

March 15, 1949.

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2,464,283

HYDRAULIC APPARATUS

Filed July 19, 1944

4 Sheets-Sheet 1

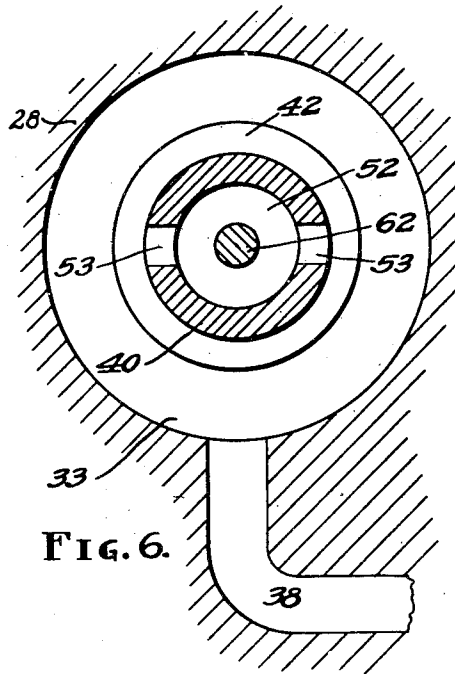
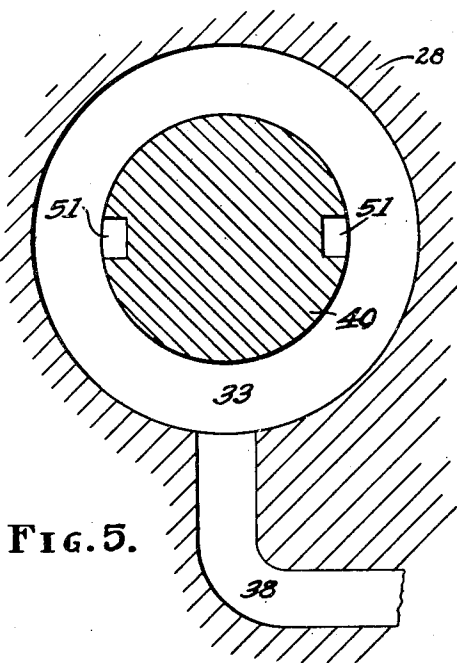
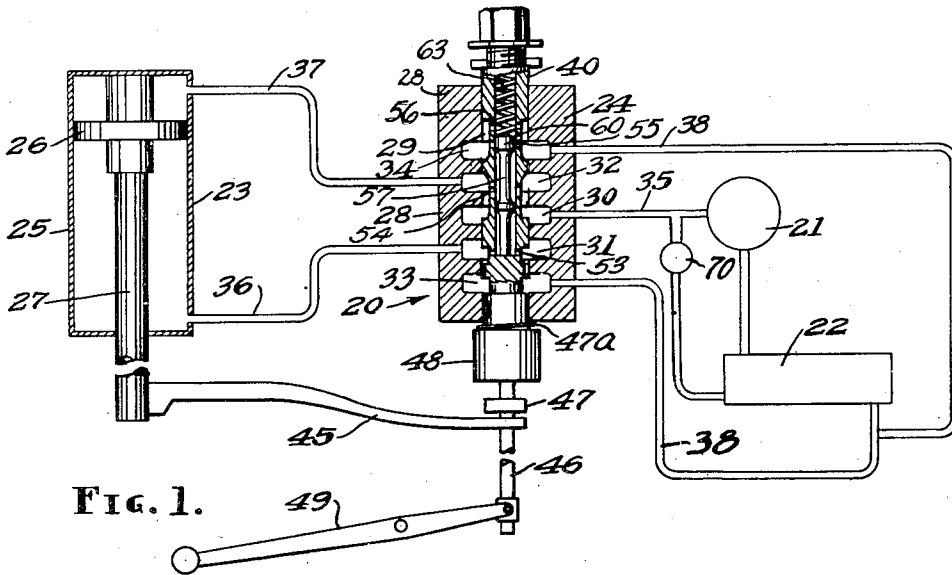


FIG. 5.

FIG. 6.

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4 Sheets-Sheet 2

FIG. 3.

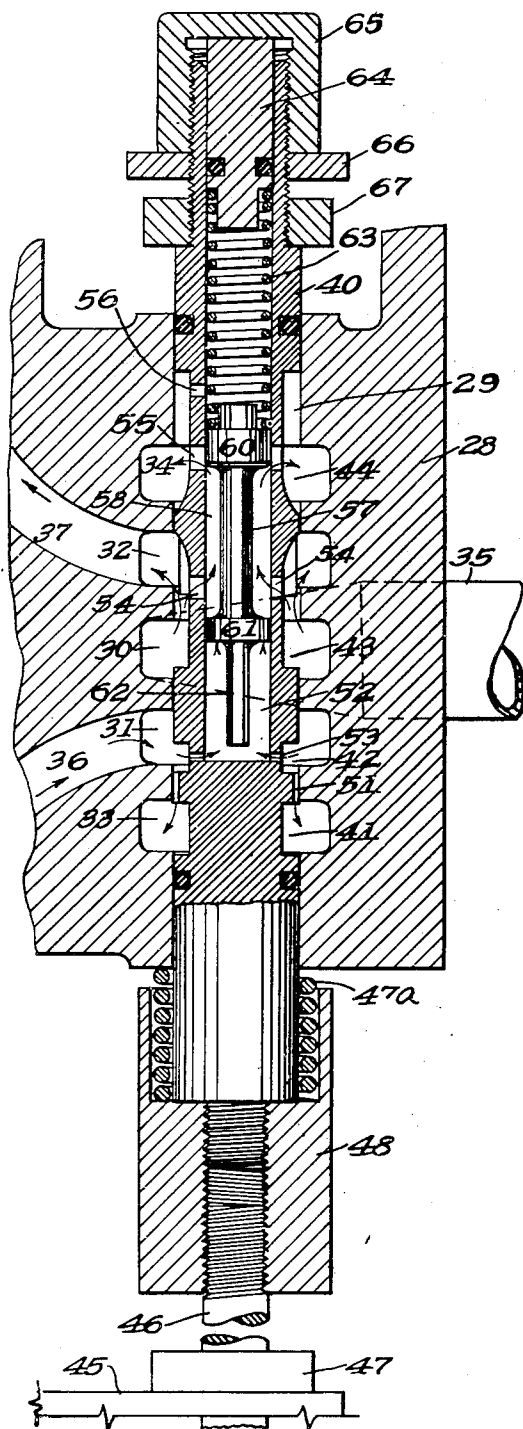
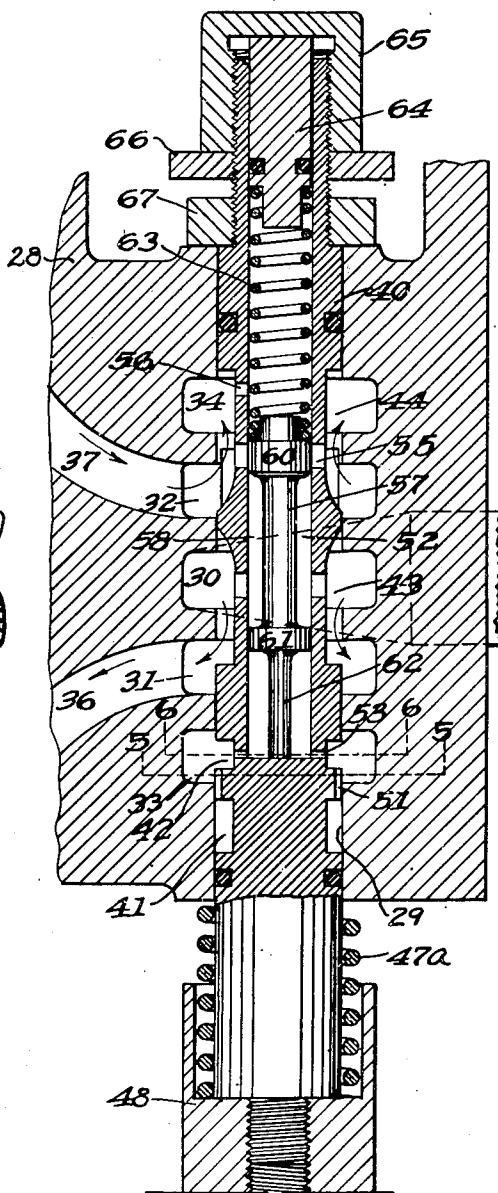


FIG. 2.



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4 Sheets-Sheet 3

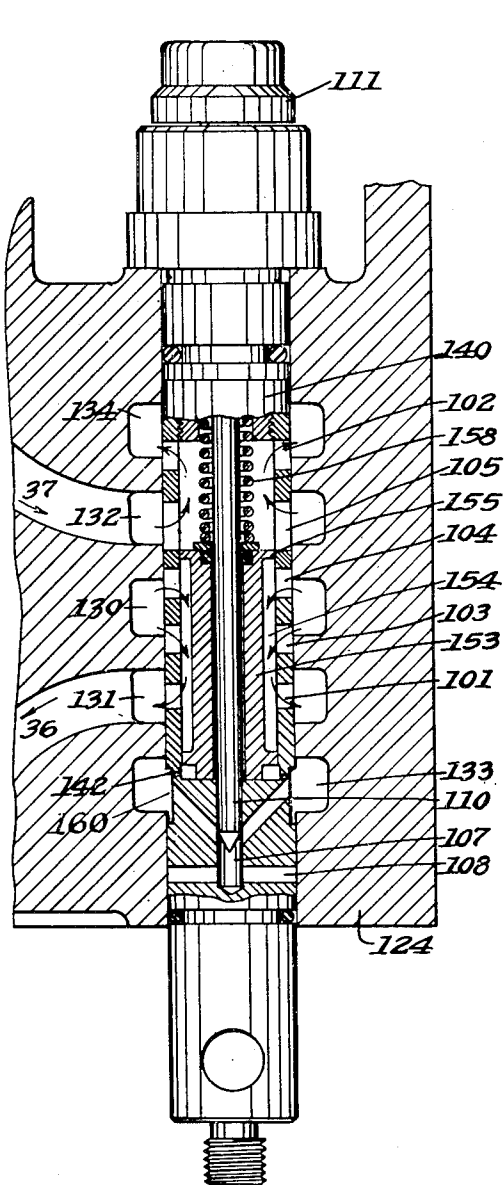


FIG. 9.

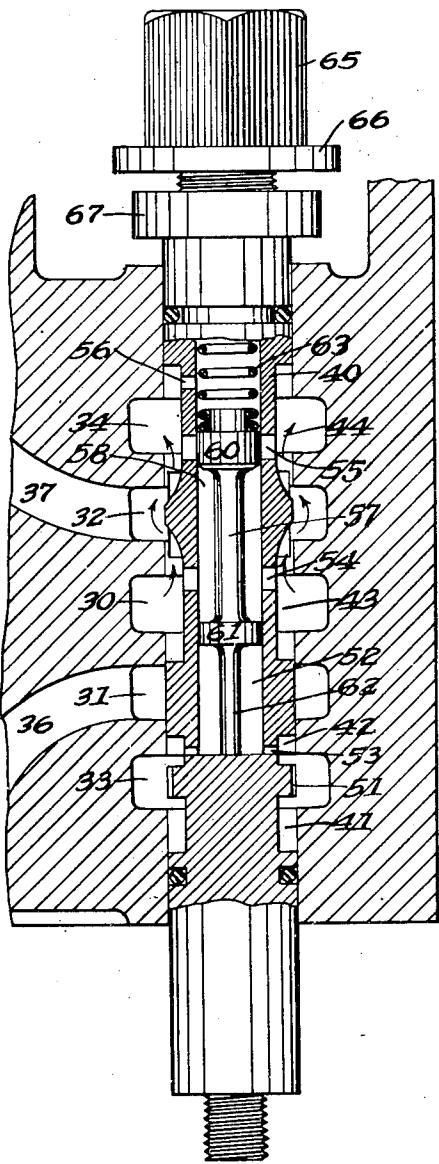


FIG. 4.

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4 Sheets-Sheet 4

FIG. 7

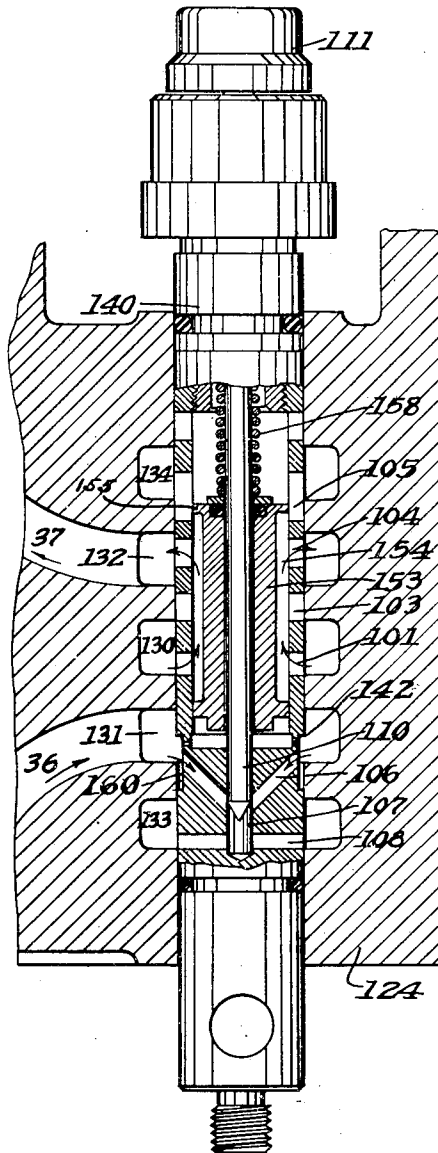
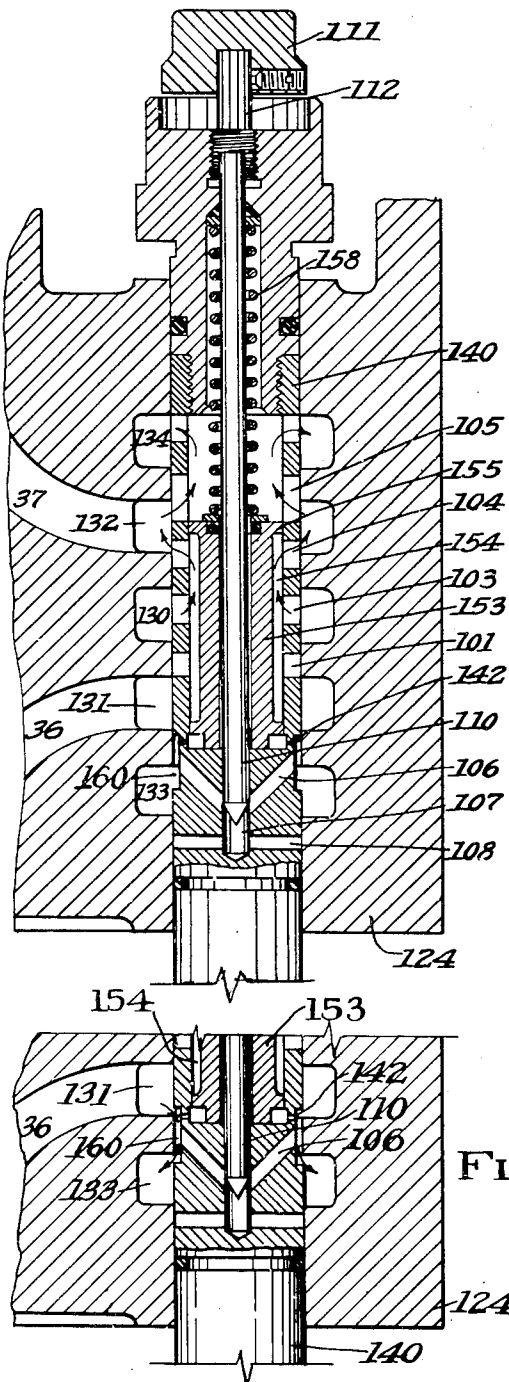


FIG. 10.

FIG. 8.

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2,464,283

HYDRAULIC APPARATUS

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Application July 19, 1944, Serial No. 545,700

20 Claims. (Cl. 121—45)

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The present invention relates to fluid pressure systems employing a fluid pressure operated power unit which drives machine tools such as presses, drills, milling machines, etc., and also relates to fluid control mechanism for governing the speed of operation of the power unit.

One of the objects of the present invention is to provide a fluid pressure system including a source of fluid pressure, such as a pump, a fluid operated power unit and a control mechanism for controlling the fluid pressure on the unit so as to operate the unit at a selected predetermined fixed rate or rates of speed.

Another object of the present invention is to provide a fluid pressure system in which the fluid pressure on the power unit is varied or maintained to compensate for variation in resistance encountered by the power unit in the work being done and to restrain the speed of the power unit in the event that extraneous force tends to permit or cause an undesirable increase in rate of speed of operation of the power unit.

In carrying out the foregoing objects, it is a further object of the present invention to utilize variation in pressure in the system, caused by the conditions imposed upon the power unit, to regulate the speed of operation of the power unit.

More specifically, it is an object of the present invention to utilize the change in pressure of the fluid being discharged from the power unit, which change in pressure is effected by the work imposed upon the power unit, to effect a change of fluid pressure delivered to the power unit whereby the power unit operates at a selected rate or rates of speed.

A further object of the present invention is to provide for selectively adjusting the pressure at which the fluid is applied to the power unit.

Another object of the present invention is to automatically vary the fluid pressure to the power unit to cause the same to operate at a constant speed regardless of the work load imposed upon the power unit.

A further object of the present invention is to provide valve mechanism which is responsive to the rate of flow of fluid being discharged from the power unit to control the fluid pressure to the power unit to carry out the foregoing objects.

A still further object of the present invention is to provide a simple fluid pressure responsive flow control mechanism wherein conventional parts of a directional flow control valve form the main body and the major parts of the mechanism.

Still another object of the present invention is

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to provide a simple fluid pressure flow control mechanism which is operable in one position for obtaining the maximum speed of operation of the power unit and operable in another position for causing the power unit to operate at a slower speed, said mechanism being capable of manipulation so as to instantly obtain the change of speed.

A further object of the present invention is to incorporate the simple fluid pressure flow control mechanism in a single unit.

More specifically, it is a further object of the present invention to provide for varying the pressure of the fluid delivered to the power unit by diverting or by-passing part of the fluid being pumped and to control the volume of fluid by-passed in response to the volume of fluid being discharged from the power unit.

Still more specifically, it is an object of the present invention to provide for restricting the flow of fluid from the power unit and utilizing variation in pressure of the fluid being discharged from the power unit for operating valve mechanism which controls the quantity of fluid delivered to the power unit.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred forms of embodiments of the invention are clearly shown.

In the drawings:

Fig. 1 is a diagrammatic view of a hydraulic system embodying the principles of the present invention;

Fig. 2 is a vertical longitudinal sectional view taken through a flow controlling mechanism forming part of the hydraulic system illustrated in Fig. 1, the flow controlling device being illustrated in one position of operation;

Fig. 3 is a similar view showing the flow controlling mechanism in another position of operation;

Fig. 4 is also a similar view showing the device in a third position of operation;

Figs. 5 and 6 are detail horizontal sectional views taken on the planes indicated by the lines 5—5 and 6—6, respectively of Fig. 2;

Fig. 7 is a vertical longitudinal sectional view taken through a modified form of control mechanism showing the same in condition to cause the power unit to remain at rest in an initial or starting position;

Fig. 8 is a similar view showing the control mechanism in condition to cause the power unit to perform a working stroke;

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Fig. 9 is a similar view showing the mechanism conditioned to return the piston of the power unit to initial or starting position; and

Fig. 10 is a fragmentary vertical sectional view taken through the lower portion of the control mechanism showing the same in condition to cause the power unit to operate at an accelerated rate.

The present invention is capable of use with various types of fluid and is herein defined as a hydraulic system. Referring more particularly to the drawings, the numeral 20 designates the entire hydraulic system shown in Fig. 1. This system includes a motor driven pump 21, a reservoir 22 from which the pump draws hydraulic fluid, a power unit 23 which is supplied with fluid by the pump 21, and a control mechanism 24 which controls the flow of hydraulic fluid from the pump to the power unit and from the latter to the reservoir 22.

In the present instance, the power unit 23 includes a cylinder 25, a piston 26 disposed for sliding movement in the cylinder and a ram 27 connected with the piston and projecting through the lower end of the cylinder. This ram 27 is utilized to perform any useful work such as stamping, pressing or operating parts in a machine.

The control mechanism 24 includes a body 28 having a longitudinally extending chamber 29 formed therein. This chamber 29 includes a plurality of annularly shaped ports 30, 31, 32, 33 and 34 spaced longitudinally of the body 28. Port 30 functions as an inlet port and is connected by a conduit 35 with the pump 21 to receive hydraulic fluid under pressure. Ports 31 and 32, which constitute work ports are connected by conduits 36 and 37, respectively, with the opposite ends of the chamber of cylinder 25 of the power unit. Ports 33 and 34 are outlet ports, communicating with the reservoir 22 by one or more pipes 38. A barrel member 40 slides within chamber 29 to control communication between certain of the ports 30 to 34, inclusive, through the chamber 29. As shown in Figs. 2 and 3, this barrel member 40 has a plurality of longitudinally spaced annular grooves 41, 42, 43 and 44 which may be selectively employed to establish communication between sets of adjacent ports 30 to 34, inclusive.

When the barrel 40 is in the position shown in Fig. 2, the groove 44 connects port 32 with port 34. Since port 32 is connected with the upper end of the cylinder 25 through the pipe 37, this end of the cylinder will then be in direct communication with the reservoir 22 through port 32, groove 44 and conduit 38. At the same time, the groove 43 in barrel 40 is in position to establish communication between the ports 30 and 31. At this time, fluid under pressure will flow from the pump 21 through the conduit 35, ports 30 and 31 and conduit 36 to the lower end of the cylinder 25. This inflowing fluid will force the piston 26 upwardly since the fluid above the piston 26 can escape from the cylinder 25. As the piston 26 and ram 27 approach the limit of upward movement, a fork 45 secured to the ram and surrounding a shipper rod 46, will engage a collar 47 on the rod 46 and move the rod 46 and barrel 40 upwardly against the action of spring 47A. Spring 47A surrounds the lower end of barrel member 40 and engages the body 28 and spring cup 48. When the barrel 40 has moved to the position shown in Fig. 4, fluid flow from the pump 21 to the lower end of cylinder 25 will be interrupted causing the ram 27 and piston 26 to come to rest.

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At this time, the proximate ends of grooves 43 and 44 will register with port 32 permitting fluid to flow from port 30 to port 32 and then to port 34 from which it will flow directly to the reservoir 22. When the control valve mechanism is disposed in the position shown in Fig. 4, the piston 26 and the ram 27 are retained in the elevated position.

When it is desired to operate the ram, a control lever 49, connected with the barrel 40 by the shipper rod 46, is operated to move the barrel 40 upwardly to the position shown in Fig. 3. In this position, the groove 43 connects chambers 30 and 32 so that fluid under pressure will flow from the pump 21 to the upper end of the cylinder 25. This incoming fluid will exert a downward pressure on the piston 26 causing it and the ram 27 to move downwardly. The fluid in the cylinder 25 below the piston then is forced through the conduit 36 to the chamber 31. This fluid must have an outlet in order to permit the descent of the piston 26 and therefore the outer surface of the barrel 40 has a plurality of longitudinally extending grooves 51 which provide limited communication between the port 31 and the port 33 when the barrel is in the position shown in Fig. 3. Since the grooves 51 are limited in size and since the piston is moving downwardly, the fluid in cylinder 25 below piston 26, in conduit 36 and port 31 will be under pressure.

This pressure is utilized to control the rate of descent of the piston 26 and ram 27. To attain this, the barrel 40 is provided with an internal cylindrical chamber 52 and a plurality of lateral ports 53, 54, 55 and 56 which are spaced longitudinally of the barrel for reasons to be set forth hereafter. A spool 57 is disposed for sliding movement in the chamber 52. This spool is provided with an annular groove 58 intermediate spool heads 60 and 61. A projection 62 extends from the head 61 and the bottom end thereof is arranged to engage the bottom wall of the chamber 52 and serves as a stop to limit the downward movement of the spool in the chamber 52. The spool 57 is urged downwardly to its lowermost position by a coil spring 63 arranged in the barrel 40 between the head 60 of spool 57 and a plug 64 slidably received by the upper end portion of the chamber 52. The uppermost longitudinal position of this plug is determined by an adjusting cap 65 threadedly received by the upper end of the barrel 40; the cap 65 is maintained in its adjusted position by a jam nut 66. The upper threaded end of the barrel 40 also receives a stop nut 67 which limits the downward movement of the barrel in the cylinder 29. Ports 53 interconnect port 42 with the lower part of the chamber 52 so that when the barrel 40 is in the position shown in Fig. 3, the ports 53 will establish communication between the port 31 and the lower part of the cylinder 52 in the barrel. Thus, when fluid is under pressure in the port 31, as previously described, this pressure will exist also in the chamber 52 below the head 61 of the spool. The size of the grooves 51 are computed with respect to the capacity of the system so that they properly impede the flow of fluid therethrough. This fluid pressure will exert an upward force causing the spool to move upwardly in opposition to the force of spring 63. The port 56 provides a relief for the fluid in the upper end of the chamber 52 permitting the fluid to flow into the groove 44 and port 34 from which it will flow to the reservoir 22. When the spool 57 moves upwardly, the head

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portion 60 thereof uncovers port 55 which port is then in registration with the port 34 and the groove 58 of the spool will establish communication between the port 54 and port 55, port 54 being formed in the barrel 40 at the groove 43. Due to this location of the port 54, some of the fluid flowing from port 30 to port 32 and the upper end of cylinder 25, will be by-passed through port 54, groove 58 and port 55 to port 34 which communicates with the reservoir 22. The amount of fluid by-passed will depend upon the fluid pressure in the port 31. Thus, if this pressure increases, more force will be applied to the spool to move it in opposition to the spring 63 and the head 60 will uncover a greater portion of the ports 55. As more fluid is by-passed through ports 54 and 34, less fluid will be directed to the upper end of the piston 26 and the downward speed of the piston will consequently be decreased. When the piston 26 reaches the limit of its downward movement, fluid flow from the lower end of cylinder 25 will cease and pressure in port 31 will fall; the spring 63 will then return the spool 57 to its lowest position where port 55 will be blocked by spool head 60.

The power unit 23 may be utilized to exert a holding or clamping force by maintaining the control lever 40 depressed to place the barrel 40 in the position shown in Fig. 3. At this time fluid pressure in conduit 35, port 30 and 32, conduit 37 and the upper end of cylinder 25 will increase until a maximum pressure, determined by a relief valve 70 has been reached. This maximum pressure will be applied to the upper end of piston 26 to exert maximum downward force on the ram 27. When this condition occurs, the full pressure and volume of fluid delivered by the pump 21 may be used in operating other mechanisms which might be disposed in the fluid circuit. After the piston and ram have reached the limit of their downward movement and have been retained there for the desired time, the lever 49 may be released to permit spring 47A to return the barrel 40 to the position shown in Fig. 2, wherein ports 32 and 34 are connected to vent the upper end of cylinder 25 to the reservoir 22. Ports 30 and 31 will also be connected to supply fluid under pressure to the lower end of cylinder 25 to cause the ram and piston to raise toward the initial or starting position. As the latter position is approached, the fork 45 will engage collar 47 and move barrel 40 to the position shown in Fig. 4, at which time the lower end of cylinder 25 will be blocked from the pump 21 and reservoir 22. Ports 30, 32 and 34 will be connected to divert fluid from the pump 21 to the reservoir 22 and the power unit will cease to operate.

The control mechanism above described permits the use of fluid discharged from a power unit to control the flow of fluid under pressure to the unit to effect its operation in a desired manner. The speed of movement of the ram may be varied by adjusting the cap 65 so that the tension of the spring 63 on the spool 57 can be varied to vary the pressure at which the fluid is by-passed. Thus the volume of fluid directed to the power unit can be varied to secure the speed desired; if it is desired, the tension of the spring 63 can be so adjusted as to prevent movement of the spool 57 to the position where the fluid normally flowing from the high pressure chamber or port to the power unit will be by-passed, thus, preventing this by-passing and

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providing for full flow of fluid to the power unit.

Desirable control can be secured by another means shown in Figs. 7 to 10, wherein a modified form of control has been disclosed. In this modified form of control mechanism, the barrel is provided with ports instead of external grooves and communication between the inlet, outlet and work ports occurs through the interior of the barrel. These ports are designed to register with the ports 30 and 34, inclusive, and the spool mechanism is arranged to connect certain ports to produce the desired action. Normally, the ram 27 and piston 26 of the power unit are at rest in an elevated or starting position and under this condition the modified valve mechanism occupies the position shown in Fig. 7 wherein the fluid pressure from the pump 21 is sent directly to the reservoir and some fluid is trapped in the lower end of cylinder 25 by blocking port 131.

When the power unit is to be operated, the control lever 49 is actuated to move the valve mechanism to the position shown in Fig. 8, wherein barrel 140 will be arranged to establish communication between an angularly extending passage 106 adjacent the lower end of the barrel, and port 131. Passage 106 terminates in a longitudinally extending bore 107, formed in the barrel 140 and connected at its lower end with a transversely extending passage 108. When the barrel is in its elevated position, shown in Fig. 8, this lateral passage 108 registers with outlet port 133 which is connected by suitable conduits with the reservoir 22. In this latter position of the barrel, the lower end of the power unit will be in communication with reservoir 22 through chamber 131, passage 106, bore 107, passage 108 and port 133. The upper end of the power cylinder will then be in communication with the source of fluid pressure 21 through conduit 35, port 130, port 101, groove 154 in the spool, port 104 and port 132, which port 132 is connected to the upper end of the power cylinder by conduit 37.

At this time, fluid under pressure will flow from the power source to the upper end of the power unit and the fluid from the lower end of this unit will be exhausted to the reservoir. A needle valve 110 is received by the bore 107 for controlling the movement of the piston in the power unit. By adjusting this needle valve, the rate of flow between passages 106 and 108 may be controlled. By restricting the communication, pressure will be generated in port 131, which pressure will be transmitted by port 142 to the interior of the barrel 140 below the spool 153. This pressure urges the spool upwardly against the action of spring 158. If the pressure is great enough, the spool will move upwardly until the head 155 at the upper end reaches a position wherein groove 154 communicates with port 105. At this time, some of the fluid under pressure will divert back to the reservoir and by-pass the power unit. Due to this diversion of fluid, the speed of movement of the piston and ram will be decreased. The degree of reduction in speed may be determined by controlling the rate of communication between passages 106 and 108, through manipulation of valve 110. If the needle valve 110 is adjusted to reduce the effective size of the outlet from the power unit, the pressure required to effect a by-pass of fluid will be built up quickly, thus causing the power unit to operate at a slower

rate than it will operate when the size of the outlet is larger and the required pressure is built up more slowly. Valve 110 is operated by means of a knob 111 connected with the upper end of the valve stem 112, projecting from the upper end of the barrel. Suitable packing is employed around the stem 112 to prevent the escape of fluid.

After the ram has completed its working stroke and it is desired to return the ram to the starting position, the control lever is released to permit spring 47A to return the barrel 140 to the position shown in Fig. 9. At this time, the barrel 140 is at its lowermost position in the body 124, when so positioned, ports 103 and 104 in the barrel will be in communication with the port 130 and the spool 153 will be in the position wherein the groove 154 thereof bridges the ports 101 and 103 and port 104. The port 101 is in registration at this time with port 131 which is connected with the lower end of cylinder 25. At this time also, another port 105 in the barrel 140 will register with port 132 which is connected with the upper end of the cylinder 25 and another set of ports 102 in the barrel 140 will register with the outlet port 134. When these ports are so positioned, fluid under pressure will flow from port 130 through ports 103 and 104, groove 154 and port 101 to port 131 from which it will flow to the lower end of the power cylinder 25. This fluid will move the piston 26 upwardly causing the fluid in the cylinder 25 above the piston to flow to the port 132 from which it will flow through port 105 into the interior of the barrel 140 and thence, through port 102 to port 134 and to the reservoir 22.

In both forms of the invention shown, the positions of the spools to by-pass fluid under pressure is dependent upon the pressure created by the exhaust or return flow of fluid from the power unit. Thus, if the return flow is decreased due to a retarding of the ram or piston, less fluid will be by-passed and therefore increased fluid pressure will be applied to the power unit to maintain the speed of the ram. The control of the speed of the ram is entirely automatic, variations therein being secured in the manner heretofore pointed out.

The modified form shown in Figs. 7, 8, 9, and 10 is provided with a two speed feature whereby the power unit or ram may be operated at two speeds during its working stroke. To secure this feature, the barrel 140 is provided adjacent its lower end with an external groove 160 which may be used to establish substantially unrestricted communication between ports 131 and 133 by stopping the barrel at the position shown in Fig. 10. When the barrel is so positioned, fluid will flow from the power unit to the reservoir 22 without building back pressure. The by-passing mechanism will not function and the necessary volume of fluid, to effect full speed operation of the power unit, will be directed thereto. By elevating barrel 140 to the position shown in Fig. 8, return flow of fluid to the reservoir will be restricted and pressure to operate the by-passing mechanism will be developed.

Either of the flow control mechanisms described in the foregoing specification may be employed to secure a selected fixed speed of operation of machine tools such as a drill or a press. This is accomplished by controlling the amount of fluid by-passing the power unit in response to the rate of flow of fluid being discharged from the power unit.

Preferably, a relief valve 70 is interposed be-

tween the high pressure conduit 35 and the tank 22 which opens automatically to return fluid from conduit 35 to the tank when the pressure exceeds the highest pressure desirable in the system.

The invention herein defined and disclosed permits using the conventional elements in parts of the well known directional control valves, the modifications consisting principally in the redesign of the barrel and the parts carried therein. Thus, a conventional direction valve has been changed in a facile manner to an automatically operated flow control valve.

While the forms of embodiments of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

I claim:

1. A control valve comprising a casing with a plurality of ports included therein, said ports including inlet, outlet and work ports; a member disposed for movement in said casing, said movable member having flow conducting means to selectively connect said work ports with said inlet and outlet ports, said movable member having a passage connecting said flow conducting means; and valve means in said passage and cooperating with said movable member for controlling fluid flow through the passage therein, said valve means being actuated by fluid pressure obtaining in a work port when connected with an outlet port.

2. A control valve comprising a casing having a chamber and a plurality of ports spaced longitudinally thereof, said ports including inlet, outlet and work ports; a plunger disposed for movement in said chamber, said plunger having spaced external recesses and being movable to selectively connect said work with said inlet and outlet ports, said plunger having an internal passage connecting said recesses; means for restricting fluid flow between a work port and an outlet to increase fluid pressure in the former; and valve means in said passage and cooperative with said plunger to control fluid flow through the passage therein, said valve means being actuated by fluid pressure obtaining in the work port from which the flow of fluid is restricted.

3. In a hydraulic system of the type having a source of fluid under pressure and a power cylinder; means for controlling the flow of fluid to and from said power cylinder comprising a body having a chamber and a plurality of inlet and outlet ports spaced longitudinally thereof; means disposed for longitudinal movement in said chamber to control communication between certain of said ports, said means having a hollow member with grooves shaped and disposed to connect certain ports in said body in predetermined positions of movement of said member, said member being provided with spaced openings to establish communication between the interior and the exterior thereof; communication between certain ports being restricted when said hollow member is in a predetermined position whereby a pressure will be built up in one of the ports; and valve means disposed for movement in said member, said valve means being responsive to the pressure built up in said port to control communication through said member between said openings.

4. A hydraulic system comprising in combination, a source of fluid under pressure; a power cylinder; means for automatically controlling the operation of said power cylinder, said means including a body having a chamber and a plurality

of ports spaced longitudinally thereof; means connecting one of said ports with said fluid pressure source, a port on either side of said first port serving as outlet ports; means connecting a port between said first port and either outlet port with the ends of said power cylinder; a barrel in the chamber in said body, said barrel having external recesses which alternately connect each cylinder port with the pressure and outlet ports upon reciprocation of said barrel in said chamber, said barrel having an internal recess and longitudinally spaced openings in the side wall establishing communication between the interior and exterior of said barrel; and a fluid pressure responsive valve mechanism in said recess for controlling communication between certain of said openings, when said barrel is in a predetermined position, said valve mechanism being actuated by the pressure obtaining in the cylinder port connected with an outlet when said barrel is in said predetermined position.

5. Flow control mechanism for hydraulic systems comprising, in combination, a casing having a chamber and inlet, outlet and work ports communicable with the chamber; valve means disposed in said chamber for movement between two extreme positions, said means serving to connect said inlet port with a predetermined work port and an outlet with a second work port when in one extreme position of movement and to reverse the inlet, outlet and work port connections in the other extreme position of movement; means for restricting fluid flow between said predetermined work port and outlet port to increase fluid pressure in said predetermined work port when said first mentioned means is in the second position; a second valve means carried by said first valve means and responsive to fluid pressure in said predetermined work port to connect the second work port with an outlet; said first mentioned means providing substantially unrestricted communication between said predetermined work port and an outlet when said means is in a stage of movement between said extreme positions whereby no pressure will be built up in said predetermined work port and said second-mentioned valve will prevent communication between the other work port and an outlet.

6. Flow control mechanism comprising, in combination, means having inlet, outlet and work ports; flow-directing means for alternately connecting said work ports with said inlet and outlet ports; means for restricting fluid flow between a predetermined work port and an outlet port whereby fluid pressure will be developed in said predetermined work port; and means in said flow-directing means responsive to said fluid pressure to connect said inlet port with an outlet port while the inlet is connected with a second work port.

7. Flow control mechanism comprising, in combination, means having inlet, outlet and work ports; flow-directing means for alternately connecting said work ports with said inlet and outlet ports; means for restricting fluid flow between a predetermined work port and an outlet port whereby fluid pressure will be developed in said predetermined work port; means for adjusting said restricting means to vary the fluid pressure developed in said predetermined work port, and means within said flow-directing means responsive to said fluid pressure to connect said inlet port with an outlet port while the inlet is connected with a second work port.

8. Flow control mechanism comprising, in com-

5 bination, a casing having a chamber and spaced inlet, work and outlet ports communicable with the chamber; a barrel member slidably disposed in said chamber, said barrel having a chamber and a plurality of lateral ports to connect the barrel chamber with the ports in said casing; spool means disposed for sliding movement in the chamber in said barrel member to control communication between certain lateral ports; means 10 tending to urge said spool member toward a position to connect predetermined lateral ports in said barrel member; and means for restricting communication between a predetermined work port and an outlet port to increase fluid pressure in said work port, said pressure being transmitted through lateral ports in said barrel member to said spool to move the same in opposition to said urging means whereby communication will be established between said predetermined and 20 other lateral ports.

9. Flow control mechanism comprising, in combination, a casing having a chamber and spaced inlet, work and outlet ports communicable with the chamber; a barrel member disposed in said chamber, said barrel member having an internal chamber and a plurality of lateral ports and being movable in said casing chamber to register the lateral with certain of said inlet, outlet and work ports in predetermined positions of said barrel member; spool means slidably disposed in the chamber of the barrel member to control communication between certain lateral ports therein; means tending to urge said spool toward a position to connect a lateral port registering with said inlet port and a second lateral port registering with a work port when said barrel member is in one position in said casing, said first and second lateral ports registering with a second work and the inlet port, respectively in a second position of movement of said barrel; means operative when said barrel member is in said second position to establish restricted communication between the first work port and an outlet port whereby a fluid pressure will be generated in said first work port, said pressure being transmitted through a lateral port in said barrel member to said spool to move the same in opposition to said urging means and connect said first and second lateral ports with a third lateral port registering with an outlet port.

10. Flow control mechanism comprising, in combination, means forming inlet, outlet and work ports; valve means for connecting a predetermined work port with said inlet and another work port with an outlet, said means being adjustable to reverse said connections; means operable when said connections are reversed to also connect said inlet with an outlet whereby a portion of the flow from said inlet will be bypassed through the outlet; and means carried by and movable relative to said valve means and responsive to the pressure of the fluid flowing from said predetermined work port to an outlet for varying the volume of fluid by-passed.

11. Flow control mechanism for hydraulic apparatus comprising, in combination, a casing having a chamber and inlet, outlet and work ports communicable with the chamber; means in said chamber operative in one position to establish communication between a predetermined work port and said inlet and between a second work port and an outlet, said means being movable to a second position to connect said second work port with said inlet and establish substantially unrestricted communication between said prede-

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terminated work port and an outlet; additional means operative when said first-mentioned means is moved in the same direction to a third position beyond said second position to restrict communication between said predetermined work port and an outlet whereby a pressure will be built up in said work port; and means responsive to said pressure to simultaneously connect the inlet, an outlet, and said second work port.

12. Flow control mechanism comprising, in combination, a body having a bore with inlet, cylinder and outlet ports spaced longitudinally thereof; a plunger having an internal chamber movably disposed in said bore, said plunger having ports spaced longitudinally thereof and registering with certain of said ports in said body in different positions of longitudinal movement of said plunger to alternately connect said cylinder ports with said inlet and outlet ports; a spool valve supported for movement within said plunger chamber; means tending to urge said spool valve toward a position to prevent communication between a cylinder port and an outlet port when said plunger is in a certain position, said plunger having a port to establish communication between a second cylinder port and the chamber when said plunger is in said certain position; means establishing a regulable fluid flow between said second cylinder port and an outlet port when said plunger is in said certain position, said means serving to build up a pressure in said second port which pressure is transmitted to the chamber in said plunger to move said spool valve in opposition to said urging means; and means formed with said plunger and operative when the latter is in another position to cause fluid flowing from said second cylinder port to exhaust to by-pass said flow establishing means.

13. A flow control valve comprising, in combination, a four-way valve having an inlet, an outlet, a pair of work ports and a spool for selectively connecting either of said work ports with said inlet and the other with said outlet; means for restricting fluid flow from a selected work port to said outlet to cause a fluid pressure to be built up in said work port when the other work port is receiving fluid from said inlet; a valve controlled passage in said spool for connecting the inlet, the outlet and the other work port; and, a valve in said passage, said valve being exposed and responsive to the fluid pressure in said selected work port to control fluid flow through said passage.

14. In a flow control valve of the type having a casing with inlet, outlet and a pair of work ports and a spool adjustable in said casing to selectively connect either of said work ports with said inlet and the other with said outlet; means for limiting the rate of fluid flow from a selected work port to said outlet to build up a fluid pressure in the selected work port when the other work port is receiving fluid from said inlet; and a valve in said spool actuated by the fluid pressure in the selected work port to direct to said outlet a portion of the fluid flowing from said inlet to the other work port.

15. A flow control valve comprising, in combination, a body having a bore and an inlet, an outlet and first and second work ports communicating therewith; a pair of members disposed for movement in unison and relative movement in said bore, said members cooperating in different positions of movement in unison to direct fluid from said inlet to one or the other of said work ports and from the other work port to said outlet;

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and means for limiting fluid flow from the first work port to the outlet to create a back pressure in said work port during the admission of fluid from said inlet to the second work port, one of said members being responsive to the back pressure to direct some of the fluid from said inlet directly to said outlet.

16. In a hydraulic system, a source of fluid pressure; a fluid motor; means for controlling the operation of said motor comprising a four-way valve between said source and said motor, said valve having a casing with inlet, motor and exhaust ports; a pair of telescoping members disposed for movement in said casing said members cooperating to direct fluid from said source to said motor and from the latter to exhaust; means yieldably maintaining said members in a predetermined relation; and, means for applying fluid pressure to said members to cause relative movement thereof in opposition to said maintaining means to establish controlled communication between said inlet and exhaust ports.

17. In a hydraulic system, a source of fluid pressure; a reversible fluid motor; means for controlling the operation of said motor comprising a four-way valve having a casing with an inlet connected with said pressure source, work ports connected with said motor, and exhaust ports; a two-part spool with flow-directing passages for controlling fluid flow through said casing, said parts being movable in unison in said casing to reverse the operation of said motor, and relatively movable by bypass fluid from said source through certain passages to exhaust to control the speed of said motor.

18. In a hydraulic system, a source of fluid pressure; a reversible fluid motor; means for controlling the operation of said motor comprising a four-way valve having a casing with an inlet connected with said pressure source, work ports connected with said motor, and exhaust ports; a two-part spool with flow-directing passages for controlling fluid flow through said casing, said parts being movable in unison in said casing to alternately connect said work ports with said inlet and exhaust ports to reverse the operation of said motor and relatively movable to bypass fluid from said source through certain of said passages to exhaust to control the speed of said motor; and means for introducing fluid pressure between said parts to effect relative movement thereof.

19. In a hydraulic system, a source of fluid pressure; a reversible fluid motor; means for controlling the operation of said motor comprising a four-way valve having a casing with an inlet connected with said pressure source, work ports connected with said motor, and exhaust ports; a two-part spool with flow-directing passages for controlling fluid flow through said casing, said parts being movable in unison to alternately connect said work ports with said inlet and exhaust ports to effect forward and reverse operation of said motor and relatively movable to bypass fluid from said source through certain of said passages to exhaust to control the speed of said motor; means for introducing fluid pressure between said parts to effect relative movement thereof; and means effective upon movement of said parts to a predetermined position during forward operation of said motor for rendering said fluid pressure introducing means inoperative.

20. In a hydraulic system, a source of fluid pressure; a reversible fluid motor; means for con-

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trolling the operation of said motor comprising a casing having an inlet connected with said pressure source, work ports connected with said motor, and exhaust ports; valve means movably supported in said casing said valve means having a hollow ported body and a spool movably disposed in said body; means tending to retain said spool in a predetermined position; means for moving said valve means to effect forward and reverse operation of said motor; restricting means operative when said motor is operating in one direction to resist exhaust flow from said motor to create back pressure; means for applying such back pressure to said spool to move the same in opposition to said retaining means to a position establishing controlled communication between said inlet and exhaust ports, and means for selectively rendering said restricting means inoperative during operation of said motor in one direction.

CECIL E. ADAMS.

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Certificate of Correction

Patent No. 2,464,283.

March 15, 1949.

CECIL E. ADAMS

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 9, line 38, claim 5, for "responsibe" read *responsive*; column 12, line 33, claim 17, for the words "by bypass" read *to bypass*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of June, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.