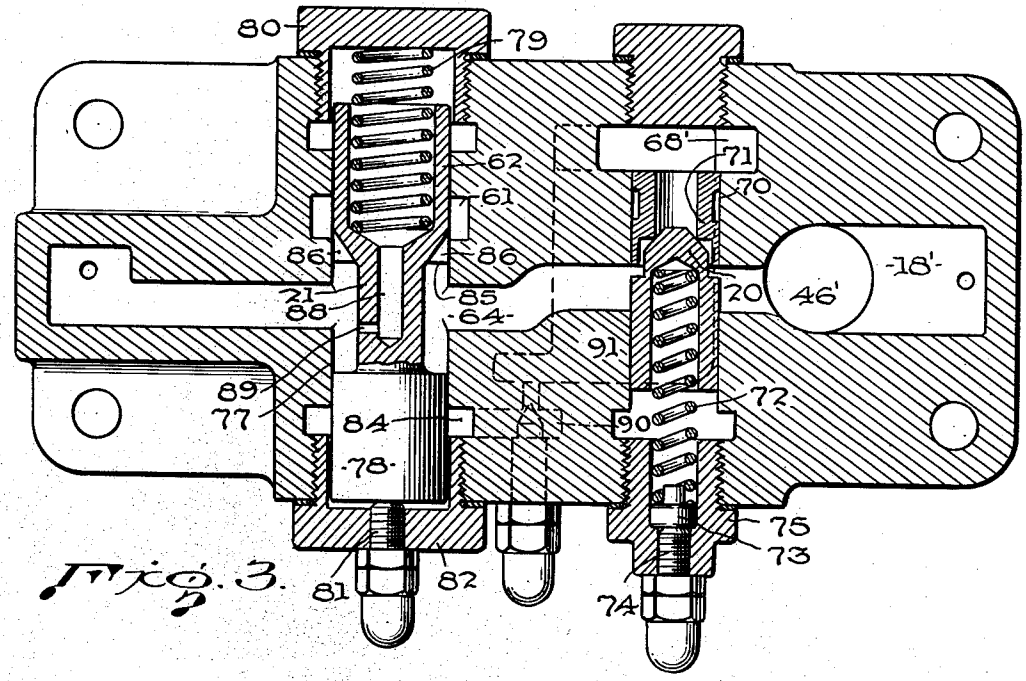


Fig. 3.

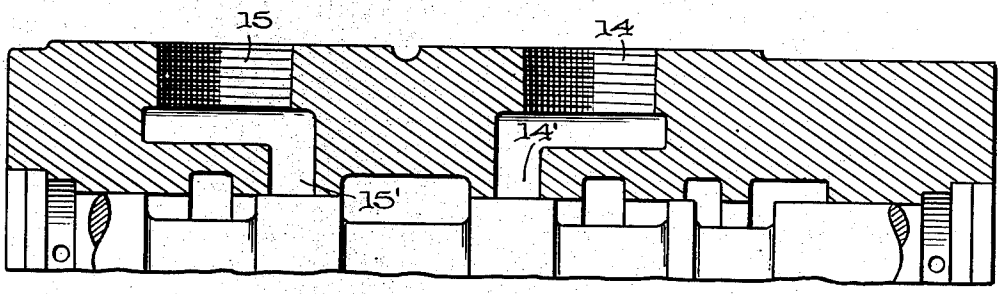


Fig. 4.

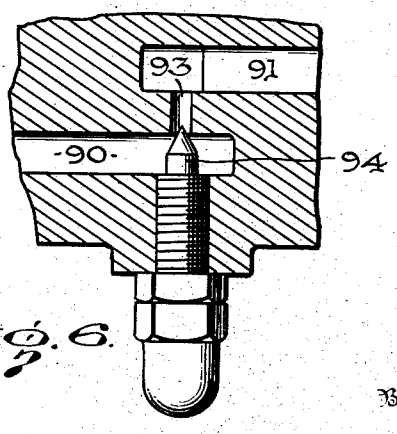


Fig. 6.

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July 22, 1952 H. KIRKHAM 2,604,327

CONTROL VALVE WITH FLOW CONTROL

Filed April 17, 1946 3 Sheets-Sheet 3

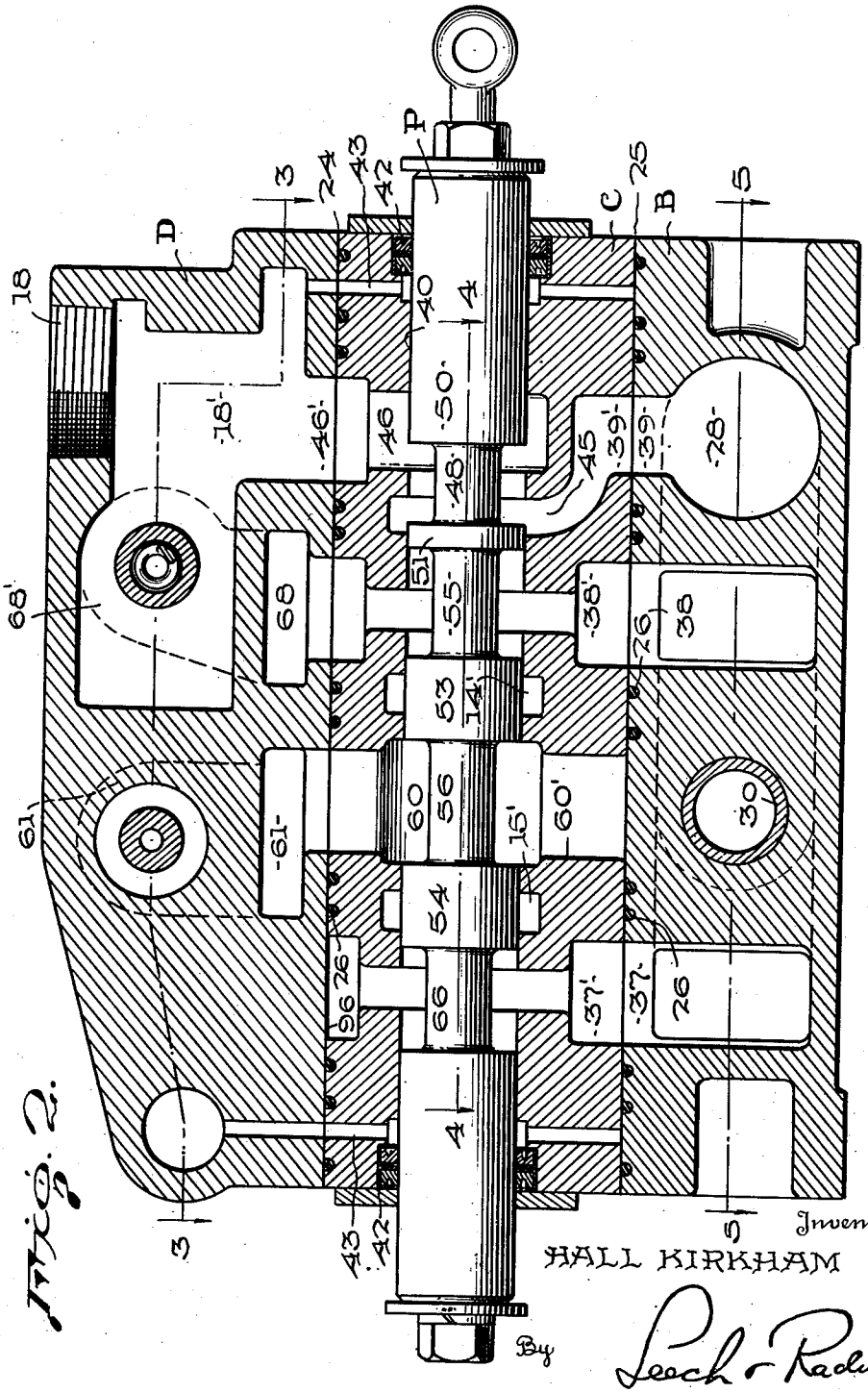


Fig. 2.

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UNITED STATES PATENT OFFICE

2,604,327

CONTROL VALVE WITH FLOW CONTROL

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Application April 17, 1946, Serial No. 662,839

17 Claims. (Cl. 277—55)

1

This invention relates to control valves for hydraulic devices equipped with liquid flow control, and more particularly to such valves for handling the flow of liquid to and from the operating plungers of double acting rams associated with such devices as bulldozers, bull graders, scrapers, lift trucks and machines of a like nature.

More particularly the invention is concerned with a control valve to be introduced between a double acting hoist or ram and a source of high pressure liquid for controlling the operation of the hoist or ram, permitting it to be raised or lowered at any desired speed and independent of the load thereon and in which is incorporated an arrangement for "float" operation.

An important object of the invention includes the provision of a control valve for hydraulic devices having associated therewith flow control valve means arranged to control the return of liquid from the low pressure side of the ram or hoist to the reservoir at a speed dependent on the rate of supply of high pressure liquid to the other side of the hoist and wholly independent of load on the hoist which may tend to advance it more rapidly than the supply of high pressure fluid.

One of the important features of the invention comprises the arrangement of the flow control valve wherein its operation is transferred from one side of the hoist to the other automatically by manual operation of the main control valve plunger.

Another important feature of the invention comprises the unique arrangement of the flow control valve whereby the return of low pressure liquid from one side of the hoist or ram is definitely controlled by the pressure on the operating liquid on the other side of the ram.

Still another important feature of the invention resides in the sectional arrangement of the whole valve housing assembly including the base or high pressure inlet section incorporating a check valve, the intermediate or control valve section and the cap section containing the flow control means and the system relief valve and providing for liquid discharge.

As a subsidiary to the last mentioned feature, the valve sections incorporate passages permitting a duplication of the control valve section interposed between the base and cap sections, the valve plunger of any one of which may be actuated when the others are in neutral position to obtain the full benefit of all the associated equipment.

For a more complete understanding of the invention reference should be had to the accompanying drawings and following specification, wherein is disclosed a single exemplary embodiment of the invention, with the understanding that such changes and modifications may be made

2

therein as fall within the scope of the appended claims without departing from the spirit of the invention.

In said drawings:

Fig. 1 is a side elevation of the assembled valve;

Fig. 2 is a vertical central section through the same on the axis of the plunger;

Fig. 3 is a horizontal section through the cap or cover element taken on broken line 3—3 of Fig. 2 and illustrating both the system relief valve and the flow control valve;

Fig. 4 is a horizontal semi-section taken on line 4—4 of Fig. 2, note being made that the valve housing is symmetrical about the central line;

Fig. 5 is a horizontal section on line 5—5 of the base portion of the valve illustrating the high pressure inlet and check valve; and

Fig. 6 is a fragmentary horizontal section on line 6—6 of Fig. 1.

In the operation of various types of equipment by means of hydraulic hoists or rams of the double acting variety, difficulty is sometimes experienced by the load taking control of the rate of movement thereof and causing the ram piston to advance more rapidly than high pressure fluid is supplied thereto, it being remembered that the fluid can either be throttled to limit the desired rate of movement or is obtained from a pump of limited capacity. In the operation of earth moving equipment such as bulldozers, bull graders, scrapers and the like, extremely smooth lowering of the blade is desired to obtain the fine results of which these machines are capable. Such lowering requires positive control of the flow of low pressure liquid from the side of the piston of the ram opposite to that to which the high pressure liquid is delivered, so that the condition noted above cannot exist. The present invention contemplates a unique arrangement of the manually manipulatable control valve and the flow control valve.

Referring now to the drawings, and particularly to Figs. 1, 2 and 5, it will be noted that the valve housing comprises three main parts, including lower or base section B, which is conveniently equipped with extending flanges 10, perforated as shown at 11 in Fig. 5 for mounting the valve housing on any convenient support. As also seen in both Figs. 1 and 5, the lower section provides threaded inlet passages 12, 12' so that liquid from the pump may be delivered to either of these as is most convenient, a plug such as shown in the passage 12' in Fig. 5 closing the unused one.

The central or control valve section C contains ports and passages for cooperation with the cap and bottom sections and with the valve plunger P. It also contains, as seen in Fig. 4, threaded passages 14 and 15, respectively, open through

the side for conducting liquid to and from the two ends of the hoist or ram. Since the section shown in Fig. 4 is symmetrical about the center line these passages 14 and 15 are duplicated on the other side, for the reasons pointed out in connection with the bottom section, and the ones not desired to be used can be appropriately plugged.

The top or cap section D includes through its upper surface the low pressure fluid delivery passage 18 from which a pipe connects to a suitable reservoir or tank for the reserve liquid. This section also houses, as seen in Fig. 3, the system relief valve 20 and the flow control valve 21 appropriately connected by passages to the center section.

As shown in Fig. 2, the several sections of the valve housing meet along plane surfaces 24 and 25, each intersected by the desired passages and ports. Leakage is prevented by means of a gasket surrounding all passages or ports or by means of composition rings, set in appropriate grooves such as are shown at 26 in Fig. 2. It will be understood that each of the grooves or channels 26 is a continuous closed passage around its corresponding port. The rings may be of the swellant variety, which expand upon contact with the liquid to thereby effect a seal, the non-swellant variety, which seal by deformation or they may be of a combination variety, which combines the virtues of the other two. The sealing ring means of preventing leakage is considered superior to the gasket means. The several sections of the valve housing are appropriately secured together by through bolts, as shown at 27 in Fig. 1.

In Fig. 5, bottom section B is shown as provided with a high pressure liquid chamber 28, to which liquid is delivered from the constantly operating pump of the positive displacement type through one of the passages 12, 12'. A cored passage 29 leads from the chamber 28 to the check valve 30, comprising a hollow plunger 31 seating on the lip 32 of bore 33 extending from passage 29. This plunger is seated by means of the housed spring 34 abutting and positioned by screw cap 35. Oil under pressure is able to lift the plunger and to flow into passage 36 parallel to passage 29 and leading to vertical ducts 37 and 38, also seen in Fig. 2. This latter figure also shows a vertical duct 39 leading from chamber 28. Each of the ducts 37, 38 and 39, extends through the top wall of the bottom section and connects to a corresponding duct 37', 38' and 39', respectively, in the center section.

This center section is longitudinally bored as at 40 throughout its length to provide a close working fit for the manually operable cylindrical plunger P, shown in this figure in its center or neutral position. The bore 40 is variously intersected by channels, passages and ports under the control of the valve plunger, which is equipped with sections of reduced diameter, or grooves, as shown, permitting fluid flow, when they are appropriately positioned between selected ones of the passages, channels and ports, as will later appear. The end portions of the plunger extend out through the walls of the housing and are maintained fluid tight by appropriate seals 42 held in position by cover plates. These seals are vented by passages 43 which lead to the low pressure discharge passage 18, as shown, to insure that the seals will never be required to prevent leakage of high pressure fluid which may seep by the controlling diameters of the valve plunger.

Passage 39' in the center section is continued in an offset passage 45 which intersects the plunger bore. Closely adjacent it is the passage 46 connected to low pressure exhaust chamber 18' by an extension 46'. The groove 48 in the valve plunger insures flow from 28 to 39 to 39' to 45 to 46 to 46' to 18' and back to the tank. This arrangement insures that the pump works against substantially zero pressure when the valve plunger is in the neutral position and no work is being done by the system. When the plunger is moved toward the left, flow is stopped between 45 and 46 by the end section 50 of the plunger and when it is moved to the right, by the narrow land 51.

When the plunger is in the neutral position shown, relief of the high pressure liquid as just described permits the check valve 30 to remain closed, but if the plunger is moved in either direction to close off the flow between 45 and 46 a simultaneous connecting of one or the other of the ram ports 14 and 15 with the high pressure liquid is effected as follows: These ram ports have connected passages of corresponding numbers primed which intersect the plunger bore as seen at 14' and 15' in Fig. 2 and which are normally closed by the lands 53 and 54 of the plunger when in neutral position. If this plunger is moved toward the left, passage 38' is connected by groove 55 with passage 14', the check valve is opened and high pressure fluid flows to one side of the ram. At the same time land 54 uncovers passage 15' and groove 56 in the plunger connects 15' to passage 60 which leads to passage 61 in the upper section of the valve. This passage extends up and around the hollow section 62 of the flow control valve, and when this valve is lifted liquid flows from 61 into cross passage 64 which connects with 46' and the low pressure chamber 18', as clearly seen in Fig. 3. The operation just described results in movement of the ram in one direction under the action of high pressure liquid and causes the return of liquid from the opposite side of its piston back to the tank under the control of valve 21.

Movement of the plunger P to the right reverses the operation of the ram as follows: High pressure liquid flows through the check valve 30 into passages 37 and 37', through groove 66 in the plunger to the passage 15' and direct to the other side of the ram. Low pressure fluid from the opposite face of the ram piston enters the valve at 14, flows into 14', and by means of groove 56 in the plunger enters 60 and 61 and eventually finds its way in the cross passage 64 and back to low pressure 18' as already described. The check valve provides a safety means to hold the ram in whatever position it may be and in spite of whatever load may be on it in the event of failure of the pump or the pipe line between the pump and the valve.

It will be noted that the high pressure chamber 38 is connected to passage 38' which intersects the plunger bore and this passage continues, having eventual connection to chamber 68 in the cover section of the valve, which has a vertical extension 68', seen in Figs. 2 and 3. This is connected to bore 70 of the system relief valve. This bore is provided with a pressed-in seat 71 against which the plunger 20 is held by helical spring 72 under the control of adjustable follower 73 positioned by means of screw threaded rod 74 in the cap 75. If for any reason pump pressure becomes too great, such as by failure

of the ram to move, clogging of pipes or hoses, etc., unseating of the relief valve 20 permits discharge of high pressure liquid from 68' into 64 and hence to the tank. It will be noted that this relief is available at all times when the plunger is not in the neutral position since 38, 38' is connected to 28 whenever the check valve is lifted.

The flow control valve 21 which determines the rate at which low pressure fluid returns from the idling side of the ram plunger to the reservoir by way of passages 60 and 61 is shown in Fig. 3. The valve plunger operates in a bore 77 extending through the cap section of the housing transverse to cross passage 64 and intersecting the same. The valve is of the spool type, having the solid end 78, the intermediate neck section and the upper section 82 hollowed out to receive the light helical spring 79 abutting against the closure cap 80 and tending to press the valve with its end 78 against the adjustable stop 81 threaded into the cap 82 in the opposite end of the bore. This cap is bored with a larger diameter than 77 to permit liquid to flow from chamber 84 to the under face of the portion 78 to move the valve against the spring. As the valve plunger 21 is moved against the spring more and more flow is permitted from 61 into 64. The cylindrical portion 82 of the plunger, which normally closes the passage 61, extends down to 85 but is equipped with tapered slots 86 which are so arranged that complete closure between 61 and 64 can never be effected. The tapering arrangement of these grooves insures increased flow as the valve moves against the spring.

The chamber receiving spring 79 is extended in a small bore 88 connected by a drilled hole 89 to the outside of the narrow portion of the valve plunger to insure discharge of any oil which may seep into the spring chamber and also to impart a dash pot action, to prevent fluttering or rapid fluctuations in the movement of the valve plunger in a manner well recognized.

The passage 84 surrounding the head 78 of the valve plunger 21 is connected by extension 90 and passage 91 with 38', which, it will be remembered, is always open by devious passages to the high pressure chamber 28. Since the pump for the system using the present valve is of a limited capacity, it will be appreciated that if because of a load on the ram tending to move it in the direction it is already being urged by fluid delivered to one side of its piston, there is a tendency for the piston to move more rapidly than fluid is provided behind it, then the pressure on the liquid being delivered by the pump will immediately fall. Advantage is taken of this in the operation of the flow control valve, for when pump pressure is reduced in passage 84 the spring 79 closes the flow control valve plunger against its stop 81 and fluid flow from the low pressure side of the ram piston is throttled between 61 and 64, stopping the unwarranted increase in speed of the ram from the load thereon. As soon as the pump catches up, pressure increases, fluid is delivered into 84 and the valve is opened to the desired degree to permit the ram to operate in its normal manner. To insure against rapid changes in pressure in 84 the connection between extension 90 and passage 91, best shown in Fig. 6, is by way of a restricted bore 93 controlled by an adjustable needle valve 94, as shown.

The needle valve 94 is in the nature of a metering pin which makes it possible to control accurately the rate of flow of fluid from the low pressure side of a double acting ram to prevent the piston from getting ahead of the fluid on the other side. Such controlled action makes it possible to have any desired lowering speeds on such machines. The position of the set screw 81 governs the amount of initial opening between passages 61 and 64 and also governs the amount of travel of the flow control valve necessary to bring the main recess in this valve into play to fully open the passage from 61 to 64.

In addition to the neutral and two power positions of the plunger P, it may be pulled out an extreme distance to the right to provide what is known as a float position. This movement carries land 51 into passage 46 so that high pressure fluid flows freely from 28 into 18 and the pump is unloaded. Groove 66 now connects ram port 15' to passage 69, which is also connected to ram port 14' by groove 56. This provides for communication between the liquid on the two sides of the piston of the ram, permitting the blade, for instance, of a bulldozer to assume any position caused by the work. The displacement of the two ends of the ram cylinder are different because of the presence of the piston rod at one end, so that when moving in one direction an excess of oil must be discharged and when moving in the other direction oil must be added to the circuit. This is simply effected in the valve shown, since the passage 60 to which both ends of the ram cylinder are now connected is always uninterrupted in communication with low pressure cross passage 64 because the valve 21 is never permitted to fully close communication between 61 and 64 because of the grooves 86. In this way oil from the reservoir can be delivered to the ram circuit or can be discharged from the latter to the reservoir to provide for the floating action. If for any reason the "float" position of the valve is not required, then the construction of valve 21 is modified by the omission of the grooves 86, which allow constant communication between 61 and 64 and thus prevent destructive load imposed pressures occurring in passages 60 and 61. These pressures can only occur when plunger P is in the float position since this is the only operating position of said plunger which does not allow for pump induced high pressure fluid acting on end 78 of plunger 21 to thus move it against spring 79 to bring passages 61 and 64 into communication via the central groove of plunger 21. It is thus evident that elimination of the float condition automatically removes any need for grooves 86 and thus allows for simplification of plunger 21.

Because of the peculiar arrangement of the passages and ports in the intermediate section of the valve housing, more than one such section can be arranged between the bottom and cover sections, permitting control of several double acting rams. In order to insure proper operation with multiple plunger sections it will be noted that passage 37' as well as passage 38' extends vertically entirely through the central housing section and is closed off at 96 by a blank section of the cap or cover. The passage 60 is also carried through to be closed off by the bottom section, as shown at 60'. These extensions provide through passages in the event of a multiple use of plunger sections. Where several of these sections are in use the ones above and/or below the one actually in operation, act merely

as elongations of the passages or ducts between the various oil channels in adjoining sections.

I claim:

1. In a valve of the type described, in combination, a housing having a single inlet for high pressure liquid and two ducts connected thereto, a check valve between the inlet and the ducts, a low pressure duct between said two ducts, a bore intersecting all said ducts, a valve plunger in said bore having lands and grooves, a power port extension intersecting said bore between each inlet duct and the low pressure duct, said grooves and lands being arranged to selectively connect either port extension to a high pressure duct and the other port extension to the low pressure duct, a second bore in said housing, a low pressure discharge passage and said low pressure duct intersecting said second bore, a flow control valve plunger in the second bore having lands and a groove to regulate the rate of flow from duct to passage, means biasing said flow control plunger towards closing of said flow and means subject to pressure in said inlet arranged to oppose said bias.

2. The valve as defined in claim 1 in which a tapered slot is arranged in one of said last mentioned lands to prevent complete closing of said flow control valve plunger.

3. The valve as defined in claim 1 in which a leakage groove is provided whereby said flow control plunger is prevented from completely closing off flow between duct and passage.

4. The valve as defined in claim 1 in which the flow control plunger incorporates dash-pot means to limit its rate of movement.

5. In a valve construction of the type described, in combination, a housing having a single inlet chamber for high pressure liquid and two ducts connected thereto, a low pressure duct extending between the first two ducts, a bore in said housing intersecting all said ducts, a valve plunger slidable in said bore, a power port extension intersecting said bore between each inlet duct and the low pressure duct, said valve plunger having alternate lands and grooves arranged to isolate said extensions when in a central position and to selectively connect one extension to one high pressure duct and the other to the low pressure duct when the plunger is in either of its "power" positions on opposite sides of "central," a second bore in said housing, a low pressure discharge passage and said low pressure duct intersecting said second bore, a flow control valve plunger reciprocable in said second bore and arranged to substantially close off flow between said passage and duct when in a first position and to progressively increase the flow area as moved toward a second position, resilient means biasing the flow control plunger toward said first position, and means responsive to pressure in said inlet chamber arranged to urge the plunger toward the second position.

6. In a valve construction of the type described, in combination, a housing having an inlet chamber for high pressure liquid and two ducts connected thereto, a low pressure duct extending between the first two ducts, a bore in said housing intersecting all said ducts, a valve plunger slidable in said bore, a power port extension intersecting said bore between each inlet duct and the low pressure duct, said valve plunger having alternate lands and grooves arranged to isolate said extensions when in a central position, to selectively connect one extension to one high pressure duct and the other to the low pressure duct when the plunger is in either of its "power" positions on opposite sides of "central" and to connect both ports to said low pressure duct when in a "float" position, a second bore in said housing, a low pressure discharge passage and said low pressure duct intersecting said second bore, a flow control valve plunger reciprocable in said second bore and arranged to substantially close off flow between said passage and duct when in a first position and to progressively increase the flow area as moved toward a second position, resilient means biasing the flow control plunger toward said first position, and means responsive to pressure in said inlet chamber arranged to urge the plunger toward the second position.

7. In a valve construction of the type described, in combination, a housing having an inlet chamber for high pressure liquid and two ducts connected thereto, a low pressure duct extending between the first two ducts, a bore in said housing intersecting all said ducts, a valve plunger slidable in said bore, a power port extension intersecting said bore between each inlet duct and the low pressure duct, said valve plunger having alternate lands and grooves arranged to isolate said extensions when in a central position and to selectively connect one extension to one high pressure duct and the other to the low pressure duct when the plunger is in either of its "power" positions on opposite sides of "central," a second bore in said housing, a low pressure discharge passage and said low pressure duct intersecting said second bore, a flow control valve plunger reciprocable in said second bore and arranged to substantially close off flow between said passage and duct when in a first position and to progressively increase the flow area as moved toward a second position, resilient means biasing the flow control plunger toward said first position, a passage from the inlet chamber opening into one end of the second bore to apply a pressure to the control valve plunger to move it against said bias and a restriction in said last mentioned passage to limit the rate of movement of the plunger toward open position.

8. The valve as defined in claim 7 in which the said flow control valve plunger is constructed and arranged to provide a dash-pot action to restrict its rate of movement in either direction.

9. The valve as defined in claim 8 in which the flow control valve plunger always provides for minimum flow between the low pressure discharge passage and the low pressure duct.

10. The valve as defined in claim 6 in which means is provided to prevent full closing of the flow control valve to provide balancing liquid at low pressure when the control valve is in "float" position.

11. In a valve of the type described, in combination, a sectional housing consisting of a base section, at least one intermediate section and a cap section, said sections being joined along parallel planes; said base section having an inlet passage for high pressure liquid, two ducts connected to said passage and leading through the surface engaging an intermediate section and a check valve between said passage and ducts arranged to open into the two ducts when higher pressure exists in the inlet passage and to close on a reverse condition; each intermediate section having through extensions of said ducts, a through low pressure duct between said extensions, a bore intersecting all said ducts and a separate power port extension intersecting said bore between each duct extension and the low

pressure duct; said base closing the lower end of the low pressure duct in the lowermost intermediate section; said cap section closing one of the high pressure ducts in the uppermost intermediate section and having a passage connected to the other high pressure duct, a low pressure liquid outlet, an extension of the said low pressure duct connected to said outlet and a system relief valve operatively arranged between said passage and duct; each intermediate section bore having a valve plunger movable therein and fitted with lands and grooves arranged to selectively connect either power port extension to a high pressure duct extension and the other to the low pressure duct or to close off both power port extensions.

12. In a valve of the type described, in combination, a sectional housing consisting of a base section, an intermediate section and a cap section, said sections being joined along parallel planes; said base section having an inlet passage for high pressure liquid and two ducts connected to said passage and leading through the surface engaging the intermediate section and a check valve between said passage and ducts arranged to open into the two ducts when higher pressure exists in the inlet passage and to close on a reverse condition; said intermediate section having extensions of said ducts, one passing therethrough, a through low pressure duct between said extensions, a bore intersecting all said ducts, a separate power port extension intersecting said bore between each duct extension and the low pressure duct; said base closing the lower end of the low pressure duct in the intermediate section; said cap section having a passage connected to the through high pressure duct, a low pressure liquid outlet chamber, an extension of the said low pressure duct, a bore intersected at spaced positions by said extension and chamber; said intermediate section bore having a valve plunger movable therein and fitted with lands and grooves arranged to selectively connect either power port extension to a high pressure duct extension and the other to the low pressure duct or to close off both power port extensions; and a flow control plunger in said last mentioned bore having lands and a groove to regulate the flow from the low pressure duct extension to the chamber.

13. The valve construction of claim 12 in which the flow control plunger is biased toward flow shut-off, and means subjecting the flow control plunger to the pressure in the high pressure passage to move it against said bias.

14. In a valve of the type described, in combination, a sectional housing consisting of a base section, at least one intermediate section and a cap section, said sections being joined along parallel planes; said base section having an inlet passage for high pressure liquid and two ducts connected to said passage and leading through the surface engaging an intermediate section and a check valve between said passage and ducts arranged to open into the two ducts when higher pressure exists in the inlet passage and to close on a reverse condition; each intermediate section having through extensions of said ducts, a through low pressure duct between said extensions, a bore intersecting all said ducts, a separate power port extension intersecting said bore between each duct extension and the low pressure duct; said base closing the lower end of the low pressure duct in the lowermost intermediate section; said cap section closing the high pressure ducts in the uppermost intermediate section, a low pressure liquid outlet chamber and an extension of the said low pressure duct; each intermediate section bore having a valve plunger movable therein and fitted with lands and grooves arranged to selectively connect either power port extension to a high pressure duct extension and the other to the low pressure duct, to close off both power port extensions or in a "float" position to connect the power port extensions to each other and to the low pressure duct, said cap having conduit means connecting said low pressure duct extension to the outlet chamber, and a valve for said conduit having means to hold it slightly open under all conditions to provide liquid for said "float" operation.

15. In a valve of the type described, in combination, a sectional housing consisting of a base section, an intermediate section and a cap section, said sections being joined along parallel planes; said base section having an inlet passage for high pressure liquid and two ducts connected to said passage and leading through the surface engaging the intermediate section and a check valve between said passage and ducts arranged to open into the two ducts when higher pressure exists in the inlet passage and to close on a reverse condition; said intermediate section having through extensions of said ducts, a through low pressure duct between said extensions, a bore intersecting all said ducts, a separate power port extension intersecting said bore between each duct extension and the low pressure duct; said base closing the lower end of the low pressure duct in the intermediate section; said cap section closing one of the high pressure ducts in the intermediate section and having a passage connected to the other duct, a low pressure liquid outlet chamber, an extension of the said low pressure duct, a bore intersected at spaced positions by said extension and chamber; said intermediate section bore having a valve plunger movable therein and fitted with lands and grooves arranged to selectively connect either power port extension to a high pressure duct extension and the other to the low pressure duct or to close off both power port extensions, a flow control plunger in said cap section bore having a land for closing the low pressure duct extension and an adjacent groove open to said chamber, means biasing said plunger toward closing position, a piston on said plunger opposing said bias and a connection between the piston end of said cap section bore and the high pressure passage in said cap section.

16. The valve as defined in claim 15 in which the last mentioned connection is provided with an adjustable restriction.

17. The valve as defined in claim 15 in which the control plunger bore is closed opposite the piston end, and a restricted passage from said closed end beyond the plunger to the low pressure duct extension to provide the plunger with dash pot action.

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