

United States Patent

[11] 3,568,718

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| [21] | Appl. No. | 806,340 |
| [22] | Filed | Feb. 17, 1969 |
| [45] | Patented | Mar. 9, 1971 |
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- | | | | |
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[54] PILOT OPERATED CONTROL VALVE
14 Claims, 6 Drawing Figs.

- [52] **U.S. Cl.**..... 137/625.6,
137/625.63
- [51] **Int. Cl.**..... **F16k11/07**;
F16k 31/38
- [50] **Field of Search**..... 137/625.6,
625.63, 625.66, 596.12, 596.18, 596.2; 91/461, 3,
449, 450, 451; 62/52 (HC), 52 (HE), 52 (CO), 52
(PJ)

[56]	References Cited
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ABSTRACT: Admittance of pressurized control fluid into a first chamber at one end of a valve spool while a second chamber at the other end of the spool is vented, effects actuation of the valve spool in one direction from neutral to an operating position allowing pressure fluid to flow from one passage to another at a rate determined by the distance the spool is displaced from neutral. Such displacement is halted when the spool effects closure of a vent in the second chamber. The position of the valve spool at the time the vent is closed is predeterminable so as to provide for stopping of the valve spool at any of a number of metering positions restricting fluid flow from said one passage to the other.

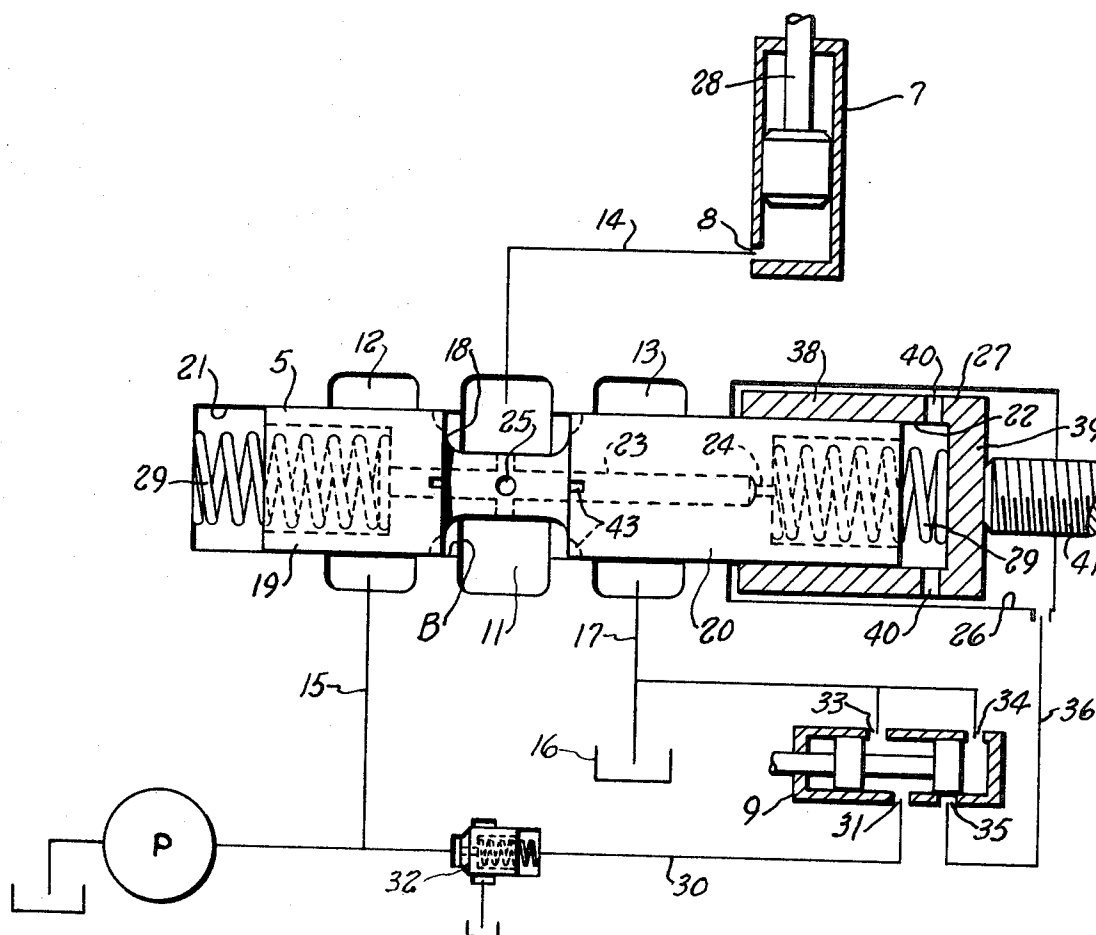


Fig. 1

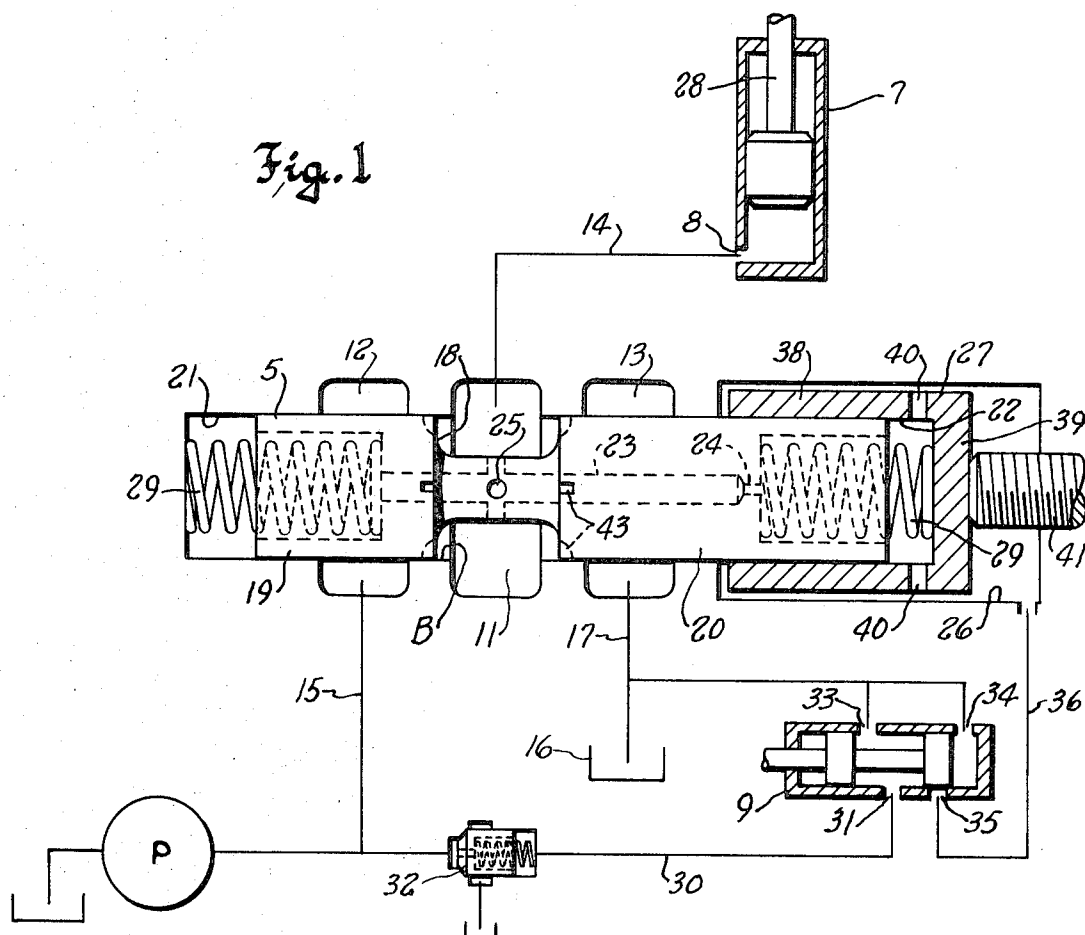
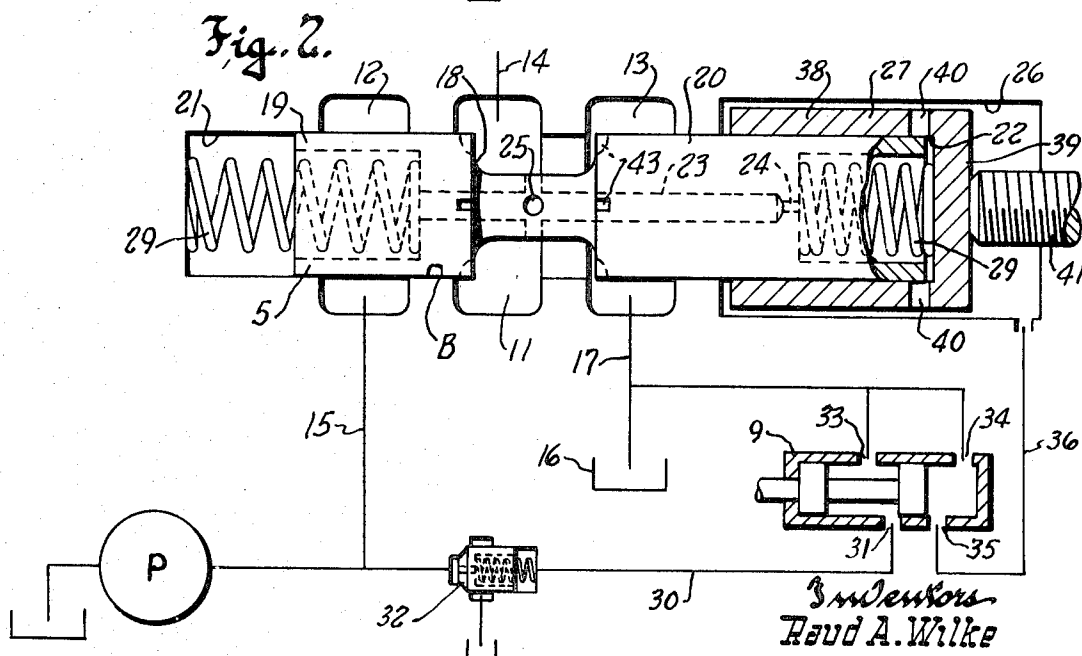


Fig. 2



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Fig. 3.

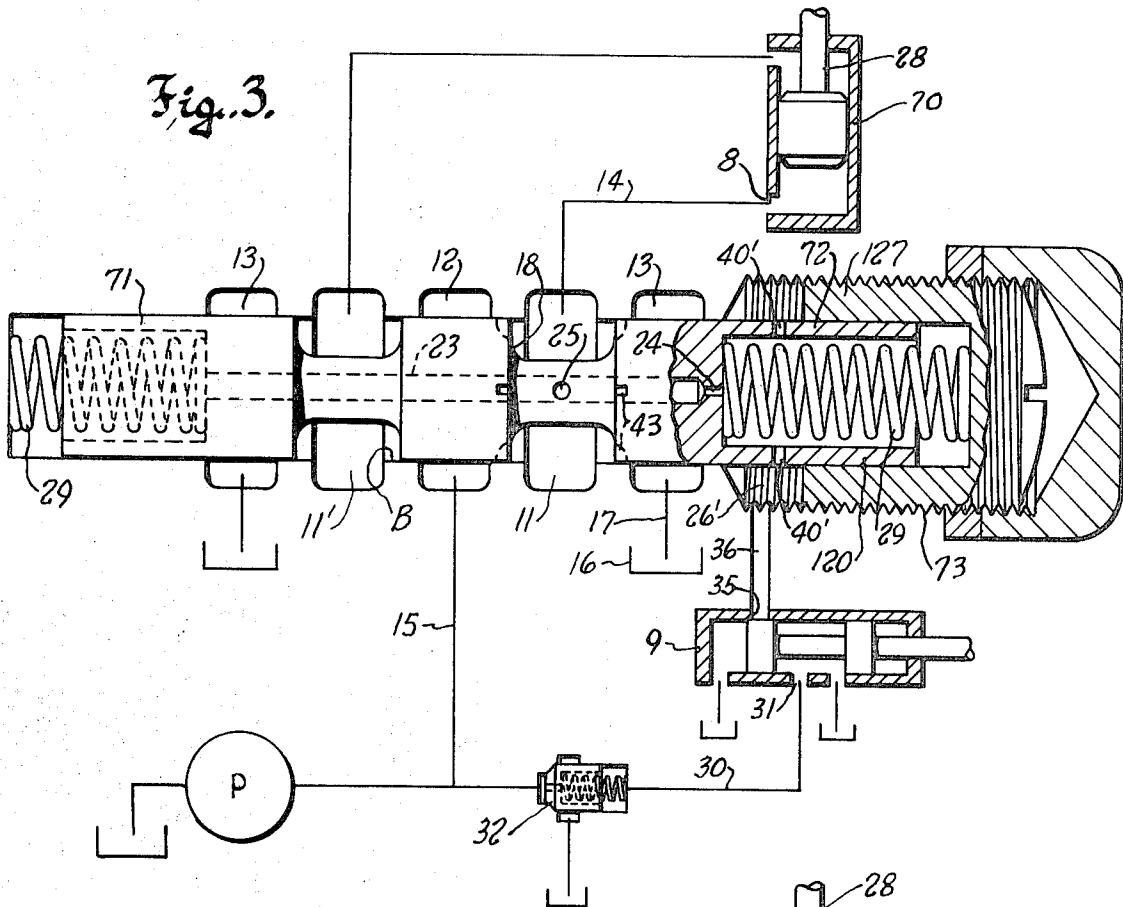
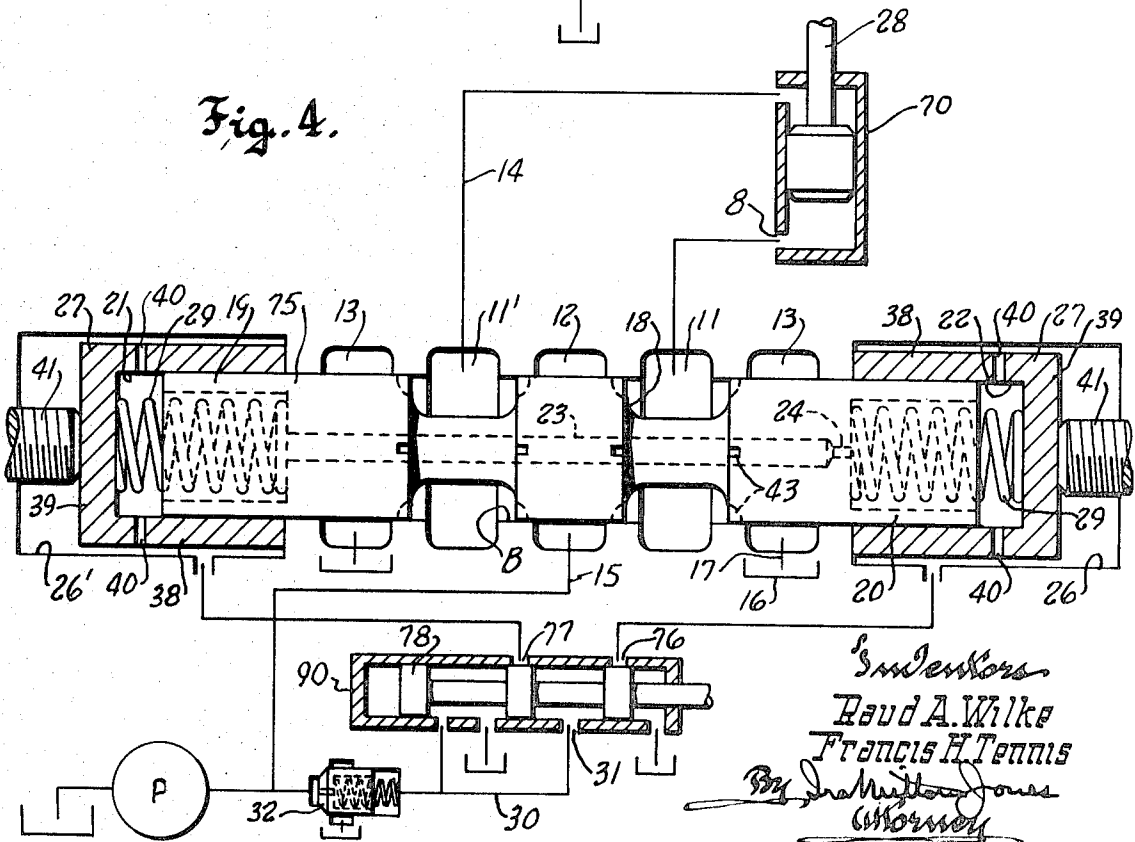


Fig. 4.



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Fig. 5.

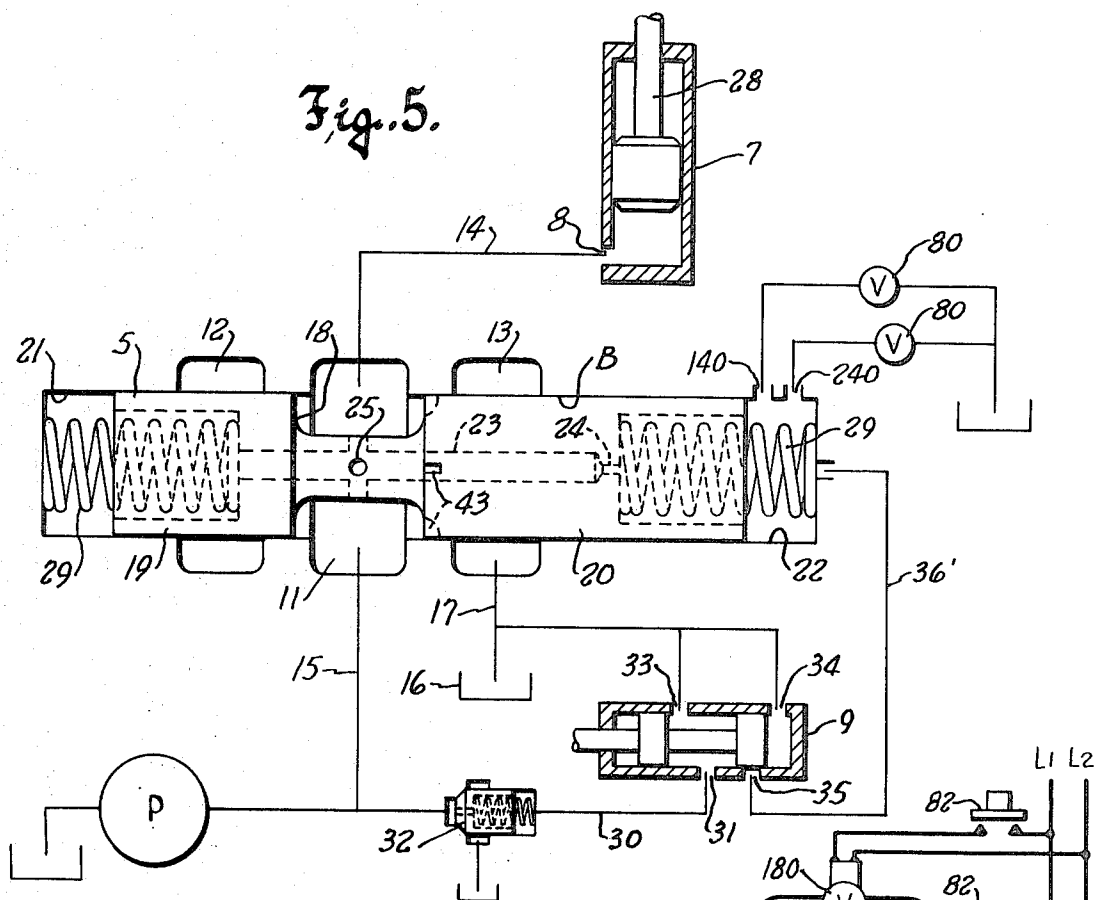
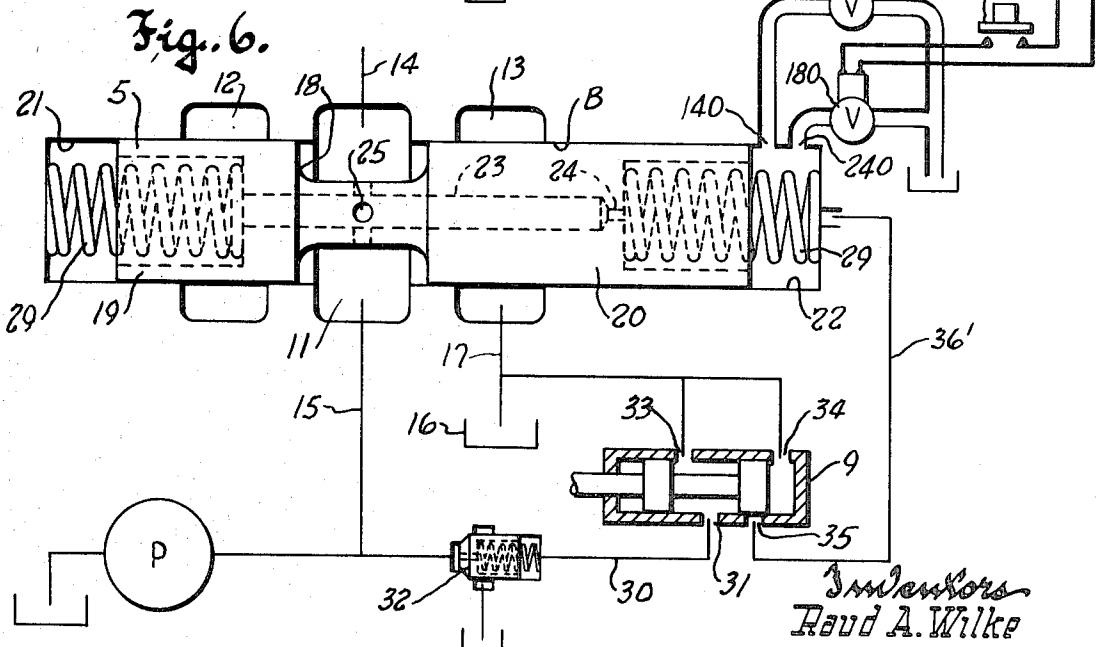


Fig. 6.



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PILOT OPERATED CONTROL VALVE

This invention relates to control valve instrumentalities for governing flow of pressure fluid to and from a hydraulic cylinder or other fluid motor, and it has more particular reference to improvements in control valves of the type having a pilot controllable fluid pressure actuatable valve element.

A typical control valve of the type referred to has a body with an elongated endwise shiftable valve spool therein. Opposite end portions of the spool provide coaxial pistons that are slidably received in cylinder defining pressure chambers in the body. Pressurized control fluid admitted into one of the chambers when the other chamber is vented effects shifting of the valve spool in one direction out of neutral position, toward the other chamber, to an operating position allowing pressure fluid to flow from one passage in the body to another.

Ordinarily, in said operating position of a conventional pilot operated control valve, fluid flows from said one passage to the other at a maximum rate because the spool is always displaced the same maximum distance out of its neutral position.

It is the object of this invention, however, to provide a pilot operated control valve with a fluid pressure actuatable valve element or spool that can be displaced different predeterminable distances out of its neutral position to effect metering of fluid flow from one passage in the valve body to another.

With this objective in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings. This disclosure is intended merely to exemplify the invention. The invention is not limited to the particular structure or method disclosed, and changes can be made therein which lie within the scope of the appended claims without departing from the invention.

The drawings illustrate several complete examples of the physical embodiment of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIG. 1 is a diagrammatic view of a hydraulically operated system including a pilot operated control valve and a single-acting hydraulic cylinder governed thereby;

FIG. 2 illustrates the spool of the control valve in an operative position metering fluid flow from one passage to another; and

FIGS. 3, 4, 5 and 6 are diagrammatic views similar to FIG. 1 but illustrating modified embodiments of the invention.

Referring now to the accompanying drawings, the numeral 5 designates the spool of a control valve by which pressure fluid from a pump P can be supplied to and/or exhausted from a single-acting hydraulic lift cylinder 7, through a port 8 in its bottom. A pilot valve 9 governs actuation of the valve spool 5.

The body of the control valve is provided with an elongated bore B in which the spool 5 is endwise slidably received; and the body also has service, supply and return passages 11, 12 and 13, respectively, formed therein with the service passage flanked by the supply and exhaust passages. The service passage 11 is communicated with the cylinder port 8 through a duct 14; the supply passage 12 is fed from the outlet of the pump through a duct 15; and the return passage 13 is communicated with a reservoir 16 through an exhaust line 17.

In the neutral position of the valve spool 5 seen in FIG. 1, the service passage 11 is closed off from the supply and return passages 12 and 13, respectively, by lands on the spool 5 at opposite axial sides of a circumferential groove 18 therein. Hence, pressure fluid can neither flow to nor exit from the cylinder 7, and a load can be held thereby against descent. The groove 18, however, is at all times in register with the service passage 11.

The pressure actuatable control valve chosen by way of example as one in which the principles of this invention can be readily embodied is of the type similar to those forming the subject matter of the copending application of Francis H. Tennis, Ser. No. 676,547, filed Oct. 19, 1967, now U.S. Pat. No. 3,464,443. Hence, the lands on the opposite end portions of its spool provide pistons 19 and 20 which are axially slidably received in pressure chambers that serve as cylinders 21 and

22, respectively. The spool also has an axial passage 23 therein by which the chamber 21 is communicated with the chamber 22. That end of the passage 23 which opens to the chamber 22 is restricted, as at 24, and a radial passage 25 opens to the circumferential groove 18 in the spool, from the axial passage 23.

The bore B is closed at the left-hand end of the valve spool 5, so as to provide the chamber or cylinder 21; but the opposite end of the bore is enlarged to provide an elongated cavity 26 in which is disposed a cylinder defining member 27 containing the chamber 22.

The radial passage 25 is at all times in register with the service passage 11, so that the latter and the cylinder port 8 with which it is connected by duct 14, are at all times restrictedly communicated with the chamber 22 at the right-hand end of the spool while being at all times less restrictedly communicated with the chamber 21 at the opposite end of the spool.

The valve spool is hydraulically actuated to an operating position to the left of neutral to communicate passages 11 and 12 for flow of pump output fluid to the cylinder 7, as for lifting a load by its piston rod 28 in consequence of creation of a fluid pressure in chamber 22 that exceeds the pressure of fluid in chamber 21. Similarly, the spool is hydraulically actuated to an operating position to the right of neutral to allow pressure fluid to exhaust from the cylinder in consequence of creation of a fluid pressure in chamber 21 that exceeds the pressure in chamber 22.

In the neutral position of the valve spool shown, the load on the lift cylinder 7 tends to retract its piston rod 28 and thus pressurizes the fluid in the bottom portion of the cylinder. This same pressure is manifested in the chambers 21 and 22, and when fluid cannot exist therefrom, the fluid pressure forces on the opposite ends of the spool are equal and opposite, and the spool can be yieldingly held in its neutral position by the centering springs 19 acting on its ends.

The output of pump P is fed through a delivery line 30 to the inlet 31 of the pilot valve 9. The supply duct 15 is a branch of the delivery line 30, connecting therewith at a point upstream from an unloading valve 32. The pilot valve has two reservoir ports 33 and 34, and a service port 35 which is communicated with the cavity 26 via a duct 36.

The cylinder member 27 mentioned earlier is cup-shaped, having a cylindrical sidewall 38 slidably embracing the piston 20 on the adjacent end of the valve spool, and having an end wall 39 that opposes the adjacent extremity of the spool. One or more radial vent holes 40 are provided in the cylindrical sidewall 38 of the cylinder defining member 27, to communicate its interior with the service port 35 of the pilot valve through the cavity 26. The vents 40 can be radially opposite one another, as shown.

The cylinder member 27 is yieldingly acted upon by the adjacent centering spring 29, which urges it axially away from the end of the valve spool and holds its end wall 39 against the extremity of an adjusting screw 41 threaded into the valve body more or less coaxially of the spool. Hence, by turning the screw 41 in one direction or the other the cylinder member can be adjusted to selected axial positions along the piston defining end of the valve spool, relative to the valve body. This is important, for it enables the vents 40 in the sidewall of the cylinder member 27 to be located closer to or farther from the adjacent end of the valve spool, in neutral, for a purpose now about to appear.

When the pump is running, its entire output will flow to the reservoir through the unloading valve 32 at times when the pilot valve spool 43 is in neutral position venting the back pressure chamber of the unloading valve. If it is desired to raise the load carried by the cylinder 7, the pilot spool is moved to the right of its figure 1 (neutral) position to communicate its inlet and service ports 31 and 35, and thereby allow pressure to build up back of the plunger of the unloading valve so as to close the same.

A small amount of control pressure fluid from the pump then flows through the unloading and pilot valves to cavity 26 and from there through vents 40 to the interior 22 of the

cylinder member 27 to exert valve actuating force on the adjacent piston end 20 of the valve spool. The pressure in chamber 22 will exceed that in chamber 21 at this time, because of the pressure drop that occurs in the latter chamber due to flow of fluid from chamber 22 through restriction 24 to axial passage 23.

The valve spool is thus caused to move to the left of its neutral position seen in FIG. 1, to a feed position at which pump output fluid flows to the cylinder via the then communicating supply and service passages 12 and 11, respectively. The valve spool 5 returns to neutral whenever the spool of the pilot valve is moved back to its neutral position, to cause pressure fluid to be trapped in the cylinder by the joint action of the main and pilot valve spools.

When it is desired to lower the load on the cylinder 7, the pilot valve spool is moved to the left of neutral to the position seen in FIG. 2, at which it communicates the chamber 22 with the reservoir through the vent holes 40 in the sidewall of the cylinder defining member 27. Load pressurized fluid from cylinder 7 can then flow into chamber 21 to cause the main valve spool to be hydraulically actuated to the right, to the position seen in FIG. 2, allowing pressure fluid from the work cylinder 7 to exhaust to the reservoir through the then communicating service and return passages 11 and 13, respectively.

It is of the essence to note, however, that the distance the main valve spool 5 moves in the cylinder exhaust direction in consequence of the predominating pressure obtaining in chamber 21 depends upon the axial adjustment of the cylinder member 27, or more particularly, upon the spacing of the vents 40 from the adjacent end of the valve spool when the latter is in neutral. These vents are opposite one another so as to be simultaneously covered by the adjacent end of the main valve spool as it moves toward the work cylinder venting position seen in FIG. 2. Travel of the spool is halted as soon as the vents 40 are substantially closed by the end of the spool. Actually, such stopping of the spool will occur when the decreasing amount of pressure fluid exhausting through the vents 40 has caused the pressure differential across the ends of the valve spool to decrease to very nearly equilibrium, at which time the vents 40 may be very slightly open to pass a trickle of fluid to the reservoir.

From this, it will be seen that the descent of the load carried by the work cylinder can be controlled by metering exhaust flow therefrom in the "lower" position of the main and pilot valves seen in FIG. 2. As therein seen, the cylinder member 27 and its vents 40 have been positioned by the adjusting screw 41 to stop motion of the main valve spool as soon as its groove 18 has established limited communication between the service passage 11 and the return passage 13. Consequently, the load on the work cylinder 7 is lowered at a safe slow speed.

If desired, the descent of the load could be slowed further, by adjustment of the cylinder member 27 slightly farther to the left of its position seen in FIG. 1, so as to cause the spool to stop in a work cylinder exhausting position at which the service passage 11 is communicated with the return passage 13 only through metering notches 43 in the valve spool.

Faster retraction of the piston rod 28 and descent of the load connected thereto results from adjustment of the cylinder member 27 to the right of its position seen in FIG. 1, so that the main valve spool 5 must travel farther away from neutral before it substantially closes off the vents 40.

Consequently, it will be apparent that the rate at which fluid flows from the service passage to the return passage 13 depends upon the extent to which the main valve spool is displaced to the right of its neutral position; and that the extent of such displacement is in turn determined by the axial adjustment of the cylinder member 27.

FIG. 3 diagrammatically illustrates a pilot operated control valve for a double-acting hydraulic lift cylinder 70, along with slightly modified means for effecting metered exhaust flow of fluid from the bottom port 8 of the work cylinder. In this case, the piston member 120 provided by the right-hand end por-

tion of the main valve spool 71 must be hollow to provide a cylindrical sidewall 72, and the vents 40' are located therein. The piston member 120 is slidable axially back and forth in a cylinder member 127, which has screw threads 73 on its exterior engaging with mating threads on the wall of the cavity 26' to enable the cylinder member to be adjusted axially relative to the valve body and to the vents 40' in the main valve spool 71.

It should be apparent that the main valve spool 71 is adapted to selectively communicate a supply passage 12 with either of a pair of service passages 11 and 11' at opposite sides of the supply passage, depending upon whether the valve spool 71 is moved to an operating position to the right or to the left of its neutral position shown. In either operating position, of course, the main valve spool communicates the non-selected service passage with an adjacent return passage 13.

The pilot valve 9 can be identical to that used in the FIG. 1 embodiment of the invention, since in this case also, load pressurized fluid from the bottom port 8 of the lift cylinder 70 is relied upon to shift the main valve spool on to the right of neutral to a piston rod retracting position when the pilot valve is actuated to its position communicating the axial passage 23 in the main spool with the reservoir through the vents 40'. In the load lowering position described, travel of the main valve spool to the right of neutral is halted at the time the vents 40' are substantially covered by the inner end of the cylinder 151 127; with the spool in a position such that the pump output fluid can flow into the upper end of the lift cylinder via the communicating passages 11' and 12'.

The cylinder member 127 is shown at a location such as to cover the vents 40' and halt motion of the main valve spool at a metering position allowing only a limited amount of fluid exhausting from the lower end of the work cylinder 70 to flow to its associated return passage 13. This assures slow lowering of the load on the work cylinder. Faster descent of the load on the work cylinder will result if the cylinder member 127 is adjusted axially outwardly to a position disposing its inner end farther from the vents 40' in the neutral position of the main valve spool.

The FIG. 4 embodiment of the invention also discloses a pilot operated control valve for a double-acting work cylinder 70, but with cylinder members 27 such as employed in the FIG. 1 embodiment at both ends of its spool 75 to receive the piston members 19 and 20 provided thereby. Again in this case, the cylinder member 27 are provided with vents 40, and they are biased axially outwardly, away from one another by the spool centering spring 29, which accordingly hold them against adjustable stops 41, one for each cylinder member.

As in all of the embodiments of the invention, the valve spool 75 is provided with the axial passage 23 and restriction 24 at its end adjacent to the piston member 20 to afford communication between the chambers 22 in the interiors of the cylinder members 27. In this case, however, the axial passage is not communicated in any way with the work cylinder 70. Hence, the fluid pressure force necessary to shift the valve spool 75 in both directions from neutral is derived from the pump P, through a pilot valve 90 having two service ports 76 and 77 communicating with cavities 26 and 26', respectively, at the right- and left-hand ends of the main valve spool. The pilot spool 78 also has a neutral position (shown) and two operating positions to selectively communicate each of its service passages with the pilot inlet 31 and the other service passage with the reservoir.

In one operating position of the pilot valve, control fluid under pressure can be directed thereby to the cavity 26, for example, for flow into the interior of the cylinder member 27 in cavity 26 while the interior of the other cylinder member is vented through its cavity 26'. This effects actuation of the main valve spool to the left, to an operating position causing pump output fluid to flow to the lower end of the work cylinder while fluid expelled from its upper end is exhausted through service passage 11' and the adjacent return passage 13 then in communication therewith.

The speed at which the piston rod of the work cylinder is extended by such flow of fluid into its lower end is determined by the rate at which fluid is allowed to exhaust from the upper end of the cylinder. The exhaust rate, of course, is determined by the extent to which the main valve spool is displaced from its neutral position for the establishment of communication between service passage 11' and its adjacent return passage 13. This displacement of the spool to the left of neutral is halted at any metering or nonmetering position predetermined by the setting of the left-hand cylinder member 27 as soon as spool piston 19 closes or substantially closes the vents 40 in that cylinder member.

Similarly, the pilot valve can effect actuation of the main valve spool to the right of neutral, to an operating position at which pressure fluid is directed into the upper end of the work cylinder while fluid expelled from its lower end is exhausted through service passage 11 and its adjacent return passage 13. The speed at which the piston rod of the work cylinder is allowed to be retracted is then determined by the setting of the right-hand cylinder member 27 in which piston member 20 operates.

With the FIG. 4 embodiment, it will be seen that it is also possible to meter the rate at which pump output fluid is supplied to the work cylinder. This results from the fact that when the piston member at either end of the main valve spool closes off the vents 40 to stop the spool at an exhaust metering position, the spool will also be disposed in a supply fluid metering position because of limited communication then possible between the supply passage 12 and the selected service passage 11 or 11'.

For example, the flow pressure fluid into the lower cylinder port 8 of the work cylinder can be metered to achieve controlled extension of the piston rod of the cylinder by proper adjustment of the left-hand cylinder member 27, so that its vents 40 will be closed or substantially closed by the piston member 19 after only a limited degree of communication has been established between passages 11 and 12. It is to be understood, of course, that in this latter event, the lands on the spool would be timed to first vent the upper end of the work cylinder through service passage 11' and the adjacent return passage 13.

In all of the embodiments of the invention thus far described, selection of the degree to which fluid flow is to be metered by the valve spool in one of its operating positions is determined by the setting of an adjusting screw. However, similar results may be achieved by selectively controlling the effectiveness of a plurality of axially-spaced vents that are arranged to be successively closed by the valve spool as it is moved away from its neutral position toward one of its operating positions, in the manner described in FIG. 5.

The control valve and pilot valve 9 therein shown are like those of the FIG. 1 embodiment of the invention, except that the pressure chambers 21 and 22 into which the piston defining ends 19 and 20 of the main valve spool 5 project are provided by the closed opposite ends of the bore B in which the main spool operates. Shifting of the pilot spool to the right of its neutral position shown effects extension of the piston rod 23 of the cylinder 7 governed by the valve to raise a load as before; while shifting of the pilot spool out of neutral to a position corresponding to that of the pilot valve seen in FIG. 2 effects lowering of the load on the cylinder.

In this case, however, the service port 35 of the pilot valve is communicated by a duct 36' with a port in the rear of the chamber 22 so that the bottom of said chamber defines an extreme load lowering position of the main valve spool at which it affords full communication between passages 11 and 13 and fast lowering of the load on the cylinder.

A plurality of venting ports 140 and 240 open laterally from the side of chamber 22 at locations spaced axially of one another and from the adjacent end of the piston 20 on the valve spool 5 when the latter is in its neutral position shown. The chamber 22 can be vented through either of ports 140 or 240 at the dictate of simple manually operable two-way valves 80, one for each port.

With the arrangement described, and assuming that both the main and pilot valve spools are in their neutral positions shown, the main valve spool 5 can be actuated from its neutral position to a first metering position severely limiting exhaust flow from cylinder 7 merely by opening the valve 80 for vent 140, which vent is closer to the end of the main valve spool than the vent 240. This first metering position of the spool is determined by closure of the vent 140 by the piston defining end 20 of the main valve spool as it moves to the right, away from its neutral position.

However, if the valve 80 for vent 240 is opened instead of the valve for port 140, the main valve spool will travel farther away from its neutral position and be brought to rest in an operative position restricting exhaust flow from the cylinder to a lesser degree, at the time the vent 240 is substantially closed by the piston defining end 20 of the spool.

From this it will be apparent that the valves 80 constitute selector means by which the main valve spool can be stopped at any of a plurality of metering positions effecting lowering of the cylinder at different speeds, all independently of the pilot valve 9. It will also be apparent, of course, that the valves 80 should be closed at times when the pilot valve 9 is operated to effect either unrestricted exhaust flow from the cylinder of extension of its piston rod.

The embodiment of the invention seen in FIG. 6 is identical to that of FIG. 5, except that normally closed electromagnetic valves 180 are substituted for the manually actuatable valves 80. The electromagnetic valves are selectively actuatable to open positions at the dictate of manually operable switches 82.

In each of the FIGS. 5 and 6 embodiments of the invention, of course, the valves 80 and 180 can be said to control the effectiveness of the venting ports with which they are associated.

From the foregoing description, together with the accompanying drawings, it will be readily apparent that this invention provides a pilot governed control valve wherein exceptionally simple means can be incorporated to adjustably predetermine the speed of operation of a cylinder controlled by the valve.

We claim:

1. A control valve having a fluid pressure actuatable valve element which can be moved in one direction from a first position toward a second position by fluid pressure force exerted on one portion thereof provided that fluid can escape from a pressure chamber associated with another portion of the valve element, characterized by:

- A. venting means for said chamber through which fluid can escape therefrom;
- B. means by which said venting means can be rendered ineffective as a consequence of movement of the valve element toward said second position thereof, and by which fluid can then be trapped in said chamber to prevent further movement of the valve element in said direction; and
- C. and selector means associated with said chamber venting means to provide for varying the extent the valve element can be moved in said direction toward its said second position before the venting means is rendered ineffective as a consequence of such motion.

2. The control valve of claim 1, further characterized by:

- A. said pressure chamber comprising a cylinder member;
- B. said other portion of the valve element providing a piston member which is slidable axially in the cylinder member; and
- C. said venting means being located in one of said members to be closed by the other member in consequence of movement of the valve element toward said second position thereof so as to thereby trap fluid in said chamber to limit such movement of the valve element and define said second position thereof.

3. The control valve of claim 2, wherein said selector means comprises structure providing for adjusting one of said members axially relative to the other member so as to enable said second position of the valve element to be varied as desired.

4. The control valve of claim 3, wherein said cylinder member is adjustable lengthwise of its axis.
5. The control valve of claim 4, wherein said vent is in the cylinder member.
6. The control valve of claim 2, further characterized by:
- A. said cylinder member being axially slidably supported on the piston defining portion of the valve element;
 - B. a spring acting upon the cylinder member and tending to move it in one axial direction relative to the valve element; and
 - C. said selector means comprising an adjustable stop against which the cylinder member is held by said spring, said stop being adjustable axially of the cylinder member to thereby enable movement of the valve element in said direction to be halted at second positions spaced different distances from said first position thereof.
7. The control valve of claim 6, wherein said spring tends to move the cylinder member in said one direction relative to the valve element.
8. The control valve of claim 1, wherein the valve element is adapted for actuation toward said second position thereof by pressure fluid expelled from one end of a hydraulic cylinder governed by the control valve.
9. The control valve of claim 1, wherein:
- A. said valve element is an elongated, axially slidable spool; and
 - B. each end of the spool projects into a pressure chamber into which pressure fluid can be admitted to effect actuation of the spool toward the other chamber.
10. The control valve of claim 9, wherein:
- A. each end portion of the spool provides a piston member;
 - B. each of said pressure chambers provides a cylinder member in which the adjacent piston member operates;

- and
- C. one of said members at each end of the spool is provided with a vent which is arranged to be closed by its cooperating other member in consequence of movement of the spool in either direction from said first position thereof, to limit such movement and define two operating positions of the valve spool.
11. The control valve of claim 10, further characterized by means for adjusting the position of at least one of said cylinder members axially relative to the spool.
12. The control valve of claim 1, further characterized by:
- A. said venting means comprising a plurality of vents located to be successively rendered ineffective as a consequence of movement of the valve element toward said second position thereof; and
 - B. said selector means comprising valve instrumentalities, one for each vent to control fluid flow therethrough.
13. The control valve of claim 1, further characterized by:
- A. said pressure chamber comprising a cylinder member;
 - B. said venting means comprising a plurality of vents in the wall of the cylinder member spaced from one another axially thereof;
 - C. said other portion of the valve element providing a piston member which is slidably axially in the cylinder member, and by which said vents are closed during movement of the valve element in said one direction from its said first position; and
 - D. said selector means comprising a valve instrumentality for each vent, to control fluid flow therethrough.
14. The control valve of claim 13, wherein said valve instrumentalities are electromagnetic valves.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,568,718 Dated March 9, 1971

Inventor(s) Raud A. Wilkie & Francis H. Tennis

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4 line 27
"151" should read member

Column 4 line 30
"12'" should read 12.

Column 4 line 46
"cylinder member" should read cylinder members

Column 4 line 48
"spring" should read springs

Column 5 line 44
"f" should read of

Column 5 line 51
"described" should read disclosed

Signed and sealed this 10th day of August 1971.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents