

June 9, 1953

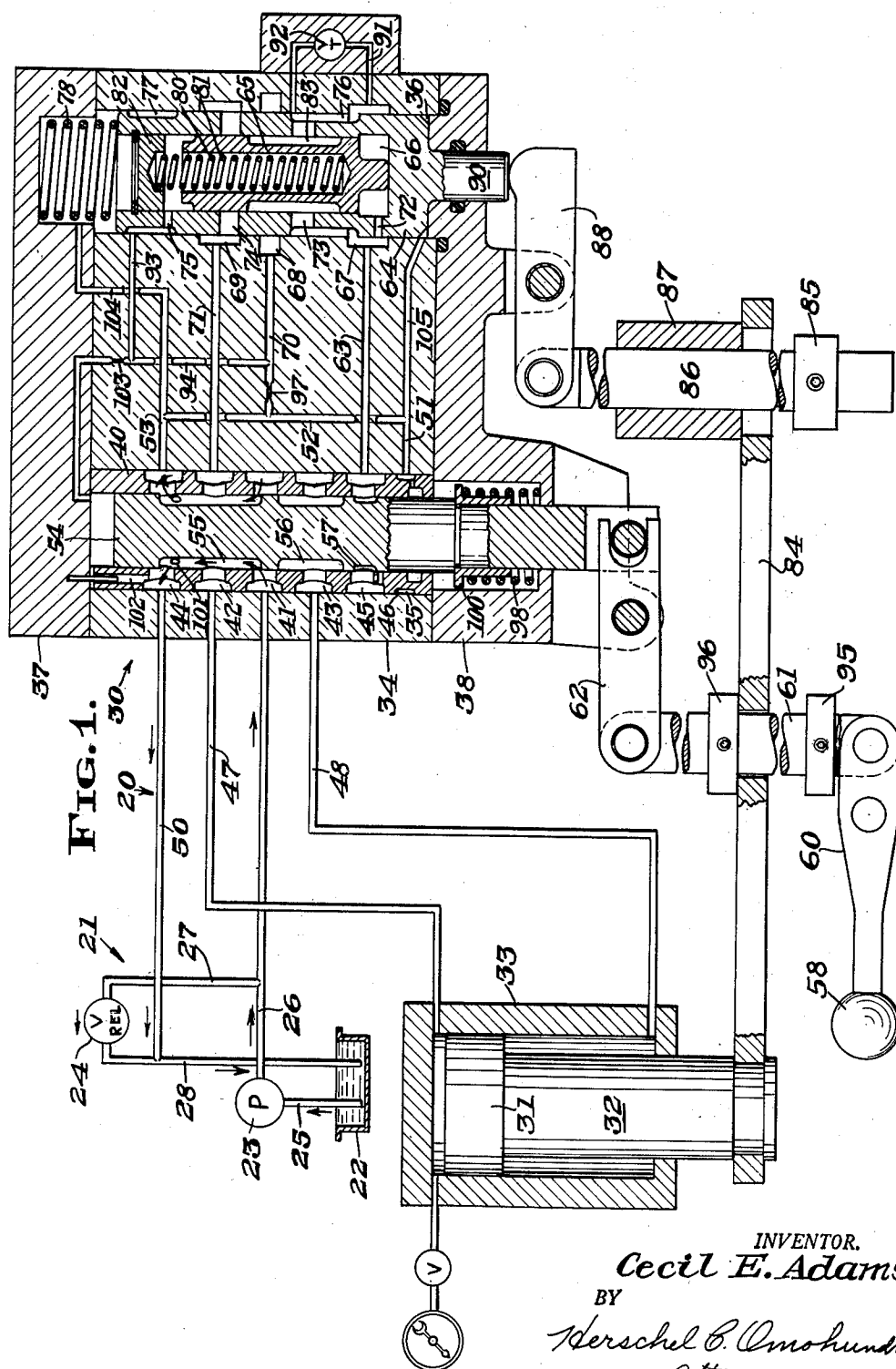
C. E. ADAMS

2,641,228

CONTROL VALVE MECHANISM FOR HYDRAULIC MOTORS

Filed May 26, 1950

3 Sheets-Sheet 1



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CONTROL VALVE MECHANISM FOR HYDRAULIC MOTORS

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3 Sheets-Sheet 2

FIG. 4.

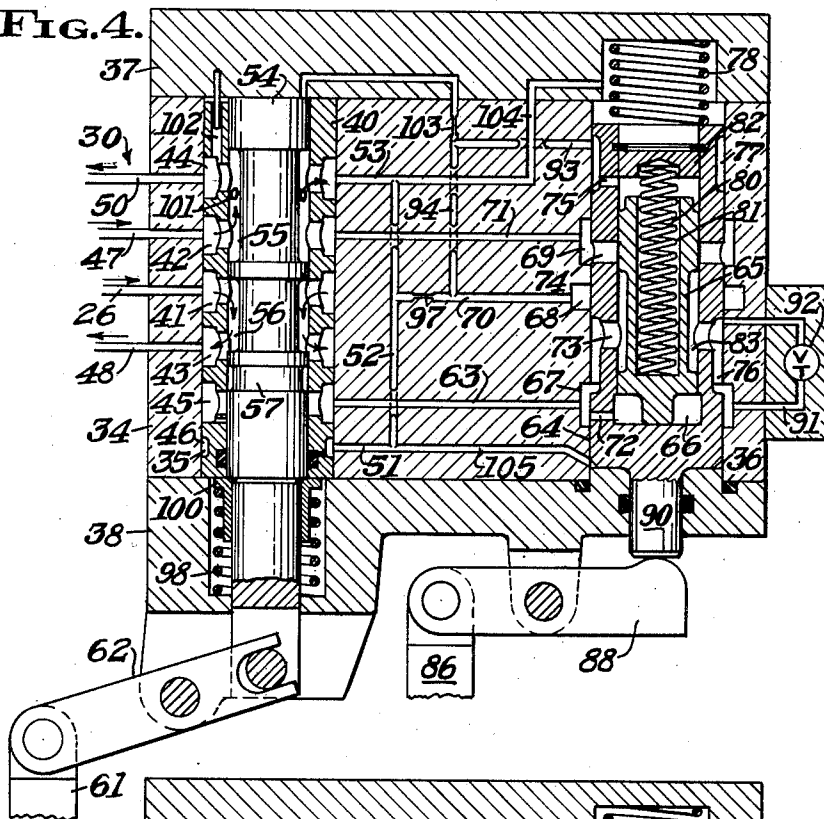
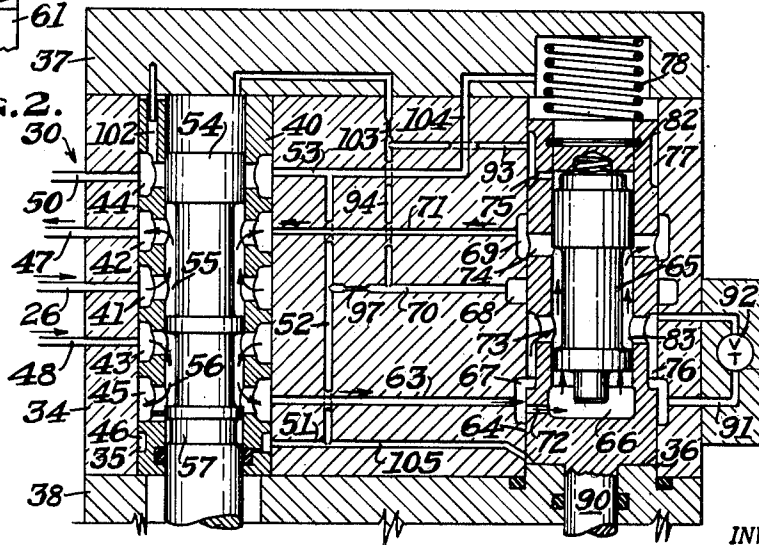


FIG. 2.



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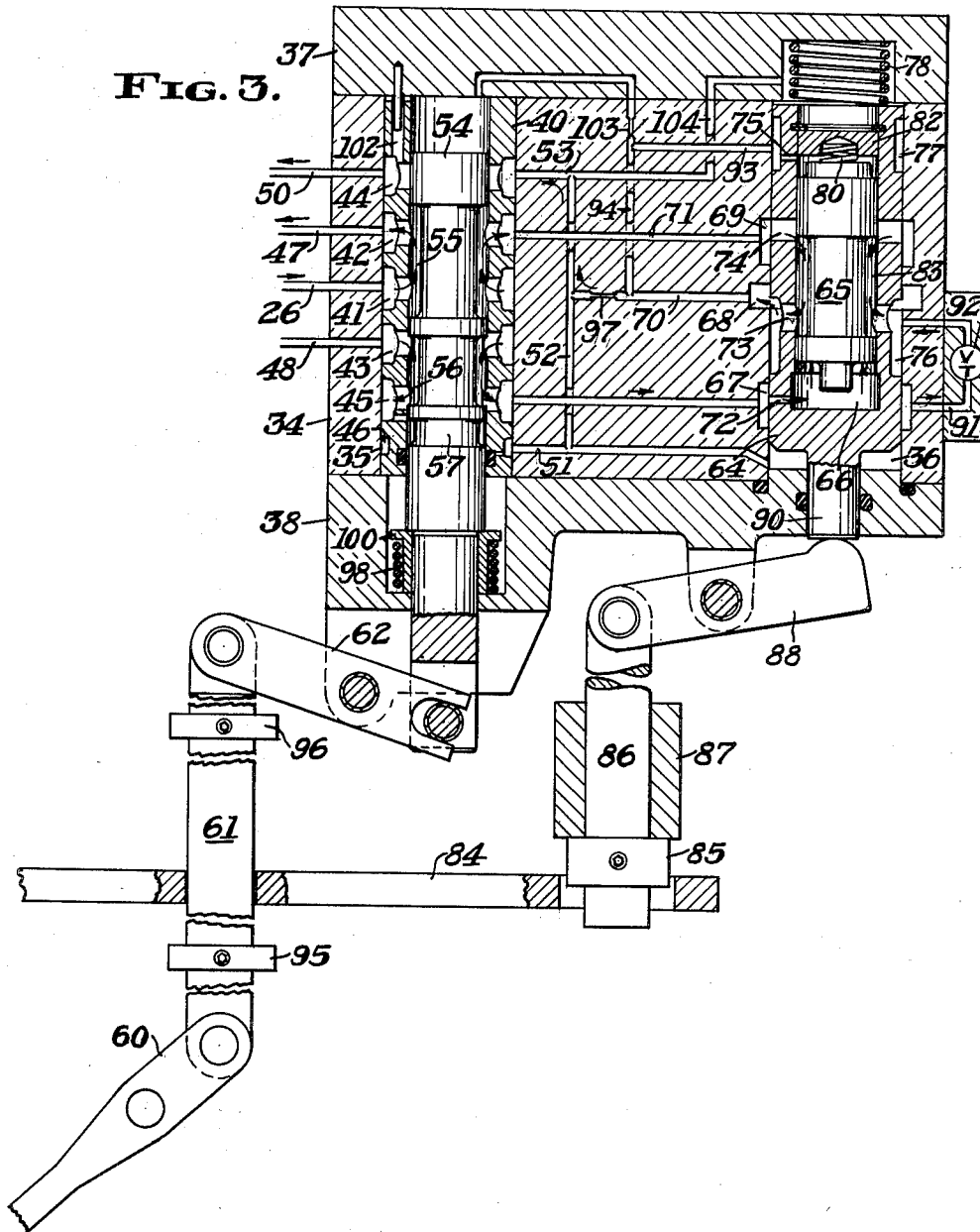
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CONTROL VALVE MECHANISM FOR HYDRAULIC MOTORS

Filed May 26, 1950

3 Sheets-Sheet 3



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2,641,228

CONTROL VALVE MECHANISM FOR
HYDRAULIC MOTORSCecil E. Adams, Columbus, Ohio, assignor to The
Denison Engineering Company, Columbus,
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Application May 26, 1950, Serial No. 164,400

9 Claims. (Cl. 121-46.5)

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This invention relates generally to hydraulic apparatus and is particularly directed to mechanism for controlling the operation of hydraulic pressure-operated motors, power cylinders and similar mechanisms.

One of the objects of the present invention is to provide a hydraulic system having a source of fluid pressure, a reversible fluid motor and control mechanism between the motor and the source of pressure, the control mechanism functioning to cause rapid operation of the fluid motor then a change over to slower operation with increased power, the control mechanism causing reverse operation of the motor upon the termination of predetermined operation in a forward direction.

Another object of the invention is to provide a control mechanism having a relatively simple, four-way valve for causing forward and reverse operation of a fluid motor and additional valve mechanism with which the motor will be caused to operate at a rapid rate during a portion of its forward operation and at a slower rate after a predetermined portion of operation in forward direction has been terminated, the mechanism having means for varying the rate of operation during the latter portion of the forward operation.

A further object of the invention is to provide a control valve mechanism having a body with a pair of valve chambers and passage means extending between the chambers, the chambers receiving valve elements, one of which functions as a reversing valve and the other as a fluid pressure-operated valve, first, to combine fluid being exhausted from a reversible fluid motor, controlled by the mechanism, with fluid from a pressure source and direct it to the motor to cause the motor to operate at a more rapid rate, the second valve element also being responsive to fluid pressure after the motor has executed a portion of its forward operation to cause the motor to operate at a slower controlled rate.

A still further object of the invention is to provide a control valve mechanism for hydraulic apparatus, this control valve mechanism having a body with first and second valve chambers, the first valve chamber receiving a four-way reversing valve and having fluid pressure inlet, forward and reverse motor, and first and second outlet ports, the body also being provided with passage means leading from the outlet ports and the forward motor port to the second valve chamber, the latter chamber receiving relatively movable valve elements which control the flow of fluid through the passage in the body, the valve elements normally functioning to prevent this communication

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but being responsive in part to fluid pressure and in part to the operation of a fluid motor controlled by the mechanism to establish fluid flow through the passage, in one instance providing for fluid flow from the second outlet to the forward motor port so that the fluid motor will operate at a rapid rate and in the second instance functioning to permit fluid flow from the forward motor port to the first outlet port so that the fluid motor will operate at a reduced rate, the second instance occurring after the fluid motor has reached a predetermined stage of forward operation.

A further object of the invention is to provide a control valve mechanism for use particularly to control the operation of a piston in a power cylinder, the control mechanism having a body with a reversing valve and an additional valve means for combining fluid exhausted from the power cylinder, when the piston therein is moving in one direction, with fluid from a power source being supplied to the power cylinder, to cause the piston to move at a rapid rate, the mechanism also being provided with suitable means for actuating parts thereof when the piston in the power cylinder has moved a predetermined distance to discontinue the combination of the fluid being exhausted with that being supplied and direct the exhaust fluid to an outlet, the valve means being further provided with means in the form of an orifice which functions when the exhaust is being directed to the outlet, to create back pressure which may be utilized to operate flow control means to cause a portion of the supply of fluid under pressure to by-pass the power cylinder and flow to an outlet whereby the rate of movement of the power cylinder will be controlled.

A further object of the invention is to provide a control mechanism of the type set forth in the preceding paragraph which will ultimately cause the piston to reverse or be retracted when movement in a forward direction is discontinued, the control mechanism also being provided with means for holding parts of the valve in position to cause forward motion to continue even though a manual means employed to initiate the operation of the piston is released, the valve position holding and flow control means functioning even though the rate of movement of the piston is reduced to a minimum.

Another object is the provision of a control mechanism of the type set forth in the preceding paragraph which may be solenoid operated, the control mechanism being such that the supply of current to the solenoid may be discontinued after

the piston has moved a predetermined distance, without the forward operation of the piston being affected.

An object also of the invention is to provide a semi-manually actuated control mechanism for a hydraulically operated motor having a ram, which control mechanism will cause the advancement of the ram at a rapid rate during a portion of a cycle of operation of the motor, the continued advancement at a reduced selective rate during another portion of the cycle of operation, the exertion of a holding force at a predetermined tonnage after the ram has engaged an object and compressed it to the extent limited by its resistance to such tonnage, and the retraction of the ram after the period of the execution of the holding force has expired, the control mechanism being so designed that the ram may be under the complete control of the operator during the period of advancement at a rapid rate whereby the ram may be caused to stop, advance slowly and retract partially or completely through the manipulation of the manual controls, the control mechanism also permitting the operator to release the manual controls after the reduced rate portion of the ram advancement has started without the interruption of such advancement, yet permitting the interruption of the advancement at the reduced rate, if desired, by the proper manipulation of the manual controls.

Another object of the invention is to provide a control mechanism of the type set forth in the preceding paragraph which will also have the attribute of so governing fluid flow to and from the fluid motor controlled thereby as to secure the transitions from forward to reverse operation and vice versa, without shock and noise, undue wear or breakage incident thereto.

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 drawings:

Fig. 1 is a diagrammatic view of a hydraulic system in which a control valve mechanism formed in accordance with the present invention has been incorporated, parts of the valve mechanism being shown in the positions occupied when the system is idle;

Fig. 2 is a diagrammatic view of the control mechanism alone, the parts being shown in the positions occupied when the fluid motor controlled thereby is operating in a forward direction at a rapid rate;

Fig. 3 is a diagrammatic view of the control mechanism showing the parts in the positions occupied when the fluid motor is operating in a forward direction at a controlled rate; and,

Fig. 4 is a similar view showing the parts in positions occupied when the hydraulic motor is operating in a reverse direction.

Referring more particularly to the drawings, the hydraulic system is designated generally by the numeral 20. This system includes a source of fluid pressure 21, having a reservoir 22, a motor driven pump 23 and a relief valve 24, a conductor 25 extending from the reservoir to the pump and another conductor 26 extending from the pump. A conduit 27 branches away from the conductor 26 and leads to the relief valve 24, the outlet of this valve being connected by a line 28 with the reservoir 22. The conduit 26 extends to the control mechanism designated generally by the numeral 30, which mechanism forms the sub-

ject matter of the present invention. It is used to control the operation of piston 31 and ram 32 in a power cylinder 33.

The control mechanism 30 includes a body 34 in which has been provided a pair of valve chambers 35 and 36, the ends of these chambers being closed by top and bottom caps 37 and 38, respectively. Chamber 35 receives a sleeve 40 which is provided on its exterior with a plurality of longitudinally spaced grooves 41 to 46 inclusive. Groove 41 is in direct communication with conduit 26 leading from the pump 23 and therefore constitutes an inlet groove or port. Grooves 42 and 43 are connected by fluid lines 47 and 48 with the upper and lower ends respectively, of the power cylinder 33, groove 42 hereinafter being referred to as the forward motor port inasmuch as fluid under pressure supplied thereto will flow through line 47 to the power cylinder and cause the ram 32 to advance or be projected from the power cylinder. Groove 43 will hereinafter be referred to as the reverse motor port because fluid under pressure admitted thereto from the pressure source will flow to the power cylinder and cause the ram to be retracted thereinto. Groove 44 will be referred to as the first outlet port, this groove being connected by line 50 with the reservoir 22. Groove 45 will hereinafter be known as the second outlet port. Groove 46 functions merely as a drain port to collect fluid seeping along the sides of the sleeve 40, this fluid being conducted by suitable passages 51, 52, and 53 to the first outlet port 44 from which it will flow to the reservoir.

Sleeve 40 receives for sliding movement therein, a spool valve element 54, which element is provided on its exterior with a plurality of longitudinally spaced grooves 55, 56 and 57, which function to establish communication between ports extending through the side wall of the sleeve 40 in registration with the grooves 41 to 45 inclusive. It will be obvious that when the spool 54 is in different positions various sets of ports will be connected. When the valve spool 54 is in the position shown in Fig. 1, groove 55 will establish communication between ports 41, 42 and 44 and fluid flowing into the inlet port 41 through the line 26 leading from the pressure source, will be directed to the first outlet port 44 from which it will flow through lines 50 and 28 to the reservoir. Since the reverse motor port 43 is not in communication with any other port when the spool 54 is in the position shown in Fig. 1, the piston and ram will remain stationary in the power cylinder. The system is then idle although the pump 23 may be in operation.

When it is desired to cause the ram to advance, the operating extremity 58 of a manual control lever 60 is depressed. This motion will cause the opposite end of the lever 60 to be elevated which motion will be transmitted by shipper rod 61 to a lever 62 which will in turn transmit motion to the spool valve 54. Since lever 62 is pivoted intermediately of its ends, the spool 54 will be caused to be moved in a downward direction. When the spool has moved a distance sufficient to interrupt communication between groove 55 and, the first outlet port 44, fluid from the pressure source will be directed through the forward motor port 42 to line 47 which extends to the upper end of the power cylinder. This fluid will exert a downward force on the upper end of the piston 31 and tend to move it in a downward direction. Fluid in the cylinder beneath the piston 31 will tend to flow through line 48 to the re-

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verse motor port 43 which is then connected by groove 56 in spool 54 with the second outlet port 45. A passage 63 extends from the second outlet port to the second valve chamber 36.

The valve chamber 36 contains a pair of relatively movable valve elements 64 and 65, the latter being disposed for movement in a chamber 66 provided in the former. The body 34 is provided with grooves 67, 68 and 69 spaced longitudinally of the chamber 36, groove 67 being in direct communication with passage 63. Groove 68 is connected by passages 70, 52, and 53 with the first outlet port 44 while a passage 71 directly connects groove 69 with the forward motor port 42. Valve element 64 has a plurality of laterally extending ports 72, 73, 74 and 75 formed therein, port 72 being in registration with groove 67, port 73 being in registration with a groove 76 formed in the exterior of the element 64, ports 74 being in registration with groove 69 and port 75 registering with a groove 77 formed in the element 64 adjacent the upper end thereof. When the parts of the valve are disposed as shown in Figs. 1, 2, and 4, the groove 76 in valve element 64 will communicate at its lower end with groove 67 in the body 34. This is the normal position of valve element 64 in which it is yieldably retained by a coil spring 78 disposed between the upper end of the element 64 and the inner surface of a socket formed in cap 37. Valve element 65, hereinafter termed a flow control spool, is also resiliently maintained in a normal lowered position by a coil spring 80, this spring being disposed within a socket 81 formed in the spool 65. The spring 80 has its upper end in engagement with an abutment plug 82 disposed in the upper end of the chamber 66.

When the flow control spool 65 and valve element 64 are normally positioned, the path for fluid being exhausted from the lower end of the power cylinder is obstructed since groove 76 does not communicate with groove 69. The resistance to flow thus causes a back pressure to be generated which will be transmitted through port 72 to the chamber 66 at the lower end of the flow control valve spool 65; this pressure will be exerted on the lower end of the spool causing it to move in an upward direction to the position shown in Fig. 2, wherein groove 83 in the exterior of the spool will establish communication between the ports 73 and 74. Since the latter ports are in registration with groove 69, which is connected by line 71 with the forward motor port 42, the exhaust fluid will be directed to the forward motor port and it will be combined with the fluid flowing from the pressure source and be directed through line 47 to the upper end of the power cylinder. By thus combining the fluid being exhausted from the lower end of the power cylinder with fluid from the source flowing to the upper end thereof, the effective area of the piston 31 is reduced to equal the area of the ram 32. The entire volume of fluid from the pressure source will thus be effective on the reduced piston area and will cause the piston to move at an increased rate of speed.

After the piston and ram have moved a predetermined distance a crosshead 84 connected with the ram will pass a collar 85, secured to a second shipper rod 86, permitting a weight 87 to be disposed on the collar, which weight will cause the shipper rod to move in a downward direction. This shipper rod is connected at its upper end to one end of a pivoted lever 88 the opposite end of which engages a projection 90 depending from

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the lower end of the valve element 64. When shipper rod 86 is lowered, lever 88 will cause element 64 to be elevated until communication between grooves 76 and 67 is interrupted and communication between groove 76 and groove 69 is established. Valve element 64 will then be in the position shown in Fig. 3. With valve element 64 in this elevated position fluid being exhausted from the lower end of the power cylinder can no longer flow direct from groove 67 to groove 76 but will be caused to flow through a passage 91 which is provided with an adjustable throttle valve or orifice 92.

When valve element 64 is in the last mentioned position the exhaust fluid flowing through passage 91 is directed into groove 68. Since this groove is connected by passages 70, 52 and 53 with the first outlet port 44, the fluid may flow directly to the reservoir through lines 50 and 28. It will be obvious that if orifice 92 is adjusted to resist the flow of fluid through passage 91 a back pressure will be created. This back pressure will be conducted through port 72 to chamber 66 at the lower end of the flow control spool 65 and will cause this spool to move in opposition to the force of its spring 80 to a position wherein groove 83 will establish communication between ports 73 and 74. When this communication is established fluid under pressure from the source may flow from the forward motor port 42 into line 71 and groove 69 to ports 74 from which it will flow through groove 83 and ports 73 to grooves 76 and 68. This fluid will be conducted by lines 70, 52 and 53 to groove 44 from which it will flow through lines 50 and 28 to the reservoir. Inasmuch as fluid pressure from the power source is by-passed directly to the reservoir in this manner the upper end of the power cylinder will not receive the full volume of fluid from the pressure source and the ram 32 and piston 31 will therefore move at a reduced rate. The amount of fluid by-passed in this manner may be regulated through the adjustment of the orifice 92. It should be obvious, therefore, that the rate of movement of ram 32 may be readily controlled through the adjustment of orifice 92.

To cause the flow control spool 65 to be responsive only to the pressure drop caused by the orifice 92, the upper end of the spool is exposed to the pressure on the down stream side of the orifice, through passages 93 and 94 the latter of which connects with passage 70. Passage 93 connects with the groove 77 which in turn is connected with the chamber 66 at the upper end of the spool 65 by port 75.

In the normal operation of a press provided with a control valve mechanism constructed in accordance with the present invention, an article to be operated upon is placed beneath the ram on a bolster or other suitable work support and the manual control knob 58 is depressed, the ram will then move down almost to the article at a rapid rate, then continue at a reduced rate until the article is engaged and the desired pressing operation performed. The ram is then retracted and the finished article removed. During the rapid advance of the ram the operator has complete control of the ram movement through the manipulation of the control knob 58. He may govern the rate of advancement of the ram by controlling the degree of communication between grooves 56 and 45; he may cause the ram to stop and remain stationary by interrupting such communication while the inlet port 41 and forward motor port 42 are in communication; he may

cause the ram to be retracted at a desired rate by allowing the control knob to move up until groove 58 establishes communication between the inlet port and the reverse motor port 43; the degree of communication will determine the rate of movement of the ram. The complete retraction of the ram may be had from any stage in the rapid advancement section of the ram cycle of movement by merely releasing the control knob 58 which will permit the spool 54 to move upward to the position shown in Fig. 4.

After the ram passes the point determined by the location of the collar 25 on shipper rod 28 and enters the reduced rate pressing section of its cycle of movement, the operator may release the control knob 58 and the ram will continue to advance at its reduced rate until it has engaged the article and performed the pressing operation thereon. When the ram stops advancing, due to the resistance being offered by the article, the spool 54 will automatically move to the position shown in Fig. 4 in which the ram will be caused to retract. The retraction will be interrupted by the movement of the spool 54, to the position shown in Fig. 1, through the engagement of the crosshead 24 with the collar 25 on shipper rod 28.

During the first part of the ram advancement, before the weight 87 is engaged with the collar 25, the fluid expelled from the lower end of the power cylinder 33 is combined with fluid from the pressure source and directed into the upper end of the power cylinder; no fluid flow through line 70 to exhaust will occur at this time. After weight 87 engages collar 25 and moves sleeve 64 upward to the position shown in Fig. 3 all fluid expelled from the power cylinder and all fluid from the pressure source which is by-passed will flow through lines 70, 50 and 53 to exhaust. The flow of this fluid is resisted by a restriction 97 in passage 79 and a back pressure is created. This back pressure is utilized to retain the spool 54 in position to cause the continued advance of the ram when the control knob 58 is released. The back pressure is applied to spool 54 through a passage 94 which has a branch extending to the chamber 35 at the upper end of the spool 54. After the ram ceases to advance the back pressure will be dissipated and spring 98 will move the spool to its upper-most position, shown in Fig. 4 in which the ram is caused to be retracted. Spring 98 is positioned between an internal shoulder in cap 28 and a shoulder on a spring abutment 100 which surrounds an extension of spool 54 and in turn engages a shoulder thereon. As spring 98 moves spool 54 upwardly the fluid will be expelled from the chamber above the spool through passages 94, 70, 52 and 53 to the outlet port 44. Fluid will flow back through these passages when the spool 54 is again moved downwardly by the crosshead engaging and elevating the collar 25 and shipper rod 28. More fluid will flow to the chamber above valve 54 through these passages when the valve is moved downwardly to the position shown in Fig. 2 by manually depressing the control lever knob 58.

The reversing valve portion of the present control valve mechanism is also provided with the shockless reversal features disclosed in the co-pending application of Cecil E. Adams and Ellis H. Born, Serial No. 77,133. To secure these features the sleeve 40 is provided with a row of small holes 101 in horizontal registration with the lower edges of the ports leading to groove 44. As the spool 54 is being moved from the position shown in Fig. 3 toward the position shown in Fig. 4 the

lower edge of the head at the top of groove 55 will first start to expose ports 101 leading to the outlet port 44. The pressure of the fluid in the upper end of the power cylinder and the pressure source will tend to cause a rapid flow of fluid into the outlet port 44 and 50. As these parts of the system then contain relatively static fluid which will exert a resistance to flow, a back pressure will be created which will tend to oppose the dissipation of fluid pressure from the chamber at the upper end of spool 54 through lines 94, 70, 52 and 53. The upward movement of the spool will, therefore, be retarded until the flow through the outlet port and line 50 is accelerated. If the spring 98 tends to move the spool too rapidly the back pressure in the outlet port and the space above the spool will increase and the movement of the spool will be opposed by the pressure in the chamber above the spool. As the rate of fluid flow from the outlet port to the reservoir accelerates the back pressure will subside permitting the spool to move toward the upper end of the chamber and provide unrestricted flow to exhaust. It is important to note that the response of the means for eliminating shock in reversing the direction of ram movement, is proportional to the necessity therefor. If the pressure in the cylinder and pressure source is high the valve operates slowly until the pressure is dissipated. If the pressure is low the necessity for eliminating shock is slight and the valve will operate more rapidly.

A hole 102 is drilled into the sleeve 40 from the upper end; it communicates with the chamber at the upper end of spool 54 and serves to permit the escape of air which might accumulate at this point, to the reservoir and consequently to the atmosphere.

To somewhat stabilize the action of the spool 54 the branch of passage 94 leading to the chamber at the upper end of the spool is provided with a restriction 103.

Additional drain lines 104 and 105 may be provided to conduct leakage from the ends of chamber 36 and to permit fluid to be discharged and flow into these chamber ends upon movement of the spool elements therein.

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 system, a source of fluid pressure having a reservoir; a reversible fluid motor; a control valve mechanism between said pressure source and said motor, said mechanism having a body; a four-way valve in said body, said four-way valve having an inlet communicating with said pressure source, forward and reverse motor ports communicating with said motor, and first and second outlet ports, the first of said outlet ports communicating directly with said reservoir; a spool in said four-way valve movable to different positions to connect certain sets of said ports; passage means in said body extending between the outlet ports and said forward motor port; first and second relatively movable valve elements in said passage means normally disposed to prevent fluid flow through said passage means, the first of said valve elements being responsive to fluid pressure in the second outlet port when the second of said elements is normally positioned, to provide for fluid flow from said second outlet port to said forward motor port; and means

operated by said reversible fluid motor for moving said second valve element from its normal position to a second position, the first valve element then being responsive to fluid pressure in the second outlet port to provide for fluid flow from said forward motor port to said first outlet port.

2. In a hydraulic system, a source of fluid pressure having a reservoir; a reversible fluid motor; a control valve mechanism between said pressure source and said motor, said mechanism having a body; a four-way valve in said body, said four-way valve having an inlet communicating with said pressure source, forward and reverse motor ports communicating with said motor, and first and second outlet ports, the first of said outlet ports communicating directly with said reservoir; a spool in said four-way valve movable to different positions to connect certain sets of said ports; passage means in said body extending between the outlet ports and said forward motor port; first and second relatively movable valve elements in said passage means normally disposed to prevent fluid flow through said passage means, the first of said valve elements being responsive to fluid pressure in the second outlet port when the second of said elements is normally positioned, to provide for fluid flow from said second outlet port to said forward motor port; means operated by said reversible fluid motor for moving said second valve element from its normal position to a second position; and fluid flow throttling means operative when said second valve element is in the second position to create a fluid pressure differential on the fluid flowing from said second outlet port, the first valve element being responsive to the fluid pressure differential thus created to provide for fluid flow from said forward motor port to said first outlet port.

3. In a hydraulic system, a source of fluid pressure having a reservoir; a reversible fluid motor; a control valve mechanism between said pressure source and said motor, said mechanism having a body; a four-way valve in said body, said four-way valve having an inlet communicating with said pressure source, forward and reverse motor ports communicating with said motor, and first and second outlet ports, the first of said outlet ports communicating directly with said reservoir; a spool in said four-way valve movable to different positions to connect certain sets of said ports; passage means in said body extending between the outlet ports and said forward motor port; first and second relatively movable valve elements in said passage means normally disposed to prevent fluid flow through said passage means, the first of said valve elements being responsive to fluid pressure in the second outlet port when the second of said elements is normally positioned, to provide for fluid flow from said second outlet port to said forward motor port; means operated by said reversible fluid motor for moving said second valve element from its normal position to a second position; and adjustable means for creating a pressure drop, said means being operative when said second valve element is in the second position, to create a fluid pressure differential on the fluid flowing from said second outlet port, the first valve element being responsive to the fluid pressure differential thus created to provide for fluid flow from said forward motor port to said first outlet port.

4. In a hydraulic system, a source of fluid pressure having a reservoir; a reversible fluid motor; a control valve mechanism between said pres-

sure source and said motor, said mechanism having a body; a four-way valve in said body, said four-way valve having an inlet communicating with said pressure source, forward and reverse motor ports communicating with said motor, and first and second outlet ports, the first of said outlet ports communicating directly with said reservoir; a spool in said four-way valve movable to different positions to connect certain sets of said ports; passage means in said body extending between the outlet ports and said forward motor port; first and second relatively movable valve elements in said passage means normally disposed to prevent fluid flow through said passage means, the first of said valve elements being responsive to fluid pressure in the second outlet port when the second of said elements is normally positioned, to provide for fluid flow from said second outlet port to said forward motor port; and means operative at a predetermined stage of operation of said reversible fluid motor, to move said second valve element from its normal to a second position, said first valve element then being responsive to fluid pressure in the second outlet port to provide for fluid flow from said forward motor port to said first outlet port.

5. In a hydraulic system, a source of fluid pressure having a reservoir; a reversible fluid motor; control valve mechanism between said pressure source and said motor; said mechanism having a four-way valve with inlet, forward and reverse motor and first and second outlet ports, said first outlet port being directly connected with said reservoir; passage means including a valve chamber establishing communication between said second and first outlet and said forward motor ports; relatively movable valve elements in said valve chamber, said elements preventing fluid flow through said passage means when normally positioned, one of said elements being responsive to fluid pressure in said second outlet port when another is normally positioned, to establish communication between said second outlet and said forward motor port; flow-restricting means in said passage means between said valve chamber and said first outlet port; means controlled by the reversible fluid motor for moving one of said valve elements from its normal position to a second position to establish communication between said outlet ports; orifice means connected in said passage means when the last mentioned valve element is in said second position, said orifice means causing a pressure drop on fluid flowing from the second to the first outlet port, the first mentioned valve element being exposed and responsive to said pressure drop to establish fluid flow from said forward motor port to said first outlet port past said flow restricting means, said flow restricting means causing a pressure drop; and passage means for applying the higher pressure of said last mentioned pressure drop to said four-way valve to retain the same in a predetermined position during the existence of said last mentioned pressure drop.

6. A control mechanism for a reversible hydraulic motor comprising a body providing first and second valve chambers, said body having an inlet, forward and reverse motor and first and second outlet ports communicating with said first valve chamber; a valve spool disposed for movement in said first valve chamber between positions establishing communication between certain of said ports; means yieldably tending to move said valve spool to a certain position; pas-

sages in said body leading from said outlet and forward motor ports to spaced points in said second valve chamber, the passage leading from said first outlet port having a restriction formed therein; a branch passage leading from one end of said first valve chamber to the passage containing the restriction at a point between the restriction and said second valve chamber; first and second valve elements disposed for relative movement in said second valve chamber; yieldable means normally maintaining said valve elements in position to prevent fluid flow through said passages, the first of said valve elements being responsive to fluid pressure in said second outlet port, when said second element is normally positioned, to establish communication between said second outlet port and said forward motor port; means for moving said second valve element from a normal to a second position in which said first and second outlet ports are in communication; an orifice connected in said passage means when said second valve element is in said second position, said orifice causing a pressure drop on fluid flowing from said second to said first outlet port, the pressures at opposite sides of said orifice being applied to opposite ends of said first valve element to move the same from its normal position to provide for fluid flow from said forward motor port to said first outlet port, said restriction serving to cause a pressure drop on the fluid flowing to said first outlet, the higher pressure of said last mentioned pressure drop being applied to one end of the first mentioned valve spool to resist movement thereof by said yieldable means during the existence of said last mentioned pressure drop.

7. Control mechanism for a reversible hydraulic motor comprising a body having first and second valve chambers, said body having an inlet, forward and reverse motor and first and second outlet ports communicating with said first valve chamber; a valve spool disposed for movement in said first valve chamber between positions establishing communication between different sets of said ports; passageways extending from said forward motor port and said first and second outlet ports to spaced points in said second valve chamber; first and second telescoping ported and grooved valve elements disposed for movement in said second valve chamber; yieldable means normally holding said valve elements in position to prevent communication between said passageways, the first of said valve elements being responsive to fluid pressure in said second outlet port when the second valve element is normally positioned to move to a position establishing communication between the passages extending from said second outlet and forward motor ports; and means for moving said second valve element to a second position interrupting such communication, said first valve element then being responsive to fluid pressure in said second outlet port to move to a position establishing communication between the passages extending from said forward motor and said first outlet port.

8. Control mechanism for a reversible hydraulic motor comprising a body having first and second valve chambers, said body having an inlet, forward and reverse motor and first and second outlet ports communicating with said first valve chamber; a valve spool disposed for movement in said first valve chamber between positions establishing communication between different sets of said ports; passageways extend-

ing from said forward motor port and said first and second outlet ports to spaced points in said second valve chamber; first and second telescoping ported and grooved valve elements disposed for movement in said second valve chamber; yieldable means normally holding said valve elements in position to prevent communication between said passageways, the first of said valve elements being responsive to fluid pressure in said second outlet port when the second valve element is normally positioned to move to a position establishing communication between the passages extending from said second outlet and forward motor ports; an orifice in said body; means for moving said second valve element to a second position in which such communication is interrupted and communication between the passages extending from said second and first outlet established through said orifice, flow from said second outlet port through the orifice causing a pressure differential, said first valve element being responsive when said second valve element is in such second position to pressure differential to establish communication between the passages extending from said forward motor and first outlet ports.

9. Control mechanism for a reversible hydraulic motor comprising a body having first and second valve chambers, said body having an inlet, forward and reverse motor and first and second outlet ports communicating with said first valve chamber; a valve spool disposed for movement in said first valve chamber between positions establishing communication between different sets of said ports; spring means normally tending to urge said valve spool to one position; motion transmitting means for moving said spool to a second position in opposition to said spring means; passageways in said body extending from said first and second outlet and said forward motor ports to spaced points in said second valve chamber; first and second telescoping valve elements disposed for movement in said second valve chamber; spring means normally urging said valve elements into a position preventing communication between said passageways, the first of said valve elements being responsive to fluid pressure in said second outlet port when the second valve element is normally positioned, to move to a position establishing communication between the passageways leading from said second outlet and said forward motor ports; an orifice in said body; motion transmitting means for moving said second valve element to a position obstructing such communication and establishing communication between said first and second outlet ports, flow from said second to said first outlet port through said orifice causing a pressure differential, said first valve element then being responsive to the pressure differential to establish communication between the passageways leading from said forward motor port and said first outlet port.

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