Dec. 11, 1951 T. F. STACY 2,577,981

HYDRAULIC MOTOR CONTROL

Filed May 15, 1945 2 SHEETS--SHEET 1

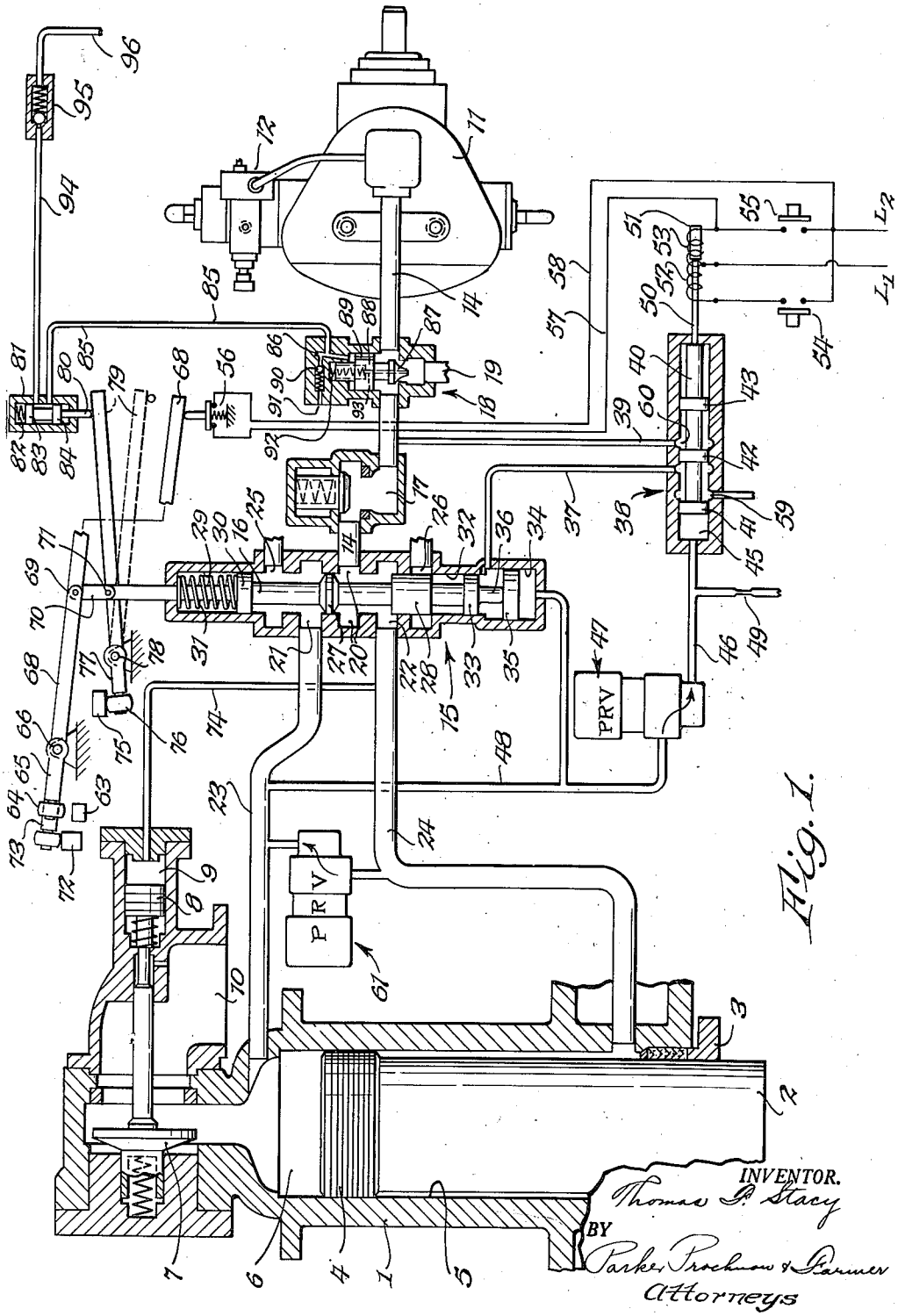


Fig. 1.

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Fig. 5.

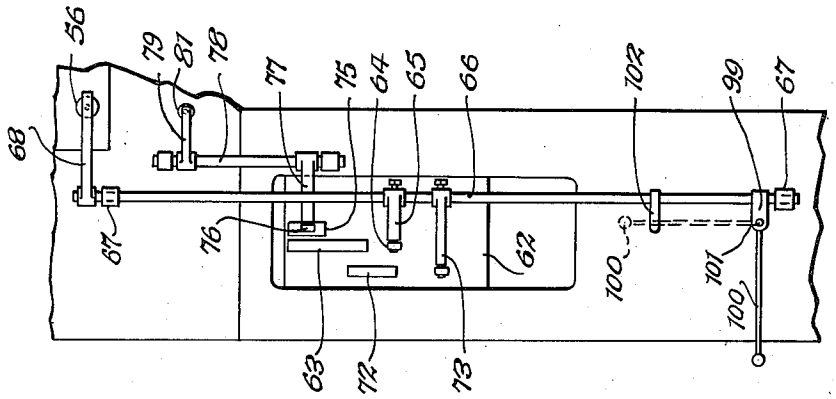


Fig. 4.

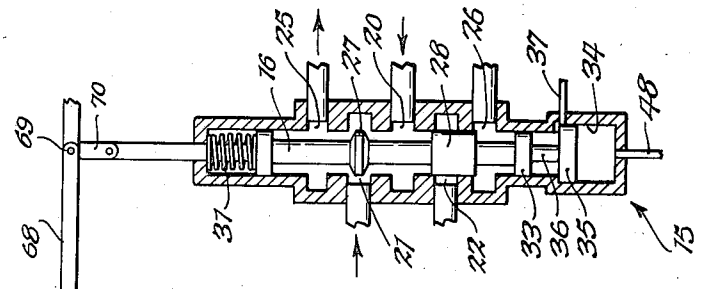


Fig. 3.

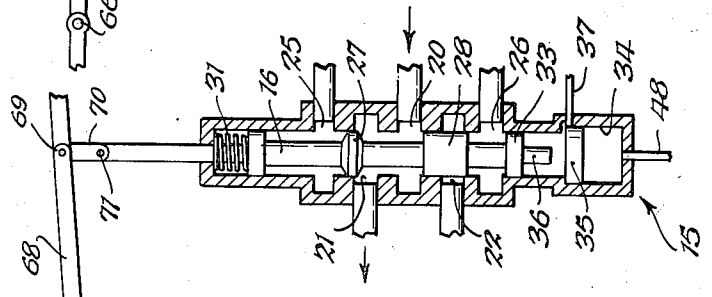
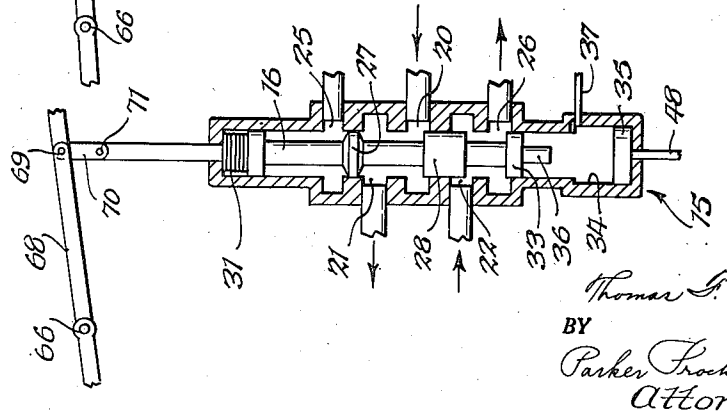


Fig. 2.



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HYDRAULIC MOTOR CONTROL

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Application May 15, 1945, Serial No. 593,851

17 Claims. (Cl. 60—52)

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This invention relates to hydraulic motors, such as hydraulic presses, and particularly to the control of the hydraulic circuits by which the working member or ram of the motor is operated in a selected manner.

An object of the invention is to provide an improved control for a hydraulic motor, with which the activity of the working member of the motor may be controlled manually or automatically; with which a fast closing or initial movement of the working member may be obtained, and then automatically a slower movement for the remainder of the advance; with which the advance travel of the working member may be terminated manually, in response to pressure, or position reached by the working member, and which will be relatively simple, dependable, sensitive, compact and inexpensive.

Another object of the invention is to provide an improved control for a hydraulic motor; with which the working member of the motor may be held in its retracted position by a definite pressure which is sufficient to prevent drifting or gradual movement of the working member away from retracted position; which will not place an undue load upon the pump, and which will have adequate safety protection against damage to the apparatus in case some control should fail to operate.

Further objects and advantages will be apparent from the following description of one embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

In the accompanying drawings:

Fig. 1 is a schematic diagram of a control system applied to a hydraulic motor, such as used in a hydraulic press, of the type where the ram or motor moves vertically, and descending during its advance movement;

Fig. 2 is a diagram of the main control or reversing valve, with its valve element in the position which it occupies during the initial advance of the ram when the press is closing rapidly;

Fig. 3 is a similar diagram, but with the valve element in the position occupied after the ram travel has been slowed down for the actual work such as a pressing or drawing movement;

Fig. 4 is a similar diagram with the valve element in the position which it occupies at the end of an advance of the working member but before reversal has occurred; and

Fig. 5 is a side elevation of part of a press illustrating some of the controls operated by the ram.

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In the illustrated embodiment of the invention, and referring first to Figs. 1 and 5, a hydraulic motor is incorporated in a hydraulic press of the type having a vertically disposed cylinder 1 open at its lower end, and with a ram or working member 2 reciprocating in the cylinder and depending through the open lower end thereof. The usual packing gland 3 at the open lower end of the cylinder 1 provides a sliding, tight connection with the ram or working member 2. The ram 2 is provided with a head 4 which fits and slides along the side walls of the interior of the cylinder 1, with a retracting chamber 5 between the head 4 and the packing gland 3, and an advancing chamber 6 at the opposite face of the head 4.

The cylinder 1 has the usual prefill check valve 7 which is spring pressed into closed position, but which may be opened by the action of a piston 8 operating in a pilot cylinder 9. The valve 7 has an open port 10 connected to the reservoir (not shown) which is frequently disposed at the top of the press, so that when the piston head 4 descends, the suction will draw operating liquid from the reservoir through the prefill valve into the advancing chamber until the descending ram encounters resistance. The valve 7 also serves as a rapid release for the fluid from the advancing chamber while the ram is being retracted, but this is common in hydraulic presses.

Fluid under pressure for the operation of the ram or hydraulic motor is obtained from a suitable pump 11 which is driven by a motor in any suitable manner. The pump is preferably continuously driven, and is shown as of the variable delivery type with a compensator control 12. The pump is connected by a pipe to the reservoir (not shown) and at its delivery side is connected by a pipe 14 to a main control or reversing valve 15 having a reciprocating valve element 16. The pipe 14 has, in series therein, a pressure relief check valve 17 which opens to pass fluid from the pump to the valve 15, but automatically closes to prevent reverse flow toward the pump. Also connected to the pipe 14 is a pressure relief or unloading valve 18 which when open connects the pipe 14 to a branch pipe 19 leading to the reservoir, so as to by-pass all or part of the fluid delivered by the pump back to the reservoir.

The reversing valve 15 has a port 20 to which the pipe 14 is connected, and arranged along the chamber of the valve 15, but on opposite sides of the port 20 are ports 21 and 22 which are connected by pipes 23 and 24 to the advancing cham-

ber 6 and retracting chamber 5 respectively. Further along the valve 15 are exhaust ports 25 and 26 which lead to the reservoir. The valve element 16 is provided with spaced lands 27 and 28 which control the fluid flow through the valve.

One end of the valve 15 is provided with a chamber 29 in which a land 30 reciprocates, and a helical compression spring 31 is compressed between the land 30 and the end of the housing of the valve 15, so as to resiliently urge the valve element 16 downwardly in Fig. 1. At the opposite end of the housing of the valve 15 is a cylinder 32 in which reciprocates a piston 33 that has a stem engaging against the land 28 or which can be coupled thereto. The cylinder 32 opens into a larger cylinder 34 having a reciprocating piston 35 which abuts against a stem 36 depending (in Fig. 1) from the piston 33. The chamber between the pistons 33 and 35 is connected by a pipe 37 to the chamber of a pilot control valve 38, and a pipe 39 also connects the valve 38 to the pipe 14 at a zone between the pump and the check valve 17. The valve 38 has a reciprocating valve element 40 with spaced lands 41, 42, and 43 all of the same size, so that the valve element is balanced against internal pressures. By reason of such balancing, the valve element 40 will remain in any of the different positions into which it may be moved, unless outside forces are applied thereto.

One end of the housing of the valve 38 is closed, which in the example illustrated, is the end in which the land 41 reciprocates, to form a chamber 45. This chamber is connected by a pipe 46 to the discharge side of a pressure relief valve 47, the other side of which is connected by a pipe 48 to the pipe 23. When the pressure in the pipe 23 exceeds the pressure for which the pressure relief valve 47 is set, that valve will open and pass fluid from the pipe 23 to pipe 46 and thence into the chamber 45 of valve 38 where the resultant pressure on the land 41 forces the valve element 40 to the right into the position shown in full lines in Fig. 1. The pipe 46 has a bleed port 49 so that when the valve 47 is closed, the pressure in the chamber 45 may be released. The valve element 40, at the end opposite the chamber 45, is coupled to a valve stem 50 that extends outside of the housing and carries an armature 51 in a position to be magnetically operated upon by either of two solenoids 52 and 53. When solenoid 52 is energized, it will move the armature 51 to the left in Fig. 1 and shift the valve element 40 to the left, whereas when solenoid 53 is energized, it will move the valve element 40 into the full line position shown in Fig. 1.

A line wire L' is connected to one end of each of the solenoids 52 and 53. Line wire L^2 is connected through a manually operated, normally open starting switch 54 to the other end of the solenoid 52, and through a normally open stop switch 55 to the other end of the solenoid 53. Thus by closing either switch 54 or 55, the solenoids 52 and 53 may be energized to cause movement of the valve element 40 in either direction, depending upon which of the switches 54 and 55 is operated. An auxiliary, normally open switch 56 is connected by wires 57 and 58 in parallel across the switch 55, so that when the switch 56 is closed, it will also energize solenoid 53 in the same manner that the solenoid is energized when switch 55 is closed.

When the valve element 40 is in the right-hand position shown in Fig. 1, the land 42 is disposed between the openings into the chamber of valve 38, of the pipes 37 and 39, which prevents the passage of fluid from pipe 39 to pipe 37. At the same time the land 41 is to the left of an exhaust port 59, leading to the reservoir, and this vents the pipe 37. The land 43 is also at the same time somewhat to the right of port 60, into which pipe 39 opens. When valve element 40 is in its right-hand position, shown in Fig. 1, escape of fluid from the space between lands 42 and 43 is blocked and no fluid flows in pipe 39.

When the valve element 40 of the pilot valve 38 is moved to the left, such as when it is moved by energization of the solenoid 52, the land 42 will move to the left of the port opening into pipe 37 to connect the pipes 37 and 39 and interrupt flow from pipe 37 to the port 59. This delivers fluid from the pump to the pipe 37 and thence to the chamber between the pistons 33 and 35 in the valve 15. The fluid pressure in that chamber forces piston 33 upwardly in Fig. 1 against the action of the spring 31 until the valve element has the position shown in Fig. 2, which is the position in which it causes a fast advance movement of the ram 2.

Since the valve element 40 of the pilot valve is balanced against internal pressures, it will remain in whichever of the two positions it is moved into by the solenoids 52 and 53. When moved into the left-hand position in Fig. 1, where it connects the pump to the chamber between pistons 33 and 35, it will not only cause the valve element 16 to be moved endwise against action of spring 31 into the position shown in Fig. 2, but also yieldingly hold it in that position by fluid pressure. This fluid pressure is obtained by a spring on the top of the check of valve 17. When this valve element 16 is in the position shown in Fig. 2, the land 27 will be between the ports 21 and 25, and land 28 will be between the ports 22 and 20. This valve element thus connects the pump directly to the pipe 23 so that the fluid from the pump will be delivered to the advancing chamber 6. The ram will drop by gravity at a high rate of speed, and the fluid displaced by the piston head 4 from the chamber 5 will be expelled through pipe 24 and will pass beneath the land 28 in Fig. 1 to exhaust port 26.

As the ram 2 advances, the prefill valve 7 will open, due to suction, but as soon as the ram encounters resistance, valve 7 will close, due to spring action, and the continued delivery of fluid to the chamber 6 through the pipe 23 from the pump will cause continued advance of the ram, but at a slower rate than that occurring when the prefill valve 7 was fully open. At an intermediate point before the same encounters resistance, it may be desired to have the speed of advance of the ram 2 also controlled, which is usually just before the press closes, or the work of the press begins. To obtain this result, the valve element 16 of the main control valve element 15 is moved endwise (which would be downwardly in Fig. 1) into the position shown in Fig. 3. This Fig. 3 position may be considered one intermediate position which the valve element 16 may occupy, and which may be also identified as the slow-down or pressing position of the valve element.

In this position of the valve element 16 (see Fig. 3), the land 27 is still between the ports 21 and 25, but the land 28 has moved entirely across the port 22 to which the pipe 24 is connected, so that further escape of fluid from the retracting chamber 5 through the valve 15 is prevented. A pressure relief valve 61 is connected between the

pipes 23 and 24 and opens to pass fluid from the pipe 24 to the pipe 23 when the pressure in the pipe 24 exceeds that in pipe 23 by a selected amount for which the valve is set. The fluid expelled from the chamber 5 during the advance of the ram after escape through valve 15 is prevented, passes through valve 61, pipe 23, and then to the advancing chamber 6. The ram 2 will therefore continue to advance at a slow speed as determined by the capacity of the pump discharging into advancing chamber 6 of cylinder 1. This increased back pressure on the piston head 4 prevents jumping of the piston in case the resistance to the advance should suddenly decrease, and it also partly balances the pressure on opposite sides of the packing or piston rings on piston head 4 so that leakage past the head will be decreased, during the pressure or working stroke of the press.

The valve element 16 is moved into this first intermediate position for this purpose, either manually or under manual control, or in response to some operative condition of the press, such as when the press reaches a selected position in its advance, usually just before the real work of the press or ram starts. In the illustrated example of the invention, the ram 2 carries a platen 62 (Fig. 5) with a cam 63 thereon, and this cam at the desired position in the advance of the ram engages a roller 64 on an arm 65 which is secured to a valve rod 66 in any of a plurality of different positions therealong. This valve rod extends vertically and is rockably mounted in bearings 67. At its upper end, the valve rod 66 carries an arm 68 which is pivoted by a pin 69 (Fig. 1 to one end of a link 70, the other end of the link being pivoted by a pin 71 to the outer end of the valve element 16. When arm 65 is rocked by the cam 63, this will rock arm 68 and move the valve element 16 downwardly in Fig. 1 from the fast advance position shown in Fig. 2, into the intermediate position shown in Fig. 3. The cam 63 will hold the arm 65 in that position during continued advance of the ram 2. In moving the valve element 16 into this intermediate position, the ram will overcome the fluid pressure which yieldingly holds the valve element in its upper position in Fig. 1.

The platen or ram also carries another cam 72, Fig. 5, which when the ram reaches a desired position in its travel, engages and operates an arm 73 also secured to, but adjustable along valve rod 66. This further rocks arm 68 until it engages and operates the switch 56 to close a circuit through the solenoid 53. The resulting energization of solenoid 53 pulls the valve element 40 of the pilot control valve back into the full line position shown in Fig. 1, which releases the pressure holding the valve element 16 in the intermediate position, whereupon the spring 31 moves the valve element 16 further in the same direction or toward the opposite end of its valve housing, but since the pressure in the chamber 34 corresponds to that in pipe 23, the piston 35 will stop the valve element 16 in another intermediate position shown in Fig. 4, until the pressure in pipe 23 has fallen sufficiently so that it can be overcome by the pressure of the spring 31. The spring 31 then moves the valve element into the position shown in Fig. 1, which is the reversing position.

This other intermediate position is shown clearly in Fig. 4, and it will be noted that when the valve element 16 is in this second intermediate position, the land 27 will be aligned with the port 21 and the land 28 will still cover the port 22. The fluid will then be trapped in the retracting chamber 5, but fluid in the advancing chamber 6 may escape through port 21 around the edge of land 27 to exhaust port 25, and the fluid delivered by the pump to the port 20 can also pass around the edge of the land 27 to the exhaust port 25.

When the valve element is moved into its full reverse position shown in full lines in Fig. 1, the land 27 will be between ports 20 and 21 and land 28 will uncover port 22 and cover exhaust port 26. The fluid from the pump will then be delivered to the pipe 24 and through it to the retracting chamber 5 where it causes an elevation or retraction of the ram 2. The fluid expelled from the advancing chamber 6 during retraction of ram 2, will escape partly through pipe 23 and valve 15 to port 25 leading to the reservoir, and partly through pre-fill valve 7 directly to the reservoir.

A pipe 74 connects the prefill pilot chamber 9 to the pipe 24, so that during the retracting operation, the pressure of the retracting chamber 5 will also be impressed on the chamber 9 which forces the prefill valve 7 open as soon as the pressure in the chamber 6 has fallen sufficiently, and thereafter fluid may escape from the advancing chamber 6 largely through the prefill valve back to the reservoir which provides a much faster return movement of the ram 2 than would be possible if all of the fluid from chamber 6 had to escape through the main reversing valve.

When the platen reaches a selected position in its return movement, which would be the desired end of the return movement, another cam 75 on the platen or ram 2 engages a roller 76 on an arm 77 carried by another valve rod 78. This rod 78 is rockably mounted in suitable bearings on the frame of the press, and at its upper end this rod 78 carries an arm 79 which engages and operates a valve element 80 (Fig. 1) of a valve 81. This valve 81 is normally urged into a closed position by a helical compression spring 82 which is compressed between the valve element and the closed end of the housing of the valve 81. The valve element 80 has spaced lands 83 and 84 so as to have a balanced interior pressure, and the space between the lands opens into a pipe 85 which is connected to a vent 86 of the pressure relief or unloading valve 18. The valve 18 is of a type known in the trade as a "hydrocone" valve which is obtainable in the open market, and one example of such a valve is illustrated in U. S. Patent No. 2,043,453.

Valves of this type, such as 18, have a valve element 87 which normally engages with a seat, and the pipe 14 opens into the valve chamber above the seat. The stem of the valve element 87 carries a piston 88 which reciprocates vertically in the chamber of the valve housing, and this piston has a restricted vent 89 between its opposite faces. The upper end of the valve chamber above the piston 86 is connected to the control vent 86. This vent 86 normally opens through a spring seated, ball check valve 90 to a vent port 91 leading to the reservoir. This ball check valve is yieldingly urged into closed position against its seat by a small compression spring, the degree of compression of which may be varied or adjusted, or otherwise predetermined. A compression spring 92, urges the valve element 87 into closed position on its seat, and the valve stem 87 has a port 93 extending endwise therewith from end to end to take care of the oil displaced above

the stem when the steam opens and closes. Since the vent 86 is also connected to the pipe 85, it will be obvious that fluid from the vent may escape either through the ball check valve 90 or through the pipe 85.

A pipe 94 leads from the valve 81 to a pressure relief valve 95 of any suitable type which may be adjusted to open at any selected pressure, and in this example this valve 95 should be set to open at a relatively low pressure, or one lower than that for which the valve 90 is set to open. When the valve element 80 of valve 81 is released, the spring 82 will operate the valve element 80 into a position to place the land 83 between the openings into the pipes 85 and 94, which disconnects these pipes. In such a case the pressure relief valve 95 will be ineffective, and valve 18 will open only in response to a pressure which is sufficient to unseat or open the ball valve element 90. When the valve element 80 is moved endwise by arm 79 into the position shown in full lines in Fig. 1, the pipes 85 and 94 are connected, and then the valve 18 will open whenever the pressure equals or exceeds that for which the relief valve 95 is set to open, which is lower than that at which the valve 90 will open.

It will be noted that pressure developed in the line 14 will be applied through the vent 89 to the vent 86, and then to the ball check valve 90. When the pressure has reached a value high enough to open ball check valve 90, the pressure above the piston 88 will be relieved. Vent 89 is smaller than vent 86, and therefore pressure above the piston 88 will be relieved faster than it can be built up. This creates a differential of pressure on the piston 88 causing it to open. When piston 88 opens, the pressure in the line 14, of course, will be relieved, which will cause the ball check valve 90 to close, and pressure building up through the vent 89 will then balance on each side of the piston 88, and the spring 92 will then again seat the valve 87. Pressure will again build up and the valve will open. Actually the dampened action of the piston 88 causes the valve element 87 to come to rest at a position where it will maintain the required pressure according to the setting of the spring on the ball check valve 90. When the valve 81 is open and connects pipes 85 and 94, then the valve 18 will open according to the lower pressure setting of the relief valve 95. When valve 81 is closed, then valve 18 opens only in response to the pressure for which ball check valve 90 is set.

When the ram is approaching its desired retracted position and has opened the valve 81, this connects the low pressure relief valve 95 to the vent 86, and as a result the valve 18 will open at a relatively low pressure, and maintain in pipe 14 that relatively low pressure which caused the opening of valve 95. Thus the pump will continue to exert this relatively low pressure in the retracting chamber 5 and hold the ram retracted under that pressure, which is sufficient to prevent advance or descent of the ram through fluid leakage, weight or other force. The press will be held in this idle position until a downward movement is initiated.

To enable a manual operation of the main reversing valve 15, the valve rod 66 has fixed thereon an arm 99 (Fig. 5) to which a handle 100 is pivoted by pin 101. The rod 66 also carries a spring clip 102 which releasably engages the handle 100 when the handle is swung into the dash-line position shown in Fig. 5. When the handle is in this dash-line position it is out of the way, and the rod 66 may be rocked by the cams 63 and 72. When manual operation of the reversing valve is desired, the handle 100 can be pulled forwardly into the full line position, and then by rocking or moving it sidewise, it will cause the valve rod 66 to be rocked, which will move the valve element 16 upwardly in Fig. 1 and cause an advance or descent of the ram 2. This descent will continue only so long as the handle 100 is held in its rocked position, and when this handle is released, spring 31 will return the valve element 16 to its reversed position shown in full lines in Fig. 1. If the operator allows the handle 100 to return only partly to the idle position, the valve element 16 may be stopped in either of the positions shown in Figs. 3 and 4 to cause a slow advance of the ram, or to stop movement of the ram and hold it in that position without reversal.

In the operation of the illustrated control system, the press will be idle while the control parts are in the position in Fig. 1, because the cam 75 on the platen or ram has rocked the arm 77, shaft 78 and arm 79 to push the valve 81 into the open position that connects the control valve or device 95 to the vent 86 of the unloading valve 18. The reversing valve element 16 is in the full line position shown in Fig. 1, so that fluid from the pump will be delivered to the retracting chamber 5 to hold the ram or working member 2 elevated. To initiate an advance movement of the ram or working member, the operator closes the switch 54 to energize solenoid 52, and this causes movement of the pilot valve element 40 to the left in Fig. 1 to connect the pipes 37 and 39. This causes fluid to be delivered between the pistons 33 and 35 of valve 15, and that pressure forces the valve element 16 upwardly in Fig. 1 into the position shown in Fig. 2. The valve element 16, in that position, connects the pump to the advancing chamber 6, and releases fluid from the retracting chamber 5 through the valve 15 to the reservoir.

The ram 2 will then descend or advance rapidly under the action of gravity, and the prefill valve 7 automatically opens by suction to allow this rapid advance. At the beginning of this descent, the cam 75 releases arm 77 and thus causes release of the valve element 80 of valve 81, which disconnects the pressure relief valve 95 from the vent 86 of the unloading valve 18. At a desired intermediate position in the descent of the ram 2, the cam 63, on the platen or ram, engages and rocks arm 65, which moves the valve element 16 into the position shown in Fig. 3, and all of the operating fluid thereafter displaced from the retracting chamber 5 will be forced through the pressure relief valve 61 into pipe 23 and then into the chamber 6.

After the ram has encountered a sufficient resistance, that is, has exerted a pressure which is a maximum desired, the pressure in the advancing chamber 6, which is communicated through the pipe 48 to the pressure relief valve 47, will open that valve and pass through pipe 46 to the cylinder 45 in the pilot valve 38. This will move the valve element 40 promptly and quickly to the right, in Fig. 1, which disconnects the pipes 37 and 39 and vents the pipe 37. The spring 31 then urges the valve element 16 toward the position shown in Fig. 1, but the pressure in the pipe 23, which was transmitted through pipe 48 to the chamber 34 in the reversing valve, forced the piston 35 upwardly into the position shown in Figs. 3 and 4, where it prevents movement of the valve element 16 beyond the second intermediate position shown in Fig. 4.

The valve element 16 in that second intermediate position releases the pressure in the advancing chamber, closes the retracting chamber,

and by-passes the delivery from the pump, but as soon as the pressure falls in pipe 23, the spring 31 will overcome the pressure in chamber 34 and automatically will continue the movement of the valve element 16 into the full reversing position, shown in Fig. 1. The ram 2 will then be elevated to a selected retracted position at the end of which it again operates valve 31 to decrease the pressure in the retracting chamber, but which holds the ram 2 in its upper position under a balancing pressure.

If the pressure in the advancing chamber 6 does not build up enough to open the valve 47 before the cam 72, that moves with the ram, engages and rocks arm 73 further in the same direction as was caused by cam 63, then the valve rod 66 will be rocked further and will positively move the valve element 16 into the position shown in Fig. 4, and also close the switch 56. The valve element 16, when in the Fig. 4 position, stops further advance of the ram and releases the pressure in the advancing chamber, and the closing of the switch 56 causes the solenoid 53 to be energized, and the latter will move the valve element 40 of the pilot valve 38 into the position shown in Fig. 1, which disconnects the pipes 37 and 39 and releases the pressure holding the valve element 16 in the Fig. 4 position. Spring 31 then continues the movement of the valve element 16 into the Fig. 1 position, and this automatically causes the ram 2 to be retracted, as explained above.

It will be understood, of course, that the pressure exerted by the ram or platen on the valve rod 66 is sufficient to move valve element 16 against the fluid pressure exerted against the end of piston 33. This fluid pressure, which is made effective by the pilot valve 38, thus yieldingly holds the valve element 16 in its upper position in Fig. 1, where it causes an advance or descent of the ram. The descent of the ram 2 may be stopped and reversed at any position of its advance by merely operating the switch 55.

It will be understood that various changes in the details, materials and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. In an operating system for a hydraulic motor of the type having a working member, advancing and retracting chambers for operating said member, a pump, and connections between the pump and chambers for controlling the movements of said member, that improvement which comprises a reversing valve in said connections for connecting said pump alternately to said chambers and having a movable valve element, a pilot valve, fluid operated means controlled by said pilot valve for moving said valve element into a position in which it connects said pump to said advancing chamber and releases fluid from said retracting chamber, and holds it yieldably in said position by fluid pressure, means yieldingly urging said valve element in the opposite direction into another position in which it connects said pump to said retracting chamber and releases fluid from said advancing chamber, hydraulic means responsive to fluid pressure in said advancing chamber for blocking movement of said valve element in said opposite direction beyond an intermediate position in which it closes said retracting chamber and releases fluid from said advancing chamber, and means operated by said member in a selected position in its advance caused by pressure in the advancing chamber, for moving said valve element against the force of said fluid operated means into said intermediate position.

2. In an operating system for a hydraulic motor of the type having a working member, advancing and retracting chambers for operating said member, a pump, and connections between the pump and chambers for controlling the movements of said member, that improvement which comprises a reversing valve in said connections for connecting said pump alternately to said chambers and having a valve element movable between four positions in one of which it connects the pump to the the advancing chamber and releases fluid from the retracting chamber, in another position of which it connects the pump to said retracting chamber and releases fluid from the advancing chamber, in one intermediate position of which nearest said one position it connects the pump to the advancing chamber and prevents the release therethrough to exhaust of fluid from said retracting chamber, and in a second intermediate position of which it prevents release of fluid therethrough to exhaust from the retracting chamber and releases fluid from said advancing chamber, fluid actuated means for moving said valve element into said one position in which the pump is connected to the advancing chamber to cause an advance of said working member, and holding it yieldingly in that position by fluid pressure, means yieldingly urging said valve element from said one position through said intermediate positions into said another position in which it connects the pump to the retracting chamber, hydraulic means responsive to fluid pressure in said advancing chamber for temporarily blocking movement of said valve element towards said other position beyond said second intermediate position, while pressure in said advancing chamber exceeds a predetermined pressure and releasing said valve element at other times, and means operated by said working member in a selected zone of its advance caused by pressure in the advancing chamber for moving said valve element against the force of said fluid actuated means into said one intermediate position, and preventing its return to said one position during further advance of said working member.

3. In an operating system for a hydraulic motor of the type having a working member, advancing and retracting chambers for operating said member, a pump, and connections between the pump and chambers for controlling the movements of said member, that improvement which comprises a reversing valve in said connections for connecting said pump alternately to said chambers and having a valve element movable between two end positions through an intermediate position, in one end position of which it connects the pump to the advancing chamber and releases fluid therethrough from the retracting chamber, in the other end position of which it connects the pump to said retracting chamber and releases fluid therethrough from the advancing chamber, and in said intermediate position connecting the pump to the advancing chamber and preventing release therethrough to exhaust of fluid from said retracting chamber, a pressure relief valve connected between said chambers and passing fluid therethrough in a direction from

said retracting chamber to said advancing chamber when the fluid pressure per unit area in said retracting chamber exceeds that in the advancing chamber by a selected amount, fluid actuated means for moving said valve element into said one position and holding it yieldingly in that position by fluid pressure, means yieldingly urging said valve element from said one position towards said other end position through said intermediate position but weaker than said fluid actuated means, and means operated by said working member while in a selected zone of its advance caused by pressure in the advancing chamber, for moving said valve element against the force of said fluid actuated means into said intermediate position and preventing its return to said one position during further advance of said working member in said zone, whereby fluid from said retracting chamber will then be forced through said pressure relief valve into said advancing chamber.

4. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chamber for controlling the movements of said member, that improvement which comprises a reversing valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, and having an intermediate position in which it connects said pump to said advancing chamber and prevents release therethrough of fluid from said retracting chamber, means yieldingly urging said valve element into the position in which it connects the pump to the retracting chamber, means yieldingly holding said valve element in the position in which it connects the pump to the advancing chamber with release of fluid from said retracting chamber, a pressure relief valve connected between said chambers and passing fluid from said retracting chamber to said advancing chamber when the fluid pressure per unit area in the retracting chamber exceeds that in the advancing chamber by a selected amount, and means operated by said working member for moving said valve element into said intermediate position during a selected zone of movement of said member.

5. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chambers for controlling the movements of said member, that improvement which comprises a reversing valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, and having an intermediate position in which it connects said pump to said advancing chamber and prevents release therethrough of fluid from said retracting chamber, means yieldingly urging said valve element into the position in which it connects the pump to the retracting chamber, means yieldingly holding said valve element in the position in which it connects the pump to the advancing chamber with release of fluid from said retracting chamber, a pressure relief valve connected between said chambers and passing fluid from said retracting chamber to said advancing chamber when the fluid pressure per unit area in the retracting chamber exceeds that in the advancing chamber by a selected amount, and means responsive to a predetermined operative condition of said motor for moving said valve element into said intermediate position during a selected zone of movement of said member.

6. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chamber for controlling the movements of said member, that improvement which comprises a reversing valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, and having an intermediate position in which it prevents release therethrough of fluid from said retracting chamber and releases therethrough fluid from said advancing chamber, means yieldingly urging said valve element into the position in which it connects the pump to the retracting chamber, means yieldingly holding said valve element in the position in which it connects the pump to the advancing chamber with the release of fluid from said retracting chamber, and means operated by said working member at a selected intermediate position in its advance movement for positively moving said valve element into said intermediate position.

7. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chamber for controlling the movements of said member, that improvement which comprises a reversing valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, and having an intermediate position in which it connects said pump to said advancing chamber and prevents release therethrough of fluid from said retracting chamber, means yieldingly urging said valve element into the position in which it connects the pump to the retracting chamber, means yieldingly holding said valve element in the position in which it connects the pump to the advancing chamber with release of fluid from said retracting chamber, a pressure relief valve connected between said chambers and passing fluid from said retracting chamber to said advancing chamber when the fluid pressure per unit area in the retracting chamber exceeds that in the advancing chamber by a selected amount, and means operated by said working member when it reaches a selected position in its advance for releasing said valve element from the action of said yielding holding means, whereby said urging means may move said valve element into the position in which it connects the pump to the retracting chamber and releases therethrough fluid from said advancing chamber.

8. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chamber for controlling the movements of said member, that improvement which comprises a reversing

valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, a pressure relief valve connected to the connection from the pump to said reversing valve, and when open, discharging fluid from the pump to exhaust, means associated with said pressure relief valve for causing it to open at a selected, relatively low pressure, means for making said last named means effective and ineffective, and additional means associated with said pressure relief valve for normally causing said pressure relief valve to open at a selected, relatively high pressure.

9. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chamber for controlling the movements of said member, that improvement which comprises a reversing valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, a pressure relief valve connected to the connection from the pump to said reversing valve, and when open, discharging fluid from the pump to exhaust, means associated with said pressure relief valve for causing it to open at a selected, relatively low pressure, means for making said last named means effective and ineffective, and means rendered effective by said working member at a selected end position in its retracting movement, for operating said control means to place the pressure relief valve under the control of said relatively low pressure control.

10. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, and connections between the pump and chamber for controlling the movements of said member, that improvement which comprises a reversing valve in said connections, and having a valve element which, by its movement between two positions, connects said pump alternately to said chambers and releases therethrough fluid from the other chamber, a pressure relief valve connected to the connection from the pump to said reversing valve, and when open, discharging fluid from the pump to exhaust, a control device associated with said pressure relief valve for causing operation of said pressure relief valve at a relatively low pressure, an additional control device also associated with said pressure relief valve for causing operation of said pressure relief valve at a relatively higher pressure, a device for normally removing the pressure relief valve from the control of said first mentioned control device, but operable to place the relief valve under control of said first mentioned control device, and means operated by the working member at a selected end position in its retracting movement for operating said device that places the pressure relief valve under the control of said first mentioned control device, whereby the working member will be held and retracted by said relatively low pressure.

11. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, connecting means between the pump and chambers for delivering fluid from the pump alternately to said chambers, and means for controlling selectively such delivery of fluid from the pump to said chambers, that improvement which comprises a valve connected to the pressure side of the pump for by-passing delivery from the pump, control devices associated with said valve for causing it to open, one under a selected, relatively low pressure, and another under a selected, relatively high pressure, means normally nullifying the control of said valve by the control device which causes opening of the valve at the relatively lower pressure, but operable to make that control device effective, and means operated by the working member at a selected end position in its movement for operating said nullifying means to place said valve under the control of said low pressure control device, whereby when the working member reaches said selected position, said valve will open and by-pass sufficient fluid from the pump to maintain said selected low pressure in the chamber to which the pump is then delivering fluid.

12. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, connecting means between the pump and chambers for delivering fluid from the pump alternately to said chambers, and means for controlling selectively such delivery of fluid from the pump to said chambers, that improvement which comprises a valve connected to the pressure side of the pump for by-passing delivery from the pump, two control devices connected to said valve for controlling the pressure at which the valve will open, one of said control devices being set to operate at a relatively low pressure, and, the other being set to operate at a relatively higher pressure, and means normally preventing control of the valve by said control device set for the relatively low pressure and operated by the working member at a selected end position in its movement thereof to place the valve under the control of said control device set for the relatively low pressure.

13. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump, connecting means between the pump and chambers for delivering fluid from the pump alternately to said chambers, and means for controlling selectively such delivery of fluid from the pump to said chambers, that improvement which comprises a pressure relief valve connected to the delivery side of said pump, and when opened, bypassing fluid from the pump away from said chambers, said valve having two control vents, either of which, when opened, will cause opening of the valve, a control device with each vent, one set to open when the pressure in the vent reaches a relatively low pressure, and the other when a relatively higher pressure is reached, a normally closed auxiliary valve in the vent connection to the control device set for the relatively low pressure, and means responsive to movement of the working member for opening said auxiliary valve when said working member reaches a selected end position in one of its movements.

14. In an operating system for a hydraulic motor of the type having advancing and retract-

ing chambers, a working member reciprocated by pressure differences in said chambers, a pump for delivering operating fluid under pressure, and connections between the pump and chambers for selectively controlling the delivery of operating fluid from said pump to said chambers and thereby controlling the direction of movement of said member, that improvement which comprises means responsive to the pressure of fluid delivered by said pump to the retracting chamber for reducing the pressure on the retracting chamber to one which will prevent an advance of said member and hold said member in its retracted position under pressure, and means rendered effective by said member when it reaches a desired end position in its return movement for making said last named means effective to cause delivery of fluid at a pressure that will hold said member retracted.

15. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump for delivering operating fluid under pressure, and connections between the pump and chambers for selectively controlling the delivery of operating fluid from said pump to said chambers and thereby controlling the direction of movement of said member, that improvement which comprises means for controlling the maximum pressure of fluid delivered by said pump to said retracting chamber, and means effective when said member reaches a desired end position in its return movement for causing the pressure of fluid delivered to said retracting chamber to fall to a point where it will sustain the weight of the working member and hold it retracted, and place a minimum practical load on said pump.

16. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump for delivering operating fluid under pressure, and connections between the pump and chambers for selectively controlling the delivery of operating fluid from said pump to said chambers and thereby controlling the direction of movement of said member, that improvement which comprises means controlled by said member and rendered effective when said member reaches a desired end position in its return movement for causing a decrease in the pressure of the fluid delivered by the pump to that which will sustain the weight of said member and hold it retracted, and place a minimum load on said pump.

17. In an operating system for a hydraulic motor of the type having advancing and retracting chambers, a working member reciprocated by pressure differences in said chambers, a pump for delivering operating fluid under pressure, and connections between the pump and chambers for selectively controlling the delivery of operating fluid from said pump to said chambers and thereby controlling the direction of movement of said member, that improvement which comprises an element operated by said member when said member reaches a selected end position in its return travel, and means controlled by said member and rendered effective by said operation of said member to reduce the pressure of the fluid delivered by said pump to said retracting chamber to a pressure which will hold said member in retracted position and place a minimum load on said pump.

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