

12

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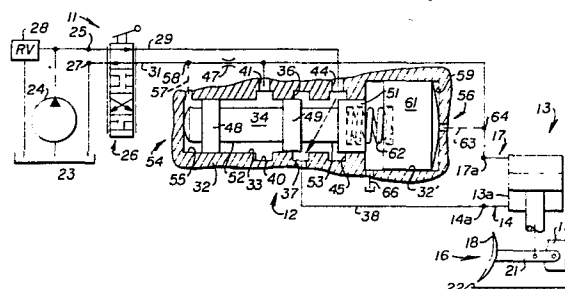
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54 Fluid motor control circuit with fast-acting quick-drop valve.

57 A control circuit (11, 11b) for a fluid pressure-operated cylinder (13, 13b) or the like has a quick-drop valve (12, 12b) which enables faster gravity-assisted lowering of a load (16, 16b) and which quickly shifts to a power-down mode of operation when dropping of the load by gravity ceases. Means (47, 47b, 54, 54b, 56, 56b) sensing flow rate to the head end of the cylinder and sensing cavitation in the head end initiate the quick-drop operation at which the discharge path from the cylinder back to tank is totally blocked and all discharge from the rod end is recirculated to the head end. When resistance to further lowering of the load occurs, the quick-drop valve responds by shifting to block communication between ends of the cylinder while establishing a rod end discharge path to tank to initiate a power-down mode of operation quickly and without lag or bounce.



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-1-

FLUID MOTOR CONTROL CIRCUIT
WITH FAST-ACTING QUICK-DROP VALVE

Technical Field

This invention relates to control systems for fluid
5 pressure-operated motors, such as fluid cylinders, fluid
actuators or the like, and more particularly to a quick-drop
valve which enables fast gravity-assisted lowering of a load
or member by directing fluid which discharges from one motor
port back to the other motor port.

10 Background Art

Control systems for fluid cylinders or the like
usually have a main control valve connected between the
cylinder and a pump or other source of pressurized fluid. In
many systems the main control valve has a raise position at
15 which pressurized fluid is supplied to the rod end of the
cylinder and at which fluid is discharged from the head end
in order to move a load against gravity or against some other
resistance. In this raise mode of operation the rate of
cylinder retraction is determined by the rate at which the
20 pump forces fluid into the cylinder. This is not necessarily
the case when the main control valve is shifted to the lower
or power-down position at which the pressurized fluid is
applied to the head end of the cylinder and at which fluid
discharges from the rod end back to tank. During the power-
25 down mode of operation gravity or other forces may be
capable of causing a rate of cylinder extension exceeding
that established by the rate of flow of pressurized fluid to
the head end of the cylinder. Severe negative pressures or
cavitation may then cause a loss of precision in controlling

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-2-

the cylinder. The cylinder may not respond quickly to shifts of the control valve and other adverse effects occur such as erratic cylinder motion and vibration and bounce or temporary reversals of cylinder motion. While these effects
5 can be avoided by restricting the rate at which fluid can discharge back to tank through the main control valve at the power-down position of the valve, this may undesirably limit the rate of lowering of the load.

To enable fast lowering of a load, a variety of
10 quick-drop valves have heretofore been designed for connection between the two flow passages to the ends of the cylinder at a location relatively close to the cylinder and in some cases as a built-in component of the cylinder itself. Quick-drop valves provide a relatively short and low
15 resistance fluid interchange path between the two ends of the cylinder that remains closed during the raise mode of operation but which is opened during gravity-assisted lowering of the load so that fluid which is discharging from one cylinder port is directed to the other port to supplement
20 the incoming flow from the main control valve. Typically, the quick-drop valve senses cavitation in the cylinder during the power-down mode of operation and opens automatically while such condition is present.

Prior quick-drop valves of known forms are subject
25 to certain operational disadvantages. Many prior quick-drop valves operate in response to a discharge pressure differential across a restriction in the flow path which connects the discharging end of the cylinder with the tank through the main control valve. Consequently the discharge

-3-

flow path must remain at least partially open and part of the discharge flow must be returned to tank during the quick-drop mode of operation instead of being recirculated to the head end to inhibit cavitation. Some other prior quick-drop valves respond to a flow restriction situated
5 in the flow path to the pressurized end of the cylinder, but in these cases the discharging flow path remains communicated with tank during the quick-drop mode of operation again preventing use of the entire discharge flow
10 for the purpose of enabling fast lowering of a load without adverse effects.

The prior art has not provided a quick-drop valve which fully seals off the rod end flow passage from tank during the quick-drop mode of operation and which fully
15 returns all discharge fluid to the head end of the cylinder at that time.

Considering an additional problem encountered with prior quick-drop valves, there are fluid cylinder usages in which it is desired to continue lowering the load by reverting
20 to a power-down mode of operation after gravity ceases to be effective for this purpose. The fluid cylinders used to raise and lower a bulldozer blade relative to a tractor body are typical of such systems. Control systems for such cylinders often provide a quick-drop mode of operation to
25 speed the dropping of the bulldozer blade towards the ground in preparation for work operations. When the blade contacts the ground it may be necessary to convert to a power-down mode of operation to drive the blade forcibly downward a short distance into the ground. An undesirable time lag tends to

-4-

occur between the quick-drop operation and the subsequent power-down operation and in some cases an undesirable bounce effect or momentary reversed motion of the bulldozer blade or other driven mechanism may occur. This effect is found in prior quick-drop systems which shift automatically by sensing increased resistance to lowering of the load as well as in systems in which the operator must manually shift the main control valve from a float or quick-drop setting to a power-down setting.

10 Disclosure of the Invention

The present invention is directed to overcoming one or more of the problems as set forth above.

In one aspect of the present invention, the control system for one or more fluid cylinders or other fluid motors includes quick-drop valve means which shifts from a power-down mode of operation into a quick-drop mode upon sensing cavitation accompanied by a fluid flow into the cylinder which is above a predetermined level. The quick-drop valve means then completely blocks the discharge flow path from the cylinder back to tank in order to recirculate all discharge fluid directly back to the cylinder. This total regeneration of the discharge flow enables an extremely fast gravity lowering of a load without adverse effects. Upon sensing resistance to continued lowering of the load the quick-drop valve means automatically reverts to the power-down mode of operation rapidly and without bounce or other adverse effects, enabling continued lowering of the load without any significant interruption.

The quick-drop valve means is biased towards a

-5-

normal position at which the two flow passages to the cylinder or the like are isolated from each other and separately communicated with the main control valve to enable raise, hold and power-down modes of operation to be selected by manipulation of the main control valve. A flow restriction is provided in the particular flow passage through which fluid is directed to the cylinder or the like during the power-down mode of operation. Pilot means respond to cavitation in the cylinder accompanied by a predetermined pressure differential across the flow restriction by shifting the quick-drop valve to an alternate position at which the discharge flow passage back to the main control valve is completely blocked and at which all discharge fluid is recirculated back to the cylinder or the like to supplement the flow arriving from the main control valve. The pilot means also respond to either or both of a drop of the pressure differential across the flow restriction and a cessation of cylinder cavitation by quickly resetting the quick-drop valve back to the power-down position.

The invention, together with further features and advantages thereof, will best be understood by reference to the following description of preferred embodiments taken in conjunction with the accompanying drawings.

Brief Description of the Drawings

Figure 1 depicts a fluid motor control circuit including a quick-drop valve under conditions which establish the raise mode of operation at which the motor lifts a load against gravity,

-6-

Figure 2 is a view of a portion of the apparatus of Figure 1 during the power-down mode of operation,

Figure 3 is a view of a portion of the circuit of Figures 1 and 2 during the quick-drop mode of operation,

5 Figure 4 illustrates a modification of a portion of the apparatus of Figures 1 to 3,

Figure 5 is a view of an alternate embodiment of the invention shown in the raise mode of motor operation,

10 Figure 6 is a view of a portion of the alternate embodiment of Figure 5 shown in power-down mode of operation, and

Figure 7 is a view of the alternate embodiment of Figures 5 and 6 during the quick-drop mode of operation.

Best Mode for Carrying Out the Invention

15 Referring initially to Figure 1 of the drawing, a fluid circuit 11 includes a quick-drop valve means 12 for controlling a fluid motor 13 that has first and second motor ports 14 and 17 respectively each of which may receive or discharge fluid depending on the direction of motor motion.

20 Motor 13 in this example is a fluid cylinder 13a in which the first motor port is a rod end port 14a to which pressurized fluid is directed to cause cylinder retraction and consequent raising of a load 16 and in which the second motor port is a head end port 17a to which the pressurized fluid may be

25 directed to cause extension of the cylinder and lowering of the load.

The load 16 in this particular example is a bulldozer blade 18 coupled to the body of a tractor 19 through vertically pivotable push arms 21 to which the rod of

-7-

cylinder 13a is coupled. Thus by supplying pressurized fluid to rod end port 14a while allowing fluid to discharge from head end port 17a, the cylinder 13a may be caused to retract to raise the blade 18 against gravity. Lowering of the blade 18 may be accomplished by directing pressurized fluid to head end port 17a while allowing fluid to discharge from rod end port 14a, but in this case two distinct modes of cylinder extension are possible.

If there is sizable resistance to lowering of the load, such as when the blade 18 is in contact with ground 22, the rate of cylinder extension is primarily determined by the rate at which pressurized fluid is directed into head end port 17a and the system is in the power-down mode of operation. Under other conditions, such as when the lower edge of the blade 18 is above the ground, cylinder extension may tend to outrun the incoming supply of pressurized fluid and the extension rate is then determined by gravity acting against mechanical friction and whatever degree of flow resistance may be present in the discharge path from rod end port 14a. It is often desirable to take advantage of the faster rate of cylinder extension obtainable by this gravity-induced or quick-drop mode of operation but this is practical only to the extent that the previously described adverse effects which accompany excessive cavitation within the head end of cylinder 13a can be prevented. The quick-drop valve means 12 of circuit 11 inhibits such effects during the quick-drop mode of operation to provide for extremely fast lowering of the load and further provides for an extremely quick automatic shift into the power-down mode of operation

-8-

when resistance to lowering of the load increases from contact of blade 18 with the ground 22 or other causes.

The circuit 11 may utilize a fluid such as oil for example, stored in a tank 23, which is pressurized and delivered to a fluid inlet 25 of a main control valve 26 by a pump 24. Main control valve 26 also has a drain outlet 27 for returning discharge fluid to tank 23. A relief valve 28 is connected between the output of the pump 24 and tank 23 to establish a predetermined maximum fluid pressure and to return excess output fluid from the pump directly back to the tank.

The main control valve 26 in this example is of the manually operated form and has four positions or settings. At the raise position of the main control valve depicted in Figure 1, pressurized fluid is directed into a first or rod end flow path conduit 29 while a second or head end flow path conduit 31 is communicated with tank 23 through drain outlet 27. The main control valve 26 may be shifted to a hold position at which both flow path conduits 29 and 31 are closed at the main control valve, while inlet 25 is communicated with drain outlet 27, thereby immobilizing the cylinder 13a. At the third or lower position of the main control valve 26, head end flow path conduit 31 receives pressurized fluid from inlet 25 while the rod end flow path conduit 29 is communicated with drain outlet 27. The fourth position of the main control valve 26 is a float position at which flow path conduits 29 and 31 are intercommunicated with each other and with drain 27.

The quick-drop valve means 12 may have a housing 32

-9-

with a bore forming a cylindrical valve chamber 33 in which a movable valve member or spool 34 is disposed. An annular groove 36 is formed in housing 32 and communicates with chamber 33 and with the first or rod end port 14a of cylinder 13a through a first valve port 37 and a flow line 38. Another spaced-apart annular groove 40 opens into chamber 33 and is communicated with the second or head end port 17a of the cylinder 13a through a second valve port 41 and head end flow line 31. Still another annular groove 45 opening into chamber 33 is communicated with the rod end flow path conduit 29 at a third valve port 44. The head end flow path conduit 31 includes a flow restriction 47 situated between the main control valve 26 and the connection to second valve port 41.

Spool 34 is shiftable in the axial direction from a normal position depicted in Figure 1, at which the spool abuts the left end of chamber 33 as viewed in the drawings, to an alternate or quick-drop position depicted in Figure 3. Referring again to Figure 1, the spool 34 has three axially spaced-apart annular lands 48, 49 and 51 of which lands 48 and 49 jointly define a broad spool groove 52 while lands 49 and 51 jointly define a second spaced-apart broad spool groove 53. The lands 48, 49 and 51 are positioned on the spool to cause the first and third valve ports 37 and 44 to be communicated by spool groove 53 and to be isolated from the second valve port 41, by land 49, when the spool is at the normal position depicted in Figure 1. When the spool 34 is shifted to the alternate or quick-drop position depicted in Figure 3, spool groove 52 communicates the first and

-10-

second valve ports 37 and 41 while blocking and completely closing off the third valve port 44 from each of the other valve ports.

Referring again to Figure 1, shifting of the valve spool 34 between the normal position and the quick-drop position is controlled by first and second pilot means 54 and 56 respectively situated at the left and right ends of spool 34 as viewed in Figure 1.

The first pilot means 54 in this example is formed by the left end of valve chamber 33, spool 34 including land 48 and a first pilot signal line 57 which communicates the first pilot chamber 55 at the left end of valve chamber bore 33 with a first region 58 of the head end flow path conduit 31 which is between main control valve 26 and flow restriction 47. The second pilot means 56 includes a second pilot chamber 59 which is of greater diameter than the valve chamber 33 and which is within an enlarged right end section 32' of housing 32. A pilot piston 61 is disposed in pilot chamber 59 and is movable in the axial direction between an unactuated position at which the pilot piston abuts the right end of the pilot chamber 59 as depicted in Figure 1 and an actuated position depicted in Figure 2 at which the pilot piston abuts the left end of the pilot chamber 59. Biasing means in the form of a resilient compression spring 62 is disposed in valve housing 32 between spool 34 and pilot piston 61 to bias the valve spool towards the normal position while biasing the pilot piston 61 towards the unactuated position as depicted in Figure 1. To exert a counter force on the pilot piston 61 under certain conditions to be described, a

-11-

second pilot signal line 63 communicates the outer or right end of pilot chamber 59 with a second region 64 of the head end flow path 31 that is on the opposite side of restriction 47 from region 58. A drain passage 66 communicates with the
5 opposite end of the pilot chamber 59, at the region of spring 62, to avoid accumulation of leakage fluid between the spool 34 and the pilot piston 61.

As will be discussed in connection with operation of the apparatus, second pilot chamber 59 including piston
10 61 have a larger diameter than the first pilot chamber 55 in order to prevent shifting of spool 34 to the quick-drop position until the pressure in chamber 55 exceeds that in chamber 59 by a sizable amount indicative of cavitation in the head end of cylinder 13a. Referring now to Figure 4,
15 this same effect may be realized with a second pilot chamber 59' which has the same diameter as quick-drop valve housing bore 33' if the first pilot chamber 55' has a smaller diameter. In this modification, the piston 61 and drain 66 of the quick-drop valve as depicted in Figures 1 to 3 are
20 eliminated and, as shown in Figure 4, a relatively small piston 61' is situated in the first pilot chamber 55' and a drain 66' is provided in the valve housing 32' between piston 61' and the valve spool 34', the apparatus otherwise being similar to that previously described.

25 Industrial Applicability of the First Embodiment

In operation, raising of the load 16 against gravity is initiated by shifting the main control valve 26 to the raise position depicted in Figure 1 at which pressurized fluid from pump 24 is transmitted to rod end conduit 29 and

-12-

at which the head end conduit 31 is opened to drain outlet 27. Spring 62 holds spool 34 at the normal position since the first pilot chamber 55 is open to drain and only lightly pressurized if at all. In addition, a somewhat higher
5 pressure is present in the second pilot chamber 59 owing to the pressure differential created across restriction 47 by the discharging flow. If the discharge flow is sufficiently high this may shift pilot piston 61 but the practical effect is simply to increase the spring force which is holding spool
10 34 at the normal position depicted in Figure 1.

Accordingly, pressurized fluid from pump 24 is transmitted to the rod end port 14a of the cylinder 13a through main control valve 26, rod end conduit 29, valve ports 44 and 37 and flow line 38. The head end port 17a of
15 the cylinder is open to drain outlet 27 through head end flow conduit 31 including restriction 47 and the main control valve 26. Thus cylinder 13a retracts to raise the load 16. As the main control valve 26 is of the infinitely variable form, the operator may, within limits, control the rate of
20 raising of the load by adjusting the main control valve to regulate fluid flow rate to the cylinder.

To stop the retraction of the cylinder 13a, main control valve 26 may be shifted to the hold position at which both the rod end flow conduit 29 and the head end flow conduit
25 31 are blocked at the main control valve. The system has not been depicted in the drawings in the hold position as all components other than the main control valve 26 remain in the positions depicted in Figure 1. The load 16 is immobilized as fluid from rod end port 14a cannot flow back to drain owing

-13-

to the closed condition of the main control valve and cannot flow into the head end of the cylinder owing to the position of land 49 which blocks first valve port 37 from second valve port 41. Similarly, fluid cannot flow into
5 or out of the head end port 17a as the head end flow path conduit 31 is also blocked at the main control valve 26.

The first and second pilot means 54 and 56 are unable to shift spool 34 or pilot piston 61 at this time since there is no flow across restriction 47 to create a pressure
10 differential which might activate the pilot means.

Additionally, the pressure within the pilot signal lines 57 and 63 tends to be low at this time as the weight of the load 16 tends to create a high-pressure condition in the rod end of cylinder 13a and a relatively low-pressure
15 condition in the head end.

Lowering of the load 16 is initiated by shifting the main control valve 26 to the third or lower position as depicted in both of Figures 2 and 3. The quick-drop valve means 12 may self-operate to either the power-down position
20 depicted in Figure 2 or to the quick-drop position depicted in Figure 3 depending on the interrelationship between two factors. The first factor is the direction of the external forces acting on cylinder 13a. If external forces are such as to oppose lowering of the load, the circuit 11 assumes the
25 power-down position depicted in Figure 2 without regard to the second factor. The second factor is the extent to which the operator has opened the main control valve 26 into the lower setting or, in other words, the rate at which pressurized fluid is being transmitted to the cylinder through restriction

-14-

47 and being discharged from the cylinder through the main control valve. If external forces such as gravity are acting to extend the cylinder, then the action of the circuit 11 depends on the relationship of the magnitude of the external force to the degree of opening of the main control valve 26. This action can best be understood by first considering the operation of the circuit in the power-down mode under conditions where there is external resistance to extension of the cylinder 13a or where the main control valve 26 has been opened only to a limited extent insufficient to enable the quick-drop mode of operation.

During the power-down mode of operation as depicted in Figure 2, spool 34 of the quick-drop valve 12 remains in the normal or leftward position while the pilot piston 61 is shifted to the actuated or leftward position by the second pilot means 56 as will hereinafter be discussed in more detail. At this normal position of spool 34, the first and third valve ports 37 and 44 remain communicated across spool groove 53 and remain blocked from the second valve port 41 by spool land 49. Pressurized fluid is therefore supplied to the head end port 17a of cylinder 13a through head end flow conduit 31, including restriction 47. The rod end port 14a of the cylinder is communicated to drain outlet 27 through flow line 38, valve port 37, spool groove 53, valve port 44, rod end flow path conduit 29 and the main control valve 26. The resulting high fluid pressure within the head end of the cylinder extends the cylinder to forcibly lower the load against the resistance to such movement.

Pilot piston 61 shifts to the actuated position at

-15-

this time since the relatively high pressure within the head end of the cylinder 13a is transmitted to pilot chamber 59 by the second pilot signal line 63 where the pressure acts against the pilot piston 61 with a force greater than that of spring 62. The flow of fluid through restriction 47 creates a pressure drop thereacross causing a somewhat higher pressure to be present in the pilot chamber 55 of the first pilot means 54 than in the second pilot chamber 59 but owing to the difference in the diameters of the two pilot chambers and to the force exerted by spring 62, the pressure difference is insufficient to shift spool 34 and pilot piston 61 rightwardly. Spool 34 therefore remains at the normal position depicted in Figure 2 to establish the power-down mode of operation. The relative diameters of the two pilot chambers 55 and 59 and the force characteristics of spring 62 are fixed to offset the effect of the pressure drop across restriction 47 at times when the flow rate through the restriction 47 has been limited by opening of the main control valve only to a limited extent.

If the main control valve 26 is opened into the lower setting to a greater extent thereby increasing the flow rate across restriction 47 and if gravity is acting to extend the cylinder 13a more rapidly than provided for by that flow rate, the circuit 11 shifts to the quick-drop mode of operation depicted in Figure 3. With spool 34 in the power-down position of Figure 2, a reversal of the pressure relationship between the ends of cylinder 13a occurs at the time that gravitational cylinder extension starts to overrun the fluid pressure-caused extension. Pressure at rod end port

-16-

14a rises while the pressure at head end port 17a drops to a negative level at which vacuum or cavitation conditions are created in the head end. The pressure in second pilot chamber 59 is therefore reduced relative to the pressure in the first pilot chamber 55. The pressure differential across flow restriction 47 is then able to offset the effect of the difference of diameters of pilot chambers 55 and 59. Spool 34, and pilot piston 61 are then forced rightwardly as viewed in the drawing to the quick-drop position of Figure 3.

At the quick-drop position the rod end port 14a of the cylinder 13a is communicated with the head end port 17a within the quick-drop valve, specifically through flow line 38, first valve port 37, spool groove 52, second valve port 41 and head end flow conduit 31. At the full quick-drop position, land 49 completely blocks the discharge flow path from the rod end port 14a back to drain outlet 27 through rod end flow conduit 29 and the main control valve 26. As there is no discharge path back to drain, all discharge fluid from rod end port 14a is regenerated back to the head end port 17a to enable very fast gravitational cylinder extension without adverse effects from an inadequate supply of fluid in the head end.

Thus there are basically two conditions which must be present for the system to shift into the quick-drop mode of operation. First, the main control valve 26 must be shifted sufficiently into the lower position to provide a flow rate through restriction 47 which produces a pressure differential between pilot chambers 55 and 59 high enough to

-17-

compress spring 62. Second, the head end of cylinder 13a must be voided of positive pressure.

The circuit 11 quickly and automatically reverts from the quick-drop mode of operation of Figure 3 back to the power-down mode of operation of Figure 2 when a substantial resistance to continued cylinder extension is encountered, for example, upon contact of the bulldozer blade 18 of Figure 1 with ground surface 22. Referring to Figures 2 and 3 in conjunction, this quick automatic reversion to the power-down mode occurs since slowing or stopping of the rate of cylinder extension eliminates the void or negative pressure in the head end of cylinder 13a and thus eliminates at least one of the two conditions which, as discussed above, are necessary to put the system in the quick-drop mode of operation. When the head end of the cylinder is no longer voided, pressure rises in the second pilot chamber 59. The force exerted on spool 34 by the larger pilot piston 61 and spring 62 then exceeds the opposing force on the spool exerted within first pilot chamber 55 causing the valve spool and pilot piston to be moved to the left, as viewed in the drawing, back to the power-down position depicted in Figure 2. Cylinder extension then continues at a slower rate in the manner described above with reference to the power-down mode of operation until such time as the operator shifts the main control valve 26 back to the hold or raise position or until such time as the limit of cylinder extension is reached.

Although the system shifts automatically between the power-down mode and the quick-drop mode, the operator may

-18-

optionally restrict the circuit to the power-down mode and lower the load slowly by limiting the extent to which the main control valve 26 is opened into the lower position.

This restricts the rate of flow through restriction 47 to

5 a value which is less than that needed to produce a pressure difference, between pilot chambers 55 and 59, sufficient to compress spring 62. With spring 62 uncompressed, valve spool 34 is necessarily at the leftward or power-down position of Figure 2. If the operator then opens the control
10 valve 26 more completely, increasing the flow rate through restriction 47, the pressure differential between pilot chambers 55 and 59 increases to compress spring 62 and the quick-drop mode of operation may result if the hereinbefore-described necessary conditions are present.

15 The system has been described above with reference to a usage involving a single cylinder 13a, but it should be appreciated that the invention is equally applicable to systems which may employ a plurality of cylinders 13 or the like and it is preferable in such cases to provide a
20 separate quick-drop valve 12 for each such cylinder. As a practical matter, it is more common to employ a pair of cylinders of this kind to manipulate a bulldozer blade 18. Similarly, it should be appreciated that the invention may also be applied to the control of other fluid actuated
25 devices provided they are of a type in which the amount of fluid discharged from one port during the quick-drop mode of operation is less than the amount which can be admitted to the other port (which condition would not be met in the system of Figure 1 if cylinder 13a were inverted so that the

-19-

head end coupled to the load 16).

Second Embodiment for Carrying Out the Invention

It should also be appreciated that variations of the circuit 11 are readily possible. Figures 5 to 7 depict
5 another embodiment of the circuit 11b having a modified form of pilot means for controlling shifting of the quick-drop valve between the power-down position and the quick-drop position.

Referring initially to Figure 5 in particular,
10 the pressurized fluid source or pump 24b together with tank 23b, relief valve 28b and main control valve 26b may all be similar to the corresponding components of the previously described embodiment. Similarly, the cylinder 13b including head end and rod end ports 17b and 14b respectively and the
15 load 16b may if desired be similar to the corresponding mechanisms hereinbefore described with reference to the first embodiment. As in the previous case, a head end flow path conduit 31b containing a flow restriction 47b is connected between main control valve 26b and the head end
20 port 17b of the cylinder and with the second valve port 41b of quick-drop valve housing 32b. A rod end flow path conduit 29b is again connected between the main control valve 26b and third valve port 44b of quick-drop valve housing 32b while the first valve port 37b again connects to cylinder rod end port
25 14b through a flow line 38b.

The quick-drop valve housing 32b has a cylindrical valve chamber 33b with three axially spaced-apart grooves 40b, 36b and 45b at which valve ports 41b, 37b and 44b respectively are located. Valve spool 34b is disposed in

-20-

bore 33b for axial movement between a normal position, depicted in Figures 5 and 6, at which the spool abuts the left end of chamber 33b as viewed in the drawing and a quick-drop position depicted in Figure 7 at which the spool abuts the opposite end of the chamber. Spool 34b is formed with four lands 71, 72, 73 and 74 which define three axially spaced-apart spool grooves 76, 77 and 78. The lands and grooves are located on the spool to cause groove 78 to communicate valve ports 37b and 44b when the spool is at the normal position depicted in Figures 5 and 6 while land 73 blocks both such valve ports from the other valve port 41b. At the quick-drop position depicted in Figure 7, the intermediate spool groove 77 communicates valve ports 37b and 41b while land 73 blocks both such ports from valve port 44b.

At either position of the valve spool 34b, a second pilot signal line 63b containing a control orifice 75 communicates spool groove 76 with a region 64b of head end flow conduit 31b located between flow restriction 47b and head end motor port 17b. A first pilot signal line 57b communicates the first pilot chamber 55b defined by the left end of valve chamber 33b with a region 58b of head end flow passage conduit 31b which is between restriction 47b and the main control valve 26b.

The opposite end of chamber 33b constitutes a second pilot chamber 59b and is communicated with spool groove 76 by a passage 79 within the spool. A compression spring 62b is situated within pilot chamber 59b to bias spool 34b towards the normal position depicted in Figure 5.

-21-

Thus pilot chamber 55b in conjunction with spool land 71 and pilot signal line 57b constitute a first pilot means 54b for exerting a force tending to urge the spool 34b away from the normal position depicted in Figure 5.

5 The opposite pilot chamber 59b in conjunction with land 74, pilot signal line 63b, spool groove 76 and spool passage 79 constitute a second pilot means 56b in which fluid pressure forces, aided by the force of spring 62b, act to urge the valve spool towards the normal position depicted in Figure 5.

10 Pressure-responsive valve means 80 are provided for equalizing the fluid pressures in the two pilot chambers 55b and 59b during the power-down mode of operation and for producing an abrupt change of pilot pressures when conditions dictate a shift between the power-down position of valve
15 spool 34b and the quick-drop position of the spool, the pressure-responsive valve means being a piloted check valve 81 of the pilot-to-close form in this example. The check valve 81 has an inlet 82 in one end communicated with first pilot signal line 57b and has an outlet 84 in one side
20 communicated with groove 76 of the quick-drop valve spool 34b. Check valve 81 further has an internal spool 86 which may retract from inlet 82 to communicate pilot signal line 57b with outlet 84 in response to fluid pressure at the inlet except when a higher pilot pressure is present in a pilot
25 chamber 87 behind the spool. A pilot port 88 at the other end of the check valve 81 communicates pilot chamber 87 with the flow line 38b which connects first valve port 41b with the rod end port 14b of cylinder 13b.

-22-

Industrial Applicability of the Second Embodiment

In operation, setting of the main control valve 26b at the raise position as depicted in Figure 5 causes pressurized fluid from inlet 25b to be transmitted to rod end port 14b of the cylinder through rod end flow conduit 29b, third valve port 44b, spool groove 78, first valve port 37b and flow line 38b. Simultaneously, fluid being discharged from the cylinder head end port 17b is drained to tank through flow conduit 31b and the main control valve.

As a result, cylinder 13b retracts to raise load 16b against gravity. The quick-drop valve spool 34b is held in the normal or leftward position at this time in part by the force of spring 62b and in part because the direction of flow through restriction 47b creates a pressure differential at which a higher fluid pressure is transmitted to pilot chamber 59b than is transmitted to the opposite pilot pressure chamber 55b. Piloted check valve 81 remains closed at this time and does not affect the net pilot pressure force on valve spool 34b since the high fluid pressure being transmitted to the rod end of cylinder 13b is also transmitted to the pilot chamber 87 of the check valve.

If the main control valve 26b is then shifted to the lower setting as depicted in Figures 6 and 7, the circuit 11b shifts either to the power-down mode of operation illustrated in Figure 6 or to the quick-drop mode of operation depicted in Figure 7 depending on the direction of the external load forces on cylinder 13b and also depending on the degree to which the operator has opened the main control valve. If the external forces acting on the cylinder

-23-

13b resist cylinder extension, then the circuit 11b remains in the power-down mode, regardless of the extent of opening of the main control valve. If external forces on the cylinder 13b are negative, that is, load forces are tending to extend the cylinder because of gravity or other causes, then the circuit shifts to the quick-drop mode of operation depicted in Figure 7 if the two conditions previously described with respect to the first embodiment are present. Specifically, the main control valve 26b must be opened to a sufficient extent to provide a flow rate through restriction 47b that creates a pressure difference between pilot chambers 55b and 59b high enough to compress spring 62b. Voiding or negative pressure must also be present in the head end of the cylinder 13b so that check valve 81 is held closed by a pressure in pilot chamber 81 higher than that at inlet 82.

In the absence of one or both of the above-described conditions, the quick-drop valve spool 34b remains in the normal position at which pressurized fluid is transmitted to the head end port 17b of the cylinder and discharge fluid from the rod end port 14b is transmitted to drain through flow line 38b, valve port 37b, spool groove 78, valve port 44b, rod end flow conduit 29b and the main control valve 26b. If the flow rate through restriction 47b is kept below a particular value the pressure differential between pilot chambers 55b and 59b is not high enough to compress spring 62b since such differential is a function of flow rate through the restriction. Further, check valve 81 opens to eliminate any pressure differential between the two pilot chambers 55b and 59b as long as the pressure at the rod end

-24-

port 14b of the cylinder is less than that in the first pilot signal line 57b which is the case until such time as a negative pressure appears at the head end port 17b.

With the main control valve 26b at the lower setting the system shifts into the quick-drop mode depicted in Figure 7, as opposed to the power-down mode depicted in Figure 6, if both of the previously described necessary conditions are present. In particular, external load forces must be causing cylinder 13b extension to overrun the supply of fluid being transmitted to the cylinder through the main control valve so that high pressure at the rod end port 14b accompanied by voiding in the head end of the cylinder closes pilot valve 81 and isolates the first and second pilot chambers 55b and 59b from each other. In addition, the main control valve 26b must have been opened into lower to a degree which provides a flow rate through restriction 47b sufficient to cause the fluid pressure acting on spool 34b within pilot chamber 55b to exceed the opposing fluid pressure acting within pilot chamber 55b by an amount sufficient to compress the spring 62b and move the spool to the Figure 7 position.

At the quick-drop position of Figure 7, spool land 73 completely blocks the discharge path from the rod end port 14b of the cylinder back to drain while diverting all discharge flow from the rod end port to the head end port 17b of the cylinder thereby enabling extremely fast cylinder extension without loss of control or other adverse effects.

The circuit 11b automatically reverts to the power-down mode of operation when resistance to cylinder extension

-25-

increases or if the operator reduces the flow rate through restriction 47b by adjustment of the main control valve 26b since either occurrence removes one of the two conditions required for the quick-drop mode. Resistance to cylinder

5 extension causes a pressure drop at the rod end port 14b accompanied by a pressure rise at head end port 17b which allows pilot valve 81 to open and equalize the fluid pressures in pilot chambers 55b and 59b. Spring 62 then restores spool 34 to the power-down position. Restoration of spool 34

10 to the power-down position also occurs if the flow rate through restriction 47b is reduced sufficiently by manipulation of the main control valve 26b since the fluid pressure differential between pilot chambers 55b and 59b, corresponding to the pressure drop across the restriction, then becomes

15 insufficient to maintain the spring^{62b} in a state of compression. Spring 62b then shifts spool 34b back to the power-down position depicted in Figure 6. In either instance, cylinder extension then continues at a slower rate in the power-down mode until terminated by operation of the main control valve

20 26b or by bottoming out of the cylinder at the maximum limit of extension.

Other aspects, objects and advantages of this invention can be obtained from a study of the drawings, the disclosure and the appended claims.

-26-

Numerical List of Elements
Case 77-543

11, 11b	fluid circuit
12, 12b	quick-drop valve means
13, 13a, 13b	fluid motor (cylinder)
14, 14a, 14b	first, rod end, motor port
16, 16b	load
17, 17a, 17b	second, head end, motor port
18, 18b	bulldozer blade
19, 19b	tractor body part
21, 21b	push arm
22, 22b	ground surface
23, 23b	tank
25, 25b	inlet of 26
26, 26b	main control valve
27, 27b	drain outlet of 26
28, 28b	relief valve
29, 29b	first, rod end flow conduit
31, 31b	second, head end flow conduit
32, 32b	housing of 12, 12b
32'	enlarged end of 32
33, 33', 33b	valve chamber bore
34, 34', 34b	spool
36, 36b	groove
37, 37b	first valve port
38, 38b	flow line
40, 40b	groove
41, 41b	second valve port
44, 44b	third valve port

-27-

Numerical List of Elements
Case 77-543
(con't.)

45, 45b	groove
47, 47b	flow restriction
48	land
49	land
51	land
52	groove
53	groove
54, 54b	first pilot means
55, 55', 55b	first pilot chamber
56, 56b	second pilot means
57, 57b	first pilot signal line
58, 58b	first region (flow junction in 31)
59, 59', 59b	second pilot chamber
61, 61'	pilot piston
62, 62b	spring
63, 63b	second pilot signal line
64, 64b	second region (flow junction in 31)
66, 66'	drain passage
68	branch of 29b
69	branch of 29b
71	land
72	land
73	land
74	land
75	control orifice
76	spool groove
77	spool groove

-28-

Numerical List of Elements
Case 77-543
(con't.)

78	spool groove
79	spool passage
80	pressure responsive valve means
81	piloted check valve
82	inlet of 81
83	outlet of 81
84	spool of 81
87	pilot chamber of 81
88	pilot port of 81

-29-

WHAT IS CLAIMED IS:

1. A fluid motor control circuit (11, 11b) for powered multi-directional movement of a load member (16, 16b) comprising:

a source (24, 24b) of fluid under pressure including a fluid reservoir tank (23, 23b);

a fluid motor (13, 13b) connected to the load member and having fluid inlet and discharge ports (14, 14b, 17, 17b) individually selectively connectable to said source and to the tank; and

means (12, 12b) for blocking the flow of fluid from the motor discharge port back to the tank and concurrently fully returning all discharge fluid to the inlet port of the motor during gravitationally induced overrunning of the motor.

2. In a fluid motor control circuit (11, 11b) having an infinitely variable main control valve (26, 26b), a fluid motor (13, 13b) having first (14, 14b) and second (17, 17b) ports, first (29, 29b) and second (31, 31b) fluid pathways connecting said motor and said valve, the improvement comprising:

valve means (12, 12b) positioned in said fluid pathways for selectively allowing fluid to be directed to and from said motor and for blocking fluid from said motor to said valve and interconnecting said ports of said motor; and

sensing means (47, 47b) in one of said fluid pathways for sensing the fluid flow and positioning said valve means in response to said flow.

-30-

3. A quick-drop valve (12, 12b) for a fluid motor control circuit (11, 11b) comprising:

a fluid motor (13, 13b) having a first and second fluid port;

a first (29, 29b) and second (31, 31b) fluid pathway connected to said first and second fluid ports, respectively;

a housing (32, 32b) having a bore (33, 33b), first (37, 37b), second (41, 41b), and third (44, 44b) spaced-apart ports;

valve spool means (34, 34b) for controllably interconnecting said ports and being positioned in said bore;

biasing means (62, 62b) for biasing said spool means to a position for interconnecting said first and third ports and blocking said second port; and

sensing means (47, 47b) for sensing the fluid flow in said second fluid pathway and automatically positioning said valve means to interconnect said first and second ports and block said third port in response to said fluid flow in said second pathway.

4. Quick-drop valve means (12, 12b) for a fluid motor control circuit (11, 11b) wherein the motor (13, 13b) has first (14a, 14b) and second (17a, 17b) motor ports and wherein the circuit includes a main control valve (26, 26b) for selectively directing pressurized fluid to said first motor port through a first flow path while discharging fluid from said second motor port through a second flow path to move a load (16, 16b) in one direction and which is shiftable to direct said fluid into said second flow path while

-31-

discharging fluid from said first flow path to move said load in an opposite direction, comprising:

a housing (32, 32b) forming a valve chamber (33, 33b) with first (37, 37b), second (41, 41b) and third (44, 44b) spaced-apart valve ports having means for communication with said first motor port, said second motor port and said first flow path respectively,

a valve member (34, 34b) in said valve chamber movable to a normal position at which said first and third valve ports are intercommunicated while being blocked from said second valve port, and also being movable to a quick-drop position at which said first and second valve ports are intercommunicated while said third valve port is completely blocked from both thereof to cause all discharge fluid from said first motor port to be returned to said second motor port at said quick-drop position of said valve member,

means defining a flow restriction (47, 47b) in said second flow path between first (58, 58b) and second (64, 64b) spaced-apart regions thereof, said first region being between said flow restriction and said main control valve and said second region being between said flow restriction and said second motor port, and

pilot means (54, 54b, 56, 56b) for using fluid pressure from said first region to produce a force tending to cause movement of said valve member towards said quick-drop position thereof and for using fluid pressure from said second region to produce a counterforce tending to cause movement of said valve member towards said normal position thereof.

-32-

5. Quick-drop valve means (12, 12b) as defined in claim 4 further comprising means (62, 62b) for maintaining said valve member (34, 34b) at said normal position thereof until said pressure at said first region (58, 58b) exceeds said pressure at said second region (64, 64b) by a predetermined amount.

6. Quick-drop valve means (12) as defined in claim 4 wherein said pilot means includes first pilot means (54) for forming a first pilot chamber (55) wherein said pressure from said first region (58) acts to urge said valve member (34) towards said quick-drop position, and second pilot means (56) for forming a second pilot chamber (59) wherein said pressure from said second region (64) acts to urge said valve member towards said normal position, said second pilot chamber having a greater diameter than said first pilot chamber.

7. Quick-drop valve means (12) as defined in claim 6 wherein said valve member (34) is a spool movable axially in said housing (32) between said normal position and said quick-drop position and wherein said first pilot chamber (55) is at one end of said spool and said second pilot chamber (59) of larger diameter is at the other end thereof, further comprising a movable pilot piston (61) of said larger diameter disposed in said second pilot chamber and being positioned therein to urge said spool towards said normal position thereof in response to said fluid pressure from said second region.

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-33-

8. Quick-drop valve means (12) as defined in claim 7 further comprising a compressible spring means (62) disposed between said pilot piston (61) and said other end of said spool (34) for biasing said spool towards said normal position thereof and for transmitting said force from said pilot piston to said spool.

9. Quick-drop valve means (12b) as defined in claim 4 wherein said pilot means has first pilot means (54b) for forming a first pilot chamber (55b) wherein said pressure from said first region (58b) acts to urge said valve member (34b) towards said quick-drop position and second pilot means (56b) for forming a second pilot chamber (59b) wherein said pressure from said second region (64b) acts to urge said valve member towards said normal position, further comprising:

pressure-responsive valve means (80) for intercommunicating said first and second pilot chambers when the pressure at said first region exceeds the pressure at said first valve port (37b).

10. Quick-drop valve means (12b) as defined in claim 9 wherein said pressure-responsive valve means (80) comprises a piloted check valve (31) having an inlet (82) communicated with said first pilot chamber (55b) and an outlet (84) communicated with said second pilot chamber (59b) and having a pilot port (86) communicated with said second valve port (41b) and having a valve element (86) movable to communicate said inlet with said outlet when the pressure at said inlet exceeds the pressure at said pilot port.

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~~-34-~~

11. Quick-drop valve means (12b) as defined in claim 9 wherein said valve member (34b) is a spool movable axially in said housing (32b) between said normal position and said quick-drop position, and wherein said first (55b) and second (59b) pilot chambers are at opposite ends of said spool and of equal diameter, further comprising spring means (62b) for urging said spool towards said normal position thereof.

12. In a fluid motor control circuit (11, 11b) having an infinitely variable main control valve (26, 26b) for selectively directing pressurized fluid to a first motor port (14, 14b) through a first flow path while discharging fluid from a second motor port (17a, 17b) through a second flow path and which is shiftable to direct fluid to said second motor port through said second flow path while discharging fluid from said first motor port through said first flow path, quick-drop valve means (12, 12b) comprising:

a housing (32, 32b) having a valve chamber bore (33, 33b) and having a first valve port (37, 37b) communicated with said first motor port and having a second valve port (41, 41b) communicated with said second motor port and having a third valve port (44, 44b) communicated with said first flow path,

a valve spool (34, 34b) disposed in said bore for axial movement therein between a normal position and a quick-drop position, said valve spool having lands (48, 49, 51, 71, 72, 73, 74) and grooves (52, 53, 77, 78) for intercommunicating said first and third valve ports while blocking said second



-35-

valve port therefrom at said normal position and for intercommunicating said first and second ports while blocking said third port therefrom at said quick-drop position,

flow restriction means (47, 47b) situated in said second flow path for developing a pressure differential in response to fluid flow therethrough,

first pilot means (54, 54b) for communicating one end of said bore with a first region (53, 53b) of said second flow path between said flow restriction means and said main control valve to cause fluid pressure from said first region to urge said spool towards said quick-drop position thereof,

second pilot means (56, 56b) for communicating the other end of said bore with a second region (64, 64b) of said second flow path between said flow restriction means and said second motor port to cause fluid pressure from said second region to urge said spool towards said normal position thereof, and

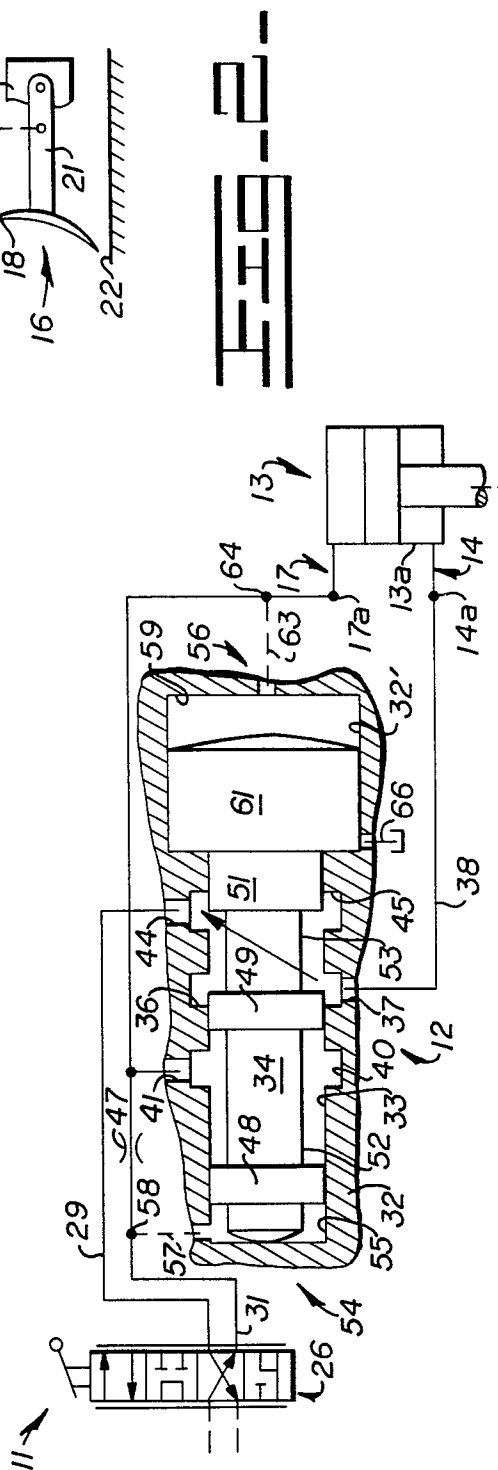
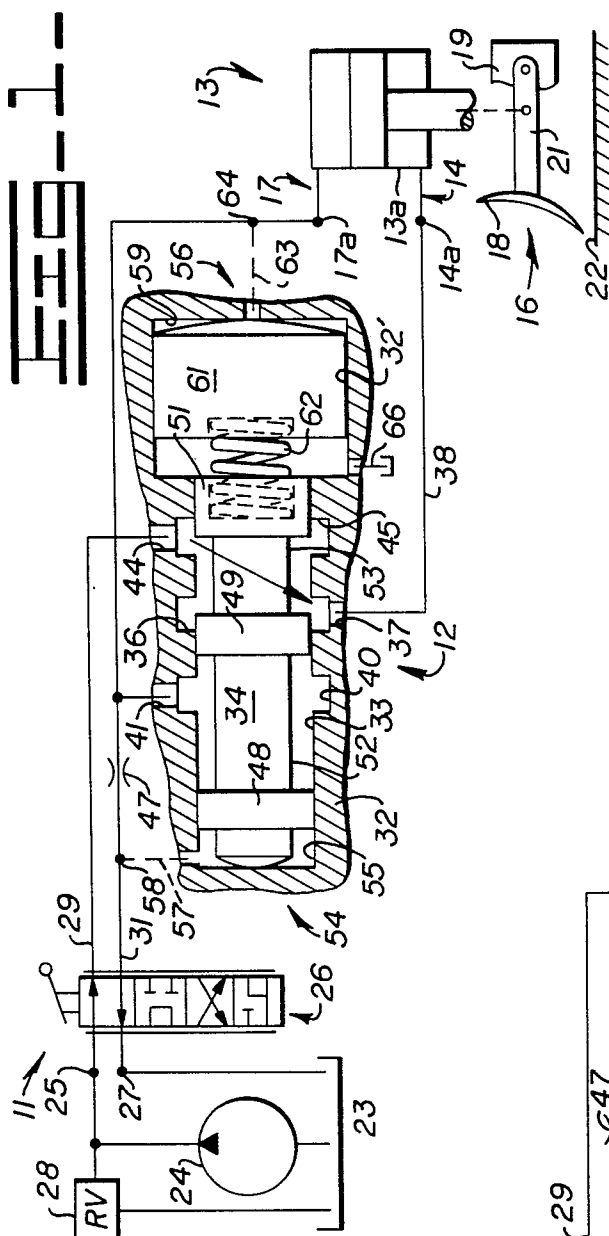
resilient means (62, 62b) for biasing said spool towards said normal position thereof.

13. The combination of claim 12 wherein said second pilot means (56) comprises means forming a pilot chamber (59) at said other end of said bore (33), said pilot chamber being of greater diameter than said one end of said bore, and a pilot piston (61) disposed in said pilot chamber and positioned to be urged towards said spool (34) by said fluid pressure from said second region (64) of said second flow path.

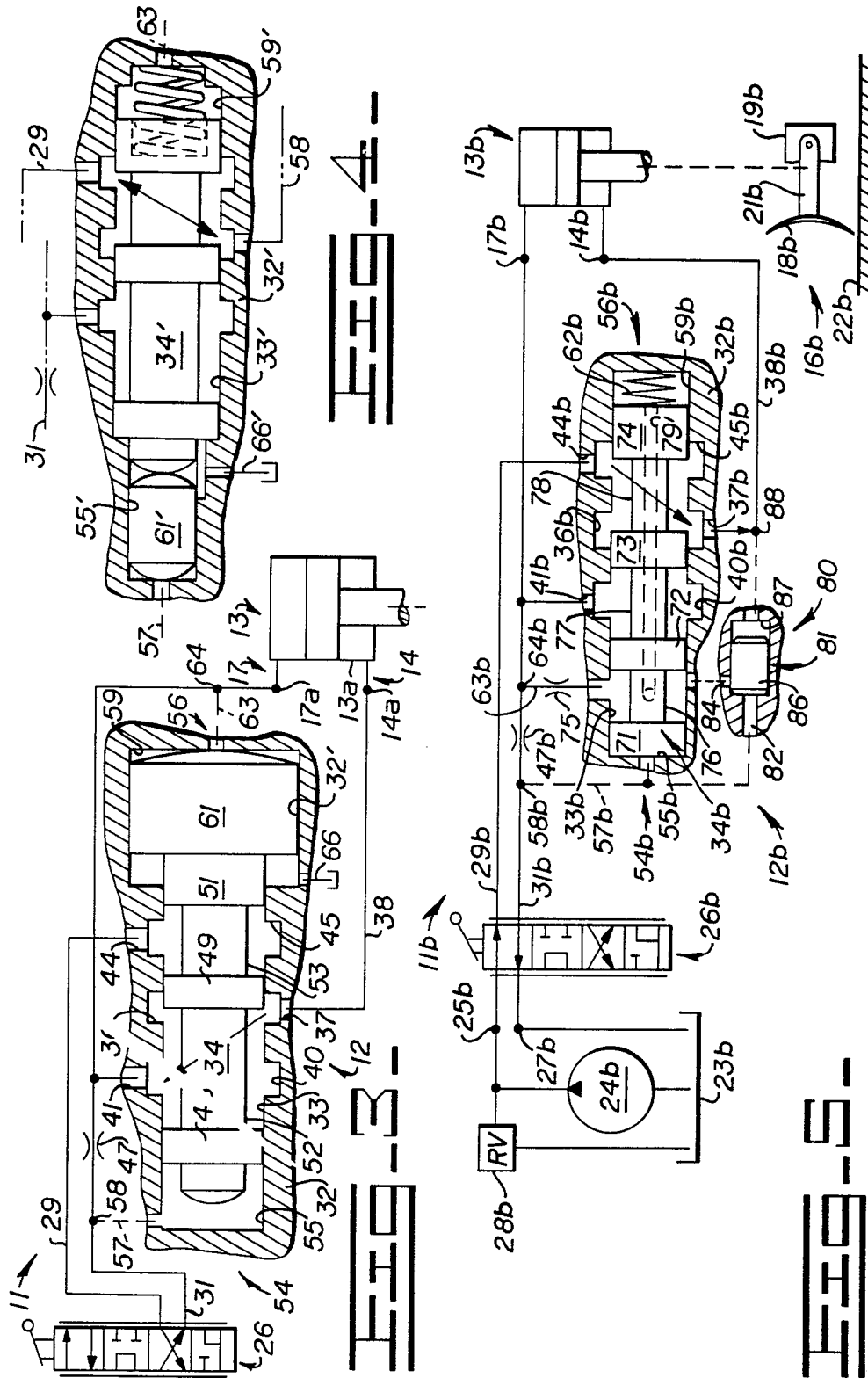
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-36-

14. The combination of claim 12 further comprising a piloted check valve (31) having an inlet (32) communicated with said one end of said bore (33b) and an outlet (34) communicated with said other end of said bore and having a pilot port (39) communicated with said first motor port (14b) to hold said check valve closed when pressure at said first motor port exceeds the pressure at said inlet.



- 2/3 -



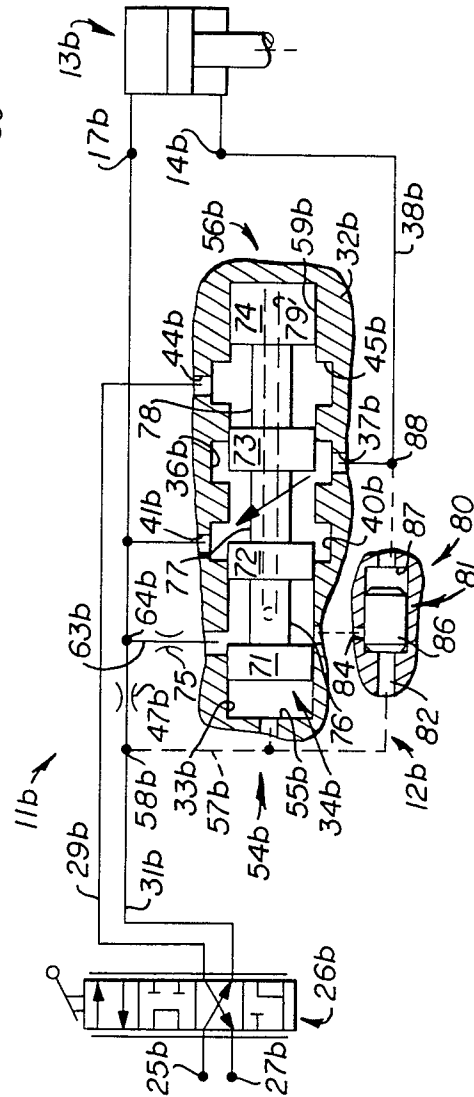
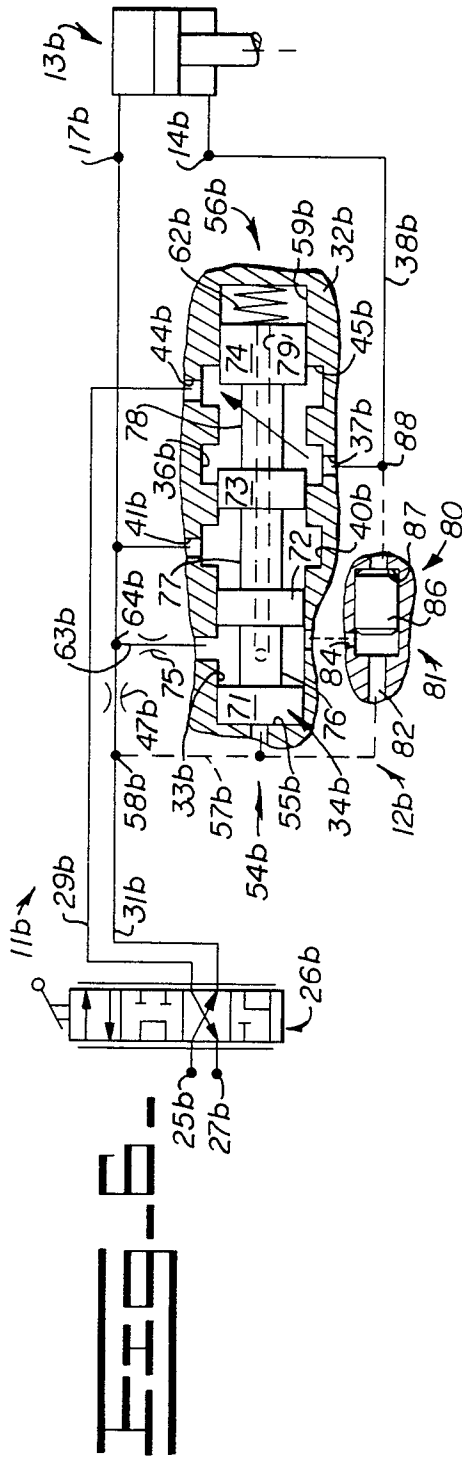


FIG. 7

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European Patent
Office

EUROPEAN SEARCH REPORT

Application number
EP 79 10 4041

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>US - A - 3 795 177 (CATERPILLAR)</u> * Column 4, line 25 - column 5, line 14 * --	1-5, 11, 12	F 15 E 13/12 E 02 F 3/86
	<u>US - A - 3 654 835 (SIEVENPIPER)</u> * Abstract * --	1-5	
	<u>US - A - 3 568 707 (SHORE)</u> * Column 3, line 50 - column 5, line 70 * --	1-9, 13	TECHNICAL FIELDS SEARCHED (Int. Cl.)
	<u>US - A - 3 474 708 (SCHMIEL)</u> * Column 1, lines 52-59 * --	1-5	F 15 E E 02 F
	<u>FR - A - 1 576 772 (CATERPILLAR)</u> * Page 5, lines 10-31 * ----	1-5	
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
			&: member of the same patent family. corresponding document
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
The Hague	08-02-1980	KNOFS	