April 4, 1950 W. E. RENICK 2,502,800

PRESSURE FLUID DIFFERENTIAL TYPE MOTOR AND CONTROL VALVE MEANS THEREFOR

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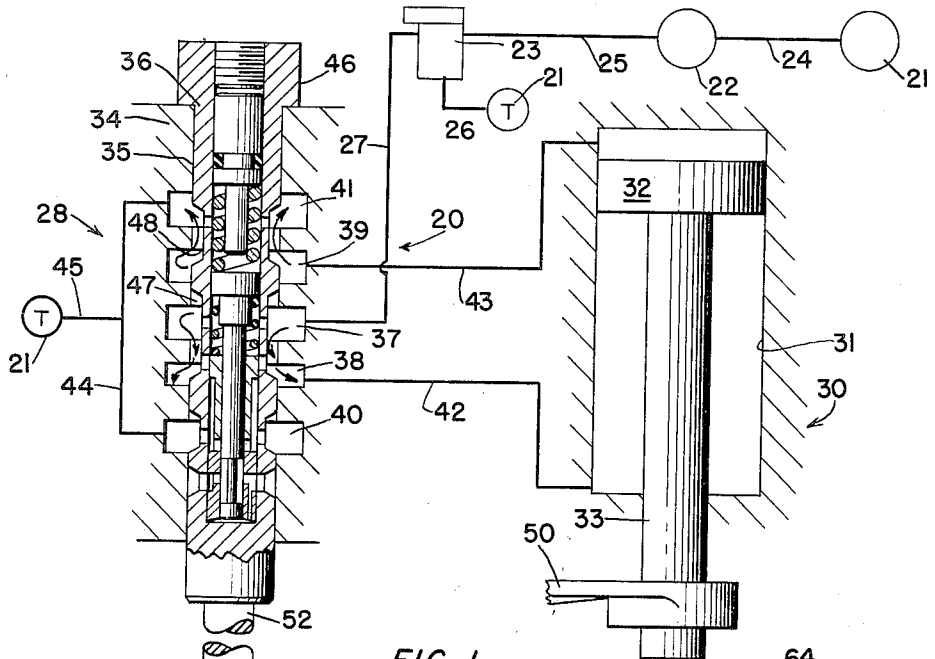


FIG. 1

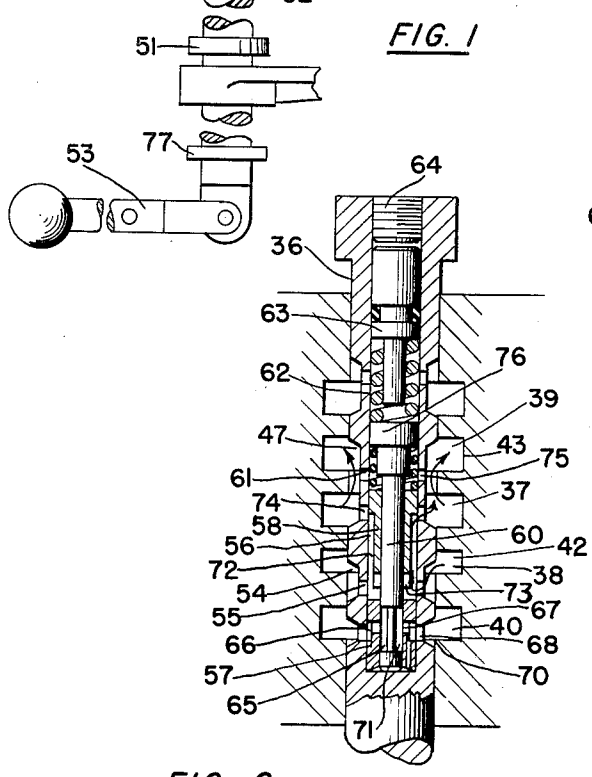


FIG. 2

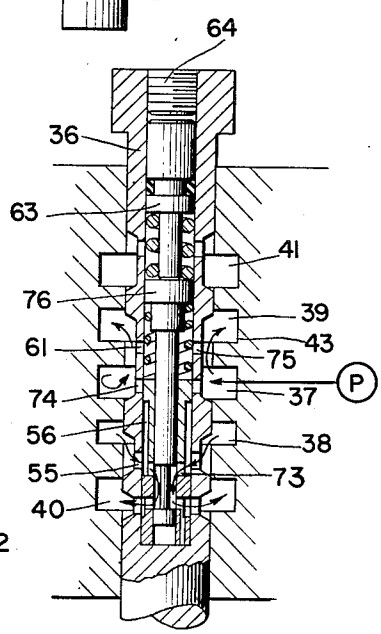


FIG. 3

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PRESSURE FLUID DIFFERENTIAL TYPE MOTOR AND CONTROL VALVE MEANS THEREFOR

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5 Claims. (Cl. 121—38)

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This invention relates generally to hydraulic apparatus and is more particularly directed to control mechanism for use in a hydraulic system, to govern the operation of a reversible fluid motor. It is still more particularly directed to valve mechanism employed to regulate the flow of fluid pressure from a source thereof to effect the operation of a reciprocating fluid pressure operated device, the valve mechanism being particularly designed for use in connection with a hydraulic press.

An object of the invention is to provide a control valve mechanism for use in a hydraulic system employing a source of fluid pressure and a power unit of the piston and cylinder type, the control valve mechanism being partially operated manually and partially automatically.

It is also an object of the invention to provide control valve mechanism to govern an operation of a ram of a hydraulic press, which control valve mechanism is operative to cause the rapid traverse of the ram of a press, a slow pressing operation thereof and an additional rapid traverse portion at the conclusion of the pressing operation, the change from the rapid traverse speed to slow pressing speed and vice versa, taking place automatically without the attention of the operator.

A still further object of the invention is to provide a control valve mechanism having an inlet port connected with a source of fluid pressure, a pair of cylinder ports connected with opposite ends of a power cylinder and exhaust ports, the mechanism having valve elements operative in one position to connect the first end of the power cylinder with the pressure source and the second end with the exhaust and to connect the second end of the power cylinder to the power source in other positions of the elements, the elements being responsive to the fluid pressure in the first end of the power cylinder, when the second end thereof is connected with the pressure source, to connect the first end of the power cylinder to the fluid pressure source also, the elements also being responsive to the pressure of the source when such pressure increases to a predetermined extent, to connect the first end of the power cylinder with exhaust. By connecting the first end of the power cylinder with the pressure source, the effective area of the piston in the power cylinder will be reduced making the entire volume of the source of fluid pressure effective upon the reduced area of the piston to cause the same to move at a rapid rate. When the first end of the power cylinder is connected with exhaust the total area of the piston is exposed to the entire volume of fluid from the pressure source thus decreasing the rate of travel of the piston and increasing the force developed thereby.

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A further object of the invention is to provide control valve mechanism for a hydraulic system, including a source of fluid pressure and a power unit of the piston and cylinder type, the control mechanism having a body, a manually operated spool member and a plurality of pressure responsive valve elements, the body, the spool member and valve elements providing fluid passages to establish communication between the source of fluid pressure and the rod end of the power cylinder and between the other end of the power cylinder and exhaust in one position of the manually operated spool, the latter end of the power cylinder being connected with the source of fluid pressure, in another position of the spool, the pressure responsive valve elements being operative when the manually operated member is in the latter position to connect the rod end of the power cylinder with the source of fluid pressure when pressure exists in such rod end of the cylinder and to connect the rod end of the cylinder to the exhaust, when the pressure in such rod end decreases beyond a predetermined extent, the latter connection being effected by the pressure of the fluid source.

Another object of the invention is to provide a control valve mechanism having a body with an inlet port, upper and lower cylinder ports and exhaust ports and a manually operated spool valve member having grooves for establishing communication between certain of the ports in the body, the spool member also having an internal chamber for the reception of spring pressed valve elements employed to control communication between laterally directed ports extending from the internal chamber in the spool valve member to the exterior thereof, the spring-pressed members and ports being so located that one of the spring-pressed members will be responsive to fluid pressure existing in the lower cylinder port and the other spring-pressed member being responsive to fluid pressure existing in the inlet port; both of the spring-pressed members being operative when the manual spool is in position to establish communication between a predetermined set of ports in the body.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred form

of embodiment of the invention is clearly shown.

In the drawing:

Fig. 1 is a diagrammatic view of a hydraulic system in which a valve formed in accordance with the present invention has been incorporated.

Fig. 2 is a fragmentary, sectional view showing the valve with the elements thereof in position to secure fast traverse of a piston in a power cylinder.

Fig. 3 is a similar view showing the valve elements in position to secure a reduced rate of movement of the piston at increased force.

Referring more particularly to the drawing, the numeral 20 designates, generally, a hydraulic system, this system being employed in a manually controlled hydraulic press. The system 20 includes a reservoir 21, a power driven pump 22 and a relief valve 23 these elements together with connecting lines 24, 25 and 26 forming a source of fluid pressure. Line 24 extends from the reservoir to the pump 22, line 25, extending from the pump to the relief valve and line 26 extending from the relief valve to the reservoir 21 to direct fluid to the latter when the pressure in the system exceeds a predetermined degree. Another line 27 extends from the relief valve and pressure source to the control valve mechanism 28 forming the subject matter of the invention, this control valve mechanism serving to govern the flow of fluid pressure from the pressure source to a power unit 30 of the piston and cylinder type. This power unit includes a cylinder 31, a piston 32 disposed for reciprocation in the cylinder and a ram 33 extending from the piston 32 through the bottom wall of the cylinder to perform useful work.

It is to be understood that although the ram is shown and specified as extending through the bottom wall of the cylinder, the cylinder could be so positioned that the ram would extend through an end wall in a horizontal angular or upward direction, if desired, the power cylinder being shown with the ram extending downwardly, merely for the purpose of illustration.

The control valve mechanism 28 includes a body 34 having a bore 35 for the reception of a spool member 36, the body also having a plurality of annular grooves spaced longitudinally of the bore 35, the grooves being designated by the numerals 37 to 41 inclusive. Groove 37 is disposed between grooves 38 and 39, while grooves 40 and 41 are disposed on the opposite sides of grooves 38 and 39 from the groove 37. The latter groove is connected with line 27, to receive fluid from the pressure source and grooves 38 and 39 are connected by lines 42 and 43 with the lower and upper ends respectively, of the power cylinder 30. Grooves 40 and 41 are connected by line 44, which incidentally, may be a passage in the body 34, line 44 being connected by line 45 with the reservoir 21.

Spool member 36 is of generally cylindrical formation and is provided at its upper end with a head 46 to limit the downward movement of the spool member in the body 34. When the spool member is disposed with the head in engagement with the top surface of the body 34 an external groove 47 formed in the spool will establish communication between grooves 37 and 38; fluid pressure admitted from the source to groove 37 may then flow from this groove to groove 38 from which it will flow through line 42 to the lower end of the power cylinder. The force of this liquid under pressure will be exerted upon the under side of the piston 32 to move the same in an upward direction, fluid above the piston 32 being exhausted from the power cylinder through

line 43 to groove 39. This fluid is conducted through a second groove 48 formed in spool member 36 to groove 41 from which it will flow through lines 44 and 45, to the reservoir 21.

When the spool valve 36 is in the position shown in Fig. 1 the piston 32 and ram 33 will move in an upward direction. As the piston approaches the upper end of the power cylinder an arm 50 secured to the ram will engage a collar 51 fixed to a shipper rod 52 depending from the lower end of the spool valve 36 and move this spool valve in an upward direction until the unreduced portion of the spool valve at the lower end of the groove 47 blocks groove 38 and prevents communication thereof with inlet groove 37; the piston and ram will then stop moving. When it is desired to cause the piston and ram to move in the opposite direction, the spool valve 36 is elevated by the manual operation of a pivoted lever 53 connected to the lower end of the shipper rod 52 to raise the spool valve 36 to the position shown in Figs. 2 and 3; with the spool valve in this position, groove 47 establishes communication between inlet port 37 and the upper cylinder port 39 and fluid may then flow from the pressure source through grooves 37, 47 and 39 to line 43, which extends to the upper end of the power cylinder. This fluid will be applied to the upper end of the piston 32 and will tend to move this piston in a downward direction, the force of the fluid being exerted on the upper side of piston 32 and transmitted therethrough to the fluid below the same causing this fluid to be under pressure also. This pressure will be transmitted through the line 42 to groove 38 and a third groove 54 formed in the spool valve 36.

In registration with the groove 54, the spool 36 is provided with lateral ports 55, which extend to an internal chamber 56 formed in the spool valve. This chamber extends into the spool valve from the upper end thereof and is formed for the reception of an insert 57, valve elements 58 and 60, springs 61 and 62, a spring abutment 63 and a plug 64, the latter closing the open upper end of the chamber. Insert 57 is disposed in the lower end of the chamber and is provided with a central bore 65, an external groove 66 and lateral ports 67 extending from the bore 65 to the groove 66. The spool member 36 is provided with lateral ports 68 in registration with the groove 66, the spool member 36 also having an external groove 70 in registration with the ports 68. Valve element 60 extends into the bore 65 and is provided with an annular groove 71 around the portion normally disposed in bore 65. The upper end of the insert 57 terminates immediately below the ports 55 and provides a shoulder which co-operates with the shoulder at the upper end of groove 71 to govern fluid flow to such groove. The insert is stationarily positioned in the chamber either by being pressed into place, or, otherwise retained. Valve element 58 is of sleeve-like form and surrounds the stem portion of valve element 60, the element 58 being slidable both in the chamber 56 and on the stem of element 60; it is normally urged in a downward direction into contact with the upper end of the insert 57 by the spring 61. The body portion of element 68 is reduced to provide an annular passage designated by the numeral 72, which communicates at its lower end with ports 55. At its lower end, the body of element 58 is notched as at 73 to expose the stem of element 60 to fluid disposed in passage 72.

When valve member 36 is in the position shown

in Fig. 2, fluid pressure in grooves 38 and 54 may flow through ports 55 to passage 72, the force of this fluid pressure being exerted on the downwardly facing shoulder at the upper end of element 58. The force of this fluid will move element 58, upwardly in opposition to spring 61 until passage 72 communicates with ports 74 formed in spool 36, these ports at this time, being in registration with groove 37. The fluid in the lower portion of the power cylinder may thus flow through line 42 to groove 38 and through groove 54 and ports 55 to groove 72, the fluid then flowing through ports 74 to groove 37, where it will mix with fluid flowing from the pressure source and be conducted through grooves 47 and 39 and line 43 to the upper end of the power cylinder.

It should be obvious that with fluid flowing directly from the under side to the upper side of the piston, the entire volume of fluid flowing from the pressure source will be applied to the area of the piston 32 corresponding to the diameter of the ram 33. Due to this reduction in effective area of the piston 32, this member and the ram 33 will be caused to move at a rapid rate. Of course, the reduction in area will also cause a reduction in force developed by the piston, but sufficient force will be exerted to move the ram at the increased rate. When the ram engages an article of work disposed in registration therewith the opposition offered will cause the fluid pressure of the source to increase. The increased pressure will exist in the inlet port 37, the grooves and lines connected therewith and in the upper end of the power cylinder. This increased pressure will be transmitted from the groove 47 to the interior of the spool 36 through other lateral ports 75 formed therein, ports 75 being disposed above the valve element 58, but below a head 76 formed at the upper end of the valve element 60; this valve element 60 is normally urged in a downward direction by the spring 62, which is disposed between the head of valve 60 and the abutment 63. Spring 62 has greater strength than spring 61 so that valve 60 will be held stationary when valve 58 is moved by fluid pressure. The fluid pressure flowing through ports 75 will be applied to the under side of the head 76 and tend to move the valve element 60 upward in opposition to the spring 62. If the fluid pressure is of sufficient magnitude, the valve element 60 will move upwardly until the groove 71 establishes communication between ports 55 and ports 67. At this time, the bottom or lower cylinder port 38 will be connected with exhaust port 40 and fluid may then flow from the under side of the piston 32 to the reservoir 21. At this time valve element 58, if it has not already done so, will be returned to its normal lowered position wherein ports 74 are prevented from communicating with ports 55. Since the communication between the upper and lower sides of the piston 32 is then interrupted and the under side of the piston is connected with the reservoir the entire top surface area of the piston will be exposed to the full volume of fluid from the pressure source; this will increase the force developed by the ram and cause it to continue the pressing operation. The rate of movement of the ram will be reduced, however, since the volume of fluid from the pressure source is being applied to the entire top surface area of the piston. If the ram moves through the article of work and the resistance to movement thereof is reduced, the fluid pressure above the piston will diminish, permitting spring 62 to move valve element 60 to the position wherein communication between ports 55 and 67 is interrupted. There will then be no outlet for the fluid beneath the piston and the pressure on the fluid in the lower end of the power cylinder will increase; if it increases sufficiently, it will again move valve element 58 upwardly as previously described, until the lower or bottom cylinder port 38 communicates with the inlet port 37 and the piston and ram may again move at the rapid rate.

When the ram has moved downwardly to a predetermined extent, the arm 50 will engage a second collar 77 on the shipper rod 52 and move the valve spool downward to a position wherein communication will be interrupted between the inlet port 37 and the top cylinder port 39. The parts of the valve will then be substantially in the positions shown in Fig. 1. The ram will then stop moving downwardly and since groove 47 then establishes communication between ports 37 and 38, the fluid from the pressure source will be directed to the bottom of the power cylinder; the ram will immediately move to its elevated, or, retracted position, the upper end of the cylinder being connected with exhaust at this time.

As previously mentioned, the final stage of movement of the piston and ram in an upward direction will move the valve spool 36 to a position wherein the flow of fluid from the pressure source to the lower end of the power cylinder will be interrupted. The ram will remain in this position as long as the valve spool 36 is stationary. A new cycle of operation of the ram may be initiated by again depressing the knob at the outer end of the lever 53.

From the foregoing, it will be apparent that a control mechanism has been provided, which will permit an operator to depress and hold the manual control element of the press, provided with the control mechanism. Without further attention, the ram will then move at a rapid rate until the work is engaged by the ram, then the maximum force will be developed to cause the ram to move through the work after which the rapid movement of the ram will be automatically resumed. Due to the particular construction of the control valve mechanism, movement of the ram, when it is not opposed, will create a back pressure in the lower end of the power cylinder, which pressure is utilized to establish communication between the lower and upper ends of the power cylinder. This communication reduces the effective area of the piston to the difference between the diameter of the piston and the exposed area of the under side, so that the full volume of fluid from the pressure source is exerted on the reduced piston area. By so reducing the area and exposing the same to the full volume of the pressure source the ram will be caused to move at a rapid rate. When the movement of the ram is opposed with a force sufficient to interrupt movement of the piston, the back pressure will fall and the pressure above the piston and in the pressure source will increase; this pressure is then utilized to establish communication between the lower end of the power cylinder and exhaust, so that the full area of the piston becomes effective and is exposed to the full volume of the pressure source. The force then developed by the piston and ram will be increased, while the speed of movement of the ram will be decreased. This transition will occur as many times as the ram is opposed by a sufficient force during its movement from one end

of the power cylinder to the other in a forward stroke. When the opposition to the movement of the ram is interrupted, the control mechanism will again operate to cause the ram to move at the increased speed.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow:

I claim:

1. In a hydraulic press, a source of fluid under pressure; a power cylinder; control mechanism between said pressure source and said cylinder comprising a body having inlet, upper and lower cylinder and exhaust ports; a valve spool disposed for movement in said body to selectively connect certain of said ports, said spool having an internal chamber, external grooves and laterally directed ports extending from said chamber to said grooves; and spring-pressed spool elements disposed for movement in the chamber in said first-mentioned valve spool, said spool elements being responsive to fluid pressure to move to positions establishing communication between certain of the laterally directed ports in said first-mentioned spool.

2. In a hydraulic press, a source of fluid under pressure; a power cylinder; control mechanism between said presure source and said cylinder comprising a body having inlet, upper and lower cylinder and exhaust ports; a valve spool disposed for movement in said body to selectively connect certain of said ports, said spool having an internal chamber, external grooves and laterally directed ports extending from said chamber to said grooves; a spring pressed spool element disposed for movement in the chamber in said first-mentioned valve spool, said spool element being responsive to fluid pressure in said lower cylinder port to move to a position establishing communication between said lower cylinder port and said inlet; and a second spring pressed spool element movably disposed in the chamber in said first-mentioned spool said second-mentioned spool being moved by fluid pressure in said inlet port to a position establishing communication between said lower cylinder port and an exhaust port.

3. In a hydraulic press, a source of fluid under pressure; a power cylinder; control mechanism between said pressure source and said cylinder comprising a body having inlet, upper and lower cylinder and exhaust ports; a valve spool disposed for movement in said body to selectively connect certain of said ports, said spool having an internal chamber, external grooves and laterally directed ports extending from said chamber to said grooves; said spool being movable to a position in which one groove establishes communication between said inlet and said upper cylinder port, a port in said spool communicating at this time with the lower cylinder port; a yieldably-pressed spool element in the chamber in the first-mentioned spool, said element being responsive to fluid pressure in said bottom cylinder port to move to a position establishing communication between said bottom cylinder port and said inlet; and a second yieldably pressed spool element in the chamber in the first-mentioned spool, said second element being responsive to fluid pressure in said inlet port to move to a position establishing communictaion between said bottom cylinder port and an exhaust port.

4. In a hydraulic press, a source of fluid pressure; a power cylinder; control mechanism between said pressure source and said cylinder comprising a body having inlet, upper and lower cylinder and exhaust ports; a valve spool disposed for movement in said body, said spool having external grooves operative in one position of said spool to establish communication between said inlet and said lower cylinder port and between said upper cylinder port and an exhaust port, one of said grooves establishing communication between said inlet port and said upper cylinder port in another position of said spool; a chamber in said spool; a plurality of passages extending laterally from said chamber to the exterior of said spool; and first and second valve elements disposed for movement in the chamber in said spool, said first element being responsive to pressure in said lower cylinder port when said spool is in the second-mentioned position to establish communication between said lower cylinder port and said inlet, said second valve element being responsive to pressure in said inlet also in the second position of said spool to establish communication between said lower cylinder port and an exhaust port.

5. In a hydraulic press, a source of fluid pressure; a power cylinder; control mechanism between said pressure source and said cylinder comprising a body having inlet, upper and lower cylinder and exhaust ports; a valve member disposed for movement in said body; passage-forming means in said member operative in one position thereof to establish communication between said inlet and said lower cylinder port and between said upper cylinder port and an exhaust port, said passage-forming means establishing communication between inlet and said upper cylinder port in another position of said member; means in said body responsive to the fluid pressure in said lower cylinder port when said member is in the latter position to establish communication between said lower cylinder port and said inlet; and additional means in said body responsive to fluid pressure in said inlet port when said member is in said latter position to establish communication between said lower cylinder port and an exhaust port.

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