United States Patent

Sievenpiper

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[54] REGENERATION VALVE

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[52] **U.S. Cl.** **91/436,** 137/117, 137/596

[51] **Int. Cl.** **F15b 11/08**

[58] **Field of Search** 91/436; 137/115, 117, 596

[56] **References Cited**

UNITED STATES PATENTS

2,646,025	7/1953	Deardorff	91/436
3,267,961	8/1966	Rice	91/436 X
3,319,653	5/1967	Stephens	137/596
3,335,739	8/1967	Rice	137/115
3,465,788	9/1969	Tennis	91/436 X
3,474,708	10/1969	Schmiel	91/436

FOREIGN PATENTS OR APPLICATIONS

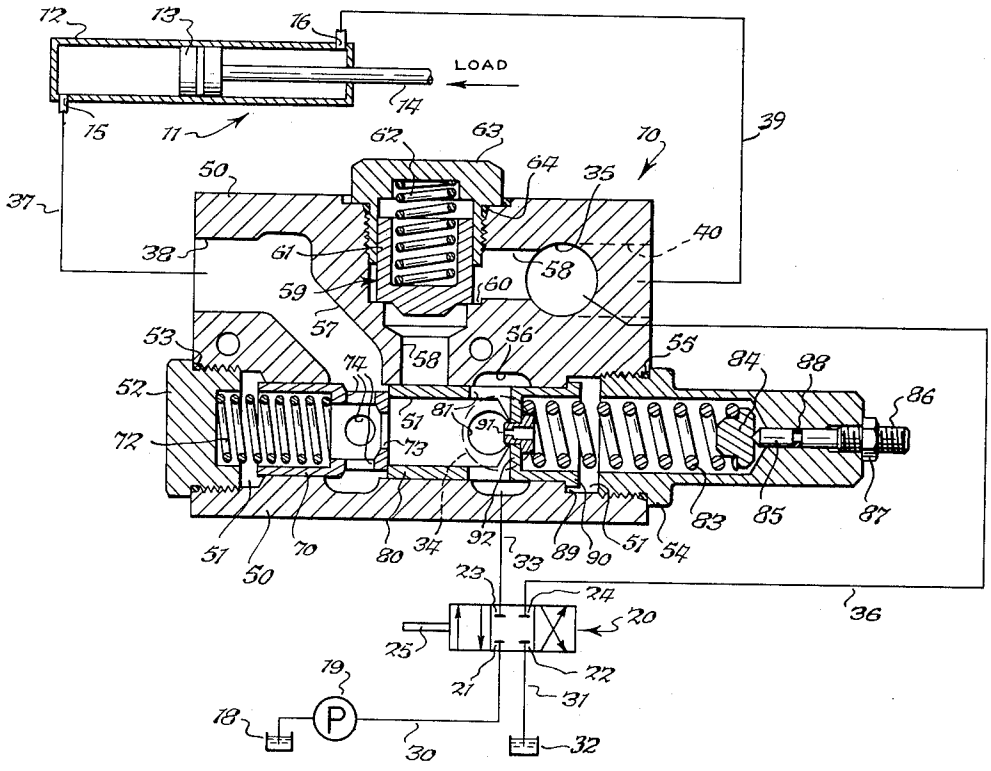
863,701	3/1961	Great Britain	91/436

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[57] **ABSTRACT**

A valve comprising a housing having an elongated chamber therein and first, second and third passages intersecting the chamber for connecting the chamber to corresponding valve ports. A generally hollow cylindrical flow controlling member is biased by a spring in a position normally closing the third passage from the chamber, and a generally hollow cylindrical flow responsive member is biased in the chamber axially adjacent and normally abutting the flow controlling member. The flow controlling member and the flow responsive member together define a flow path between the first and second passages, and the flow responsive member is provided with a restricted passage which defines a constriction in the flow path. In an illustrative application, the second and third passages of the valve are connected to the piston and rod ends, respectively, of an hydraulic cylinder, and fluid is supplied to and exhausted from the valve in a direction and at a rate determined by a conventional directional control valve. The valve of the present invention functions to provide a direct flow path from the piston to the rod end of the hydraulic cylinder when the rate of fluid flow, as controlled externally by the direction control valve, reaches a predetermined magnitude.

9 Claims, 4 Drawing Figures

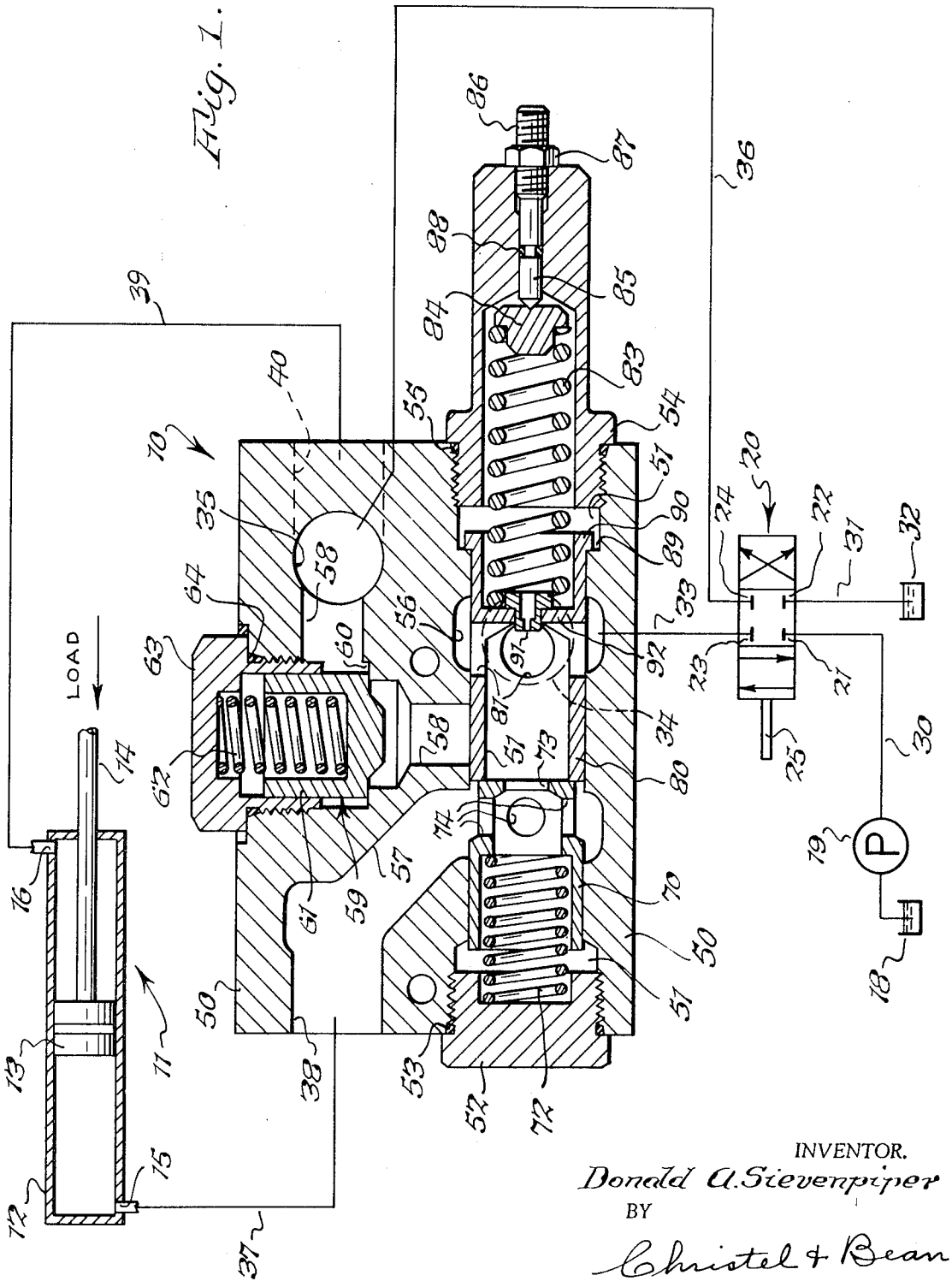


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SHEET 1 OF 2

Fig. 1.



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Fig. 4.

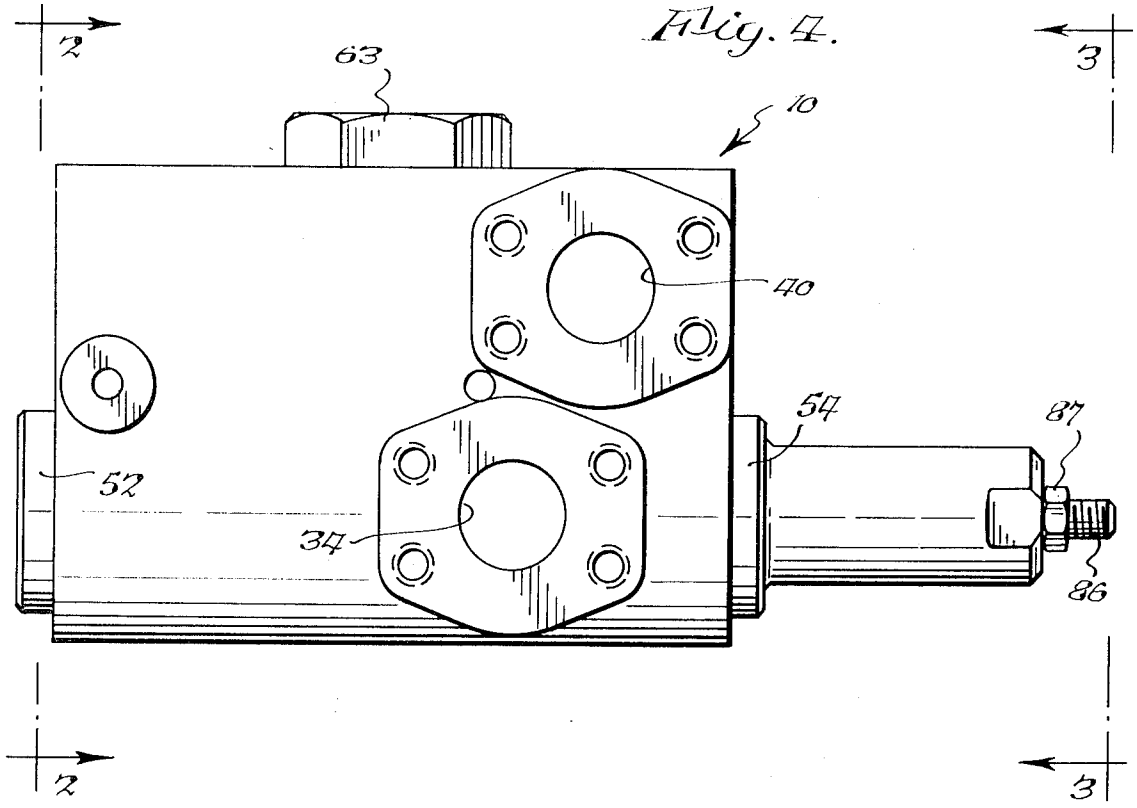


Fig. 2.

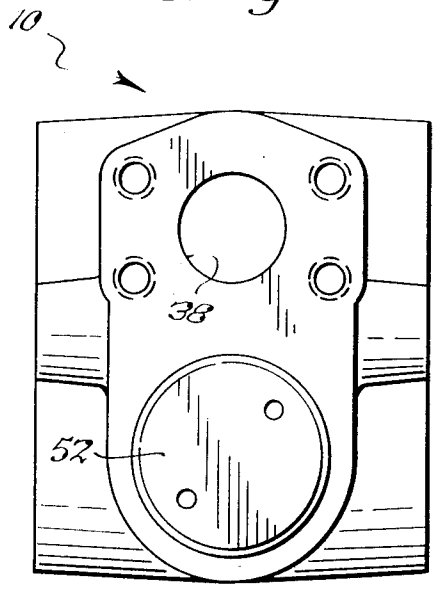
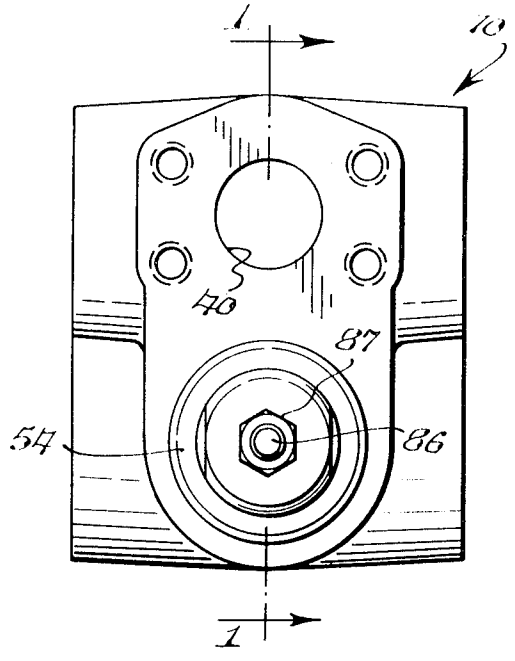


Fig. 3.



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REGENERATION VALVE

BACKGROUND OF THE INVENTION

This invention relates to the valve art, and more particularly, to a bypass valve for metering a flow of fluid from the piston end to the rod end of an hydraulic cylinder.

One area of use of the present invention is in hydraulic systems for actuating hydraulic cylinders which are employed on front end loaders for raising and lowering a load. Hydraulic systems of this kind include, briefly, a multi-position directional control valve having an inlet port connected with a pump, an exhaust port connected with a reservoir or tank, and a pair of motor ports which are connected with the piston and rod ends of the hydraulic cylinder. The directional control valve has at least a neutral or standby position in which each motor port is isolated from the other ports, a raise position in which one motor port connected with the exhaust port, and a lower position in which the connections between the motor ports and the inlet and exhaust ports are reversed.

A significant problem occurring with such systems is the suction or vacuum created in the rod end of the cylinder during rapid lowering of the piston, which suction undesirably draws dirt, air and other unwanted material into this region of the cylinder. A proposed solution to this problem of cavitation is the rapid introduction of fluid into the rod end of the cylinder as the piston is lowered quickly and as fluid is exhausted from the piston end of the cylinder. To this end, various fluid bypass valves have been proposed, an example of which is found in Rice U.S. Pat. No. 3,267,961 issued Aug., 1966. One limitation of such prior art valves is that the amount of fluid bypassed depends upon the capacity of the system pump and the magnitude of the load with the result that the rate of bypass flow cannot be controlled by the system operator.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide a valve which allows a bypass flow of fluid from the contracting to the expanding side of an hydraulic cylinder and in an amount which is externally controllable and independent of the influence of the load on the cylinder.

It is a more particular object of this invention to provide such a valve wherein the magnitude of the bypass flow is determined by the rate of flow to the valve.

It is a further object of this invention to provide such a bypass valve constructed so as to prevent any fluid leakage therein during the system standby condition.

It is a further object of this invention to provide such a bypass valve which is both simple in construction and convenient and easy to maintain.

The present invention provides a fluid bypass valve adapted to be connected to the piston and rod ends of an hydraulic cylinder. Fluid is supplied to the cylinder and bypass valve by means of a standard directional valve adapted to control the rate of fluid flow therethrough. The bypass valve of the present invention places the directional control valve in fluid communication with the piston end of the hydraulic cylinder in response to the flow of fluid in that direction. When the flow of fluid is reversed by means of the directional valve, the bypass valve of the present invention places the piston end of the hydraulic cylinder directly in fluid communication with the rod end thereof and by an amount determined by the system rate of flow as controlled by the directional valve. This regenerative action provided by the bypass valve prevents the formation of vacuum or suction in the rod end of the cylinder.

The foregoing and additional advantages and characterizing features of the present invention will become clearly apparent upon a reading of the ensuing detailed description, together with the included drawing wherein:

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a longitudinal cross-section view, taken about on line 1—1 of FIG. 3, of the fluid bypass valve of the present invention and showing schematically the manner whereby it is connected to an hydraulic cylinder and a directional control valve;

FIG. 2 is an elevational view of one end of the bypass valve shown in FIG. 1, taken about on line 2—2 of FIG. 4;

FIG. 3 is an elevational view showing the opposite end thereof taken about on line 3—3 of FIG. 4; and

FIG. 4 is a top plan view thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a valve **10** constructed in accordance with this invention and illustrates the manner in which it is connected to an hydraulic cylinder **11**. Hydraulic cylinder **11** includes a piston **12** reciprocable within a casing **13** and operatively connected through a rod **14** to a load. Fluid enters and leaves the piston end of hydraulic cylinder **11** through a port or opening **15** provided in casing **12**, and fluid enters and leaves hydraulic cylinder **11** at the rod end thereof through a port or opening **16** provided in the other end of casing **12**. Hydraulic cylinder **11** as shown in FIG. 1 is intended to be exemplary of many such devices, all well understood by those familiar with the art, and for this reason a detailed description thereof is believed unnecessary. Hydraulic cylinder **11** has numerous applications for moving a mechanical load such as a front end loader for raising and lowering a load, or on a bulldozer to raise and lower the bucket and blade thereof.

Fluid for operating hydraulic cylinder **11** and for actuating valve **10** is obtained from a supply **18** by a pump **19**, indicated schematically in FIG. 1, and under control of a directional flow control valve represented schematically at **20** in FIG. 1. Valve **20** includes, briefly, an inlet port **21**, an exhaust port **22**, a pair of motor ports **23**, **24**, and a movable control element **25**. Control element **25** is movable, for example, manually by an operator or automatically such as by being operatively connected to a solenoid, and element **25** functions to connect the motor ports **23**, **24** selectively to corresponding ones of the inlet **21** and exhaust **22** ports and to control the rate of flow of fluid through valve **20**. Directional control valves such as that designated **20** in FIG. 1 are readily commercially available and well understood by those familiar with the art, so that a detailed description thereof is believed unnecessary.

Valve **10** of the present invention, hydraulic cylinder **11** and directional control valve **20** are connected in an hydraulic circuit in the following manner. Pump **19** is connected through a conduit **30** to inlet port **21** of directional control valve **20**, and exhaust port **22** thereof is connected through a conduit **31** to a tank or reservoir designated schematically at **32** in FIG. 1. Motor port **23** of directional control valve **20** is connected through a conduit **33** to a port **34** of valve **10** and another port **35** of valve **10** is connected through a conduit **36** to the other motor port **24** of directional control valve **20**. A fluid path between the piston end of hydraulic cylinder **11** and valve **10** is provided by a conduit **37** which connects port **15** of cylinder casing **12** with a port **38** of valve **10**. The rod end of hydraulic cylinder **11** is connected to valve **10** by means of a conduit **39**, one end of which is connected to port **16** of cylinder housing **12** and the other end of which conduit is connected to a port **40** of valve **10**. Port **40** is in fluid communication with port **35** and, therefore, conduit **39** could be connected to valve port **35** as will be apparent hereafter. Valve **10** of the present invention functions to provide a fluid flow path between hydraulic cylinder **11**, pump **19** and reservoir **32**, and, under appropriate operating conditions, a direct path from the piston end to the rod end of cylinder **11** under control of directional flow control valve **20**. The structure and operation of valve **10** of the present invention now will be described.

Valve **10** comprises a housing **50** cast or otherwise formed from metal and provided with a chamber **51** therein. Chamber **51** is elongated and generally cylindrical, extending along the entire length of housing **50**. Chamber **51** is closed at one end, in this particular example the left hand end in FIG. 1, by an

end cap member 52 secured in housing 50. An 0-ring 53 is provided between cap 52 and housing 50 to provide a fluid-tight seal therebetween. Chamber 51 is closed at the other end thereof, in this example the right hand end in FIG. 1, by a hollow, elongated end cap member 54, whereby chamber 51 is extended in length slightly beyond the termination of housing 50. An 0-ring 55 is positioned between cap 54 and housing 50, to provide a fluid-tight seal therebetween.

Chamber 51 is intersected by axially spaced passages in valve housing 50 for connecting the chamber to corresponding ports of valve 10. Referring now to FIG. 1, a first passage 56 intersects chamber 51 somewhat beyond the mid-point thereof in an axial direction toward end cap 54, which passage 56 preferably is annular and is open to or in fluid communication with valve port 34. A second passage 57 intersects chamber 51 beyond the mid-point thereof and in an opposite axial direction, that is, toward end cap 53 which passage 57 places chamber 51 in fluid communication with valve port 38. A third passage 58 intersects chamber 51 at about the mid-point thereof, in any event at a point axially spaced between passages 56 and 57, which passage 58 places chamber 51 in fluid communication with valve ports 35 and 40.

Valve 10 further comprises check valve means 59, located in passage 58 and arranged to permit a flow of fluid from passage 58 to ports 35 and 40, but to prevent flow in the reverse direction. As shown in FIG. 1, passage 58 includes a right angle turn or bend, and is enlarged in the vicinity thereof to provide an annular valve seat 60. Valve means 59 includes a cup-shaped check member 61 arranged to seat on valve seat 60 to normally block fluid flow but to be movable therefrom to allow fluid flow through passage 58. Check member 61 is biased toward seat 60 by a spring 62, one end of which urges against the inner end wall surface of cup 61, and the other end of which spring 62 urges against the underside of a cap member 63, secured in housing 50. Cap member 63 includes a depending skirt portion having an inner diameter slightly greater than the outer diameter of cup member 61, whereby the latter is movable within cap 63 in a telescopingly guided manner, and thus is movable into and out of seating engagement with surface 60. An 0-ring 64 is provided between cap 63 and housing 50 to provide a fluid-tight seal therebetween.

Valve 10 further comprises metering means in chamber 51 and movable in response to the flow of fluid so as to place only passages 56 and 57 in fluid communication with each other and then passages 57 and 58 in fluid communication with each other, depending upon the direction of fluid flow through chamber 51. In both instances, the respective chambers are placed in fluid communication in a manner such that the amount of fluid flow therebetween is determined by the rate of flow of fluid through valve 10. This rate of flow, in turn, is controlled externally of valve 10, as will be described in more detail hereafter. Referring now to FIG. 1, the metering means comprises a flow responsive member 70 which is generally hollow cylindrical in shape, having an outer diameter slightly less than the diameter of chamber 51 along the portion thereof intersected by passage 57 and in a direction toward end cap 52 providing a sliding fit therein. The inner diameter of member 70 is constant from the end thereof near cap 52 to a point slightly beyond the mid-point thereof, whereupon it decreases at a right angle thereby defining an annular shoulder adapted to abut one end of a biasing spring 72, the other end of which spring abuts the inner surface of cap 52. In the opposite axial end wall of member 70 there is provided an opening or orifice 73, whereby the interior of member 70 is placed in fluid communication with the rest of chamber 51. A second opening 74 is provided in the side wall of member 70 and positioned therealong so as to open into pasage 57. Actually, a series of openings 74 can be spaced circumferentially around member 70 since passage 57 extends circumferentially around member 70. Passages 74 function to place the interior of flow responsive member 70 in fluid communication with passage 57. In addition, the area or diameter of opening 73 is less than the area provided by openings 74 whereby opening or orifice 73 constitutes a restricted passage for the flow of fluid through member 70 as will be explained in more detail hereafter. In addition, the outer portion of the end wall surrounding opening 73 provides a surface upon which fluid can act in a direction forcing or otherwise moving member 70 against the force of spring 72.

The metering means of valve 10 further comprises a flow controlling member 80, which is generally hollow cylindrical in shape and has an outer diameter slightly less than the inner diameter of chamber 51, having a sliding fit whereby it is reciprocable therein within a limited range of movement. Member 80 is provided with an opening 81, whereby the interior thereof is in fluid communication with valve passage 56. Actually, a series of such openings 81 can be provided in the side wall of member 80 circumferentially therearound. The side wall of member 80 to the left of openings 81 in FIG. 1 is of constant thickness and the inner diameter thereof in this region is less than the outer diameter of the adjacent end wall of member 70, but greater than the diameter of aperture 73. Member 80 is biased by a spring 83 in a position normally closing passage 58 from chamber 51, this position being shown in FIG. 1. The annular end face of member 80 is urged into contact with the outer portion of the end wall of member 70 in sealing relationship. It should be noted that in this position the distance between openings 81 and the annular end face of member 80 must be such that passage 58 is sealed from chamber 51. One end of spring 83 urges against an annular wall within member 80 intermediate the ends thereof, and the other end of spring 83 urges against an annular retainer member 84 positioned within end cap 54. The biasing force of spring 83 is adjustable by movement of retainer 84 effected through a pin spacer 85, which operatively engages a set screw 86 which projects from end cap 54 and is secured by means of a jam nut 87. An 0-ring 88 seated in an annular groove provided in pin 85 effects a fluid tight seal between chamber 51 and this adjusting mechanism. Chamber 51 is enlarged in diameter at the end thereof to which cap 54 is secured thereby defining an annular shoulder 89 which is engaged by an annular lip 90 on the end of member 80 to limit movement thereof in the direction toward member 70. Movement of member 80 in the opposite axial direction is limited by engagement between this annular end surface thereof and the opposed end surface of cap 54. A small diameter opening 91 is defined in an internal wall 92 of member 80 to act as a snubber and thereby prevent unwanted vibration or clattering of valve member 80.

By virtue of this arrangement, flow controlling member 80 is biased in a position normally closing passage 58 from chamber 51, and flow responsive member 70 is axially adjacent and biased in contact with flow controlling member 80. In addition, flow controlling member 80 and flow responsive member 70 together define a flow path between passage 56 and passage 57 which path has a constriction therein defined by orifice 73, whereby in response to a flow of fluid in a reverse direction from passage 57 into the path defined by the two members, a pressure reduction is created in the portion of the path defined by flow controlling member 80.

Valve 10 of the present invention operates in the following manner in conjunction with hydraulic cylinder 11 to raise and lower a mechanical load such as that of a front end loader or the blade of a bulldozer. When the load, which is connected to rod 14 of cylinder 11, is to be raised, fluid must be introduced to the piston end of hydraulic cylinder 11 so as to extend piston 13 and rod 14. In this mode of operation, directional control valve 20 is placed in a position by means of member 25 whereby motor port 23 is connected to pump 19 and motor port 24 to reservoir 32. Operating fluid from pump 19 is transmitted through conduit 30 to port 21 of directional control valve 20, and thence from motor port 23 thereof through conduit 33 to port 34 of valve 10. Fluid flows from port 34 through valve 10 to port 38 thereof in a path including passage 56, port or opening 81 in flow controlling member 80, the interior of member 80, opening 73 in the end face of flow

responsive member **70**, the interior of member **70**, openings **74** in member **70** and passage **57**. From port **38** of valve **10** operating fluid flows through conduit **37** and opening **15** in cylinder casing **13** into that end of hydraulic cylinder **11** where it acts on piston **13**.

During this mode of operation fluid flowing through valve **10** between ports **34** and **38** from the interior of member **80** toward member **70** acts on the outer annular surface provided by the end wall surrounding opening **73** thereby moving member **70** against the force of spring **72** in a direction toward the left in FIG. **1**. Member **80** will be at the limit of its travel in this direction by virtue of the engagement between lip **90** and shoulder **89** formed in chamber **51**. As a result, the interior of member **80** is open directly to passage **57**, as well as being in communication therewith through opening **73**, the interior of member **70** and openings **74**, thereby increasing the amount of flow from chamber **51** to passage **57**. This movement of member **70** can occur only when the flow is at a rate sufficient to establish a force on the end surface thereof greater than the force exerted by spring **72**. The throttling action of member **70**, therefore, is controllable externally as a function of system flow rate by means of control valve **20** and as a function of the tension of spring **72**, which can be varied or adjusted. In other words, valve **10** has the capability of providing a relatively slow or fast operation of hydraulic cylinder **11** to raise the mechanical load depending, among other things, upon the system flow rate established by control valve **20**.

During this mode of operation when valve **10** operates to transmit fluid from pump **19** to the piston end of hydraulic cylinder **11**, flow controlling member **80** is maintained in the position shown in FIG. **1** normally closing passage **58** from chamber **51**. To maintain this position, the force exerted by spring **83** must be at least equal to the force exerted by operating fluid within the interior of member **80**. The tension of spring **83** is adjustable by the arrangement shown in FIG. **1** including retainer **84** which is axially movable by means of set screw **86**, operatively connected through pin **85** to retainer **84**. It will be noted also that the portion of chamber **51** containing spring **83** is placed in fluid communication with the remainder of chamber **51** by means of opening **91** in the intermediate end wall **92** of member **80**. This small diameter opening **91** provides a pressure relief to function as a snubber whereby vibration or clattering of member **80** is prevented.

When the load is raised to a desired position and hence piston **13** is to be extended no further, directional control valve **20** would be shifted to a standby or neutral position whereby fluid flow is stopped. In particular, flow of fluid through valve **20** in either direction between pump **19** and conduit **33** is blocked. The flow responsive member **70** of valve **10** then would be moved to the right in FIG. **1** into abutting relationship with member **80** and a steady state fluid condition would thus exist in the circuit from pump **19** through valve **10** to hydraulic cylinder **11**. Flow controlling member **80** being maintained in the position shown whereby passage **58** is blocked from chamber **51** positively prevents any fluid leakage from this fluid circuit through the valve **10**.

Lowering of the mechanical load on cylinder rod **14** in the system of FIG. **1** is effected by shifting directional control valve **20** to a position wherein motor port **23** is in fluid communication with reservoir **32** and motor port **24** is in communication with pump **19**. As a result, fluid from pump **19** is supplied to the rod end of hydraulic cylinder **11** through a path including conduit **30**, motor port **24** of valve **20**, conduit **36**, ports **35** and **40** of valve **10** and the portion of passage **58** which connects them, conduit **39**, and port or opening **16** in cylinder housing **12**. At the same time, fluid from the piston end of the hydraulic cylinder is returned to reservoir **32** along a path from port or opening **15** in cylinder housing **12** including conduit **37**, a fluid path in valve **10** including port **38**, passage **57**, the interiors of members **70** and **80**, passage **56** and port **34**, conduit **33**, motor port **23** and exhaust port **22** of valve **20**, and conduit **31**. The system rate of flow of fluid from the piston end of hydraulic cylinder **11** through the aforementioned path in valve **10** between ports **38** and **34** thereof to reservoir **32** is controlled by the particular setting of directional control valve **20** and it is a particular feature of this invention that when the system rate of flow of fluid in this path reaches a predetermined magnitude, fluid leaving the piston end of hydraulic cylinder **11** is transmitted through valve **10** directly to the rod end of cylinder **11** thereby circumventing or short-circuiting directional control valve **20** as well as pump **19** and reservoir **32** in a regenerative manner.

Referring now to FIG. **1**, it is seen that opening **73** in the end face of member **70** is a restricted passage for fluid flowing in a direction from valve port **38** through passage **57** through the interior of member **70** to the interior of member **80**. As fluid flows in this path during the mode of operation when piston **13** is being retracted, a pressure reduction occurs in the interior of member **80** relative to the pressure in passage **57**. The pressure being greater in passage **57** and in member **70** than the pressure within member **80** results in a force acting on member **80** and in a direction moving it to the right in FIG. **1** against the force of spring **83**. The magnitude of the pressure drop and hence the force acting on member **80** is controlled as a function of the system rate of flow of fluid which, in turn, depends upon the setting of valve **20**. When the rate of flow is sufficient to create a pressure drop in the interior of member **80** sufficient to overcome the force of spring **83**, which force also can be varied, member **80** is moved to the right in FIG. **1** thereby placing **58** in fluid communication with chamber **51**. Operating fluid then flows directly from chamber **51** into passage **58** so as to unseat check valve member **61** and flow through the remaining portion of passage **58** and thence from port **40** through conduit **39** to the rod end of hydraulic cylinder **11**.

By way of specific example, in an arrangement like that of FIG. **1** designed for a normal system flow rate of 100 gallons per minute, spring **83** would be tensioned to provide a force of 100 pounds per square inch and the diameter of orifice **73** would be dimensioned in relation to the diameter of openings **74** so as to provide a pressure drop of 150 pounds per square inch at a flow rate of 50 gallons per minute.

The arrangement of flow responsive member **70** and flow controlling member **80** therefore meters the flow of fluid as it acts on the end of member **70** so as to provide a throttling action. When the flow direction is reversed by valve **20** during the mode of operation when the load is to be lowered, passage **57** of valve **10** is placed in fluid communication with passage **58** when the rate of flow of fluid, controlled externally as by directional control valve **20**, reaches a predetermined magnitude. The extent of movement of flow controlling member **80** against the force of spring **83** and hence to the right in FIG. **1** is determined by the magnitude of the pressure drop and hence by the system rate of flow of fluid. Thus, the amount by which passage **58** is in communication with chamber **51** and passage **57** is determined by the rate of flow of fluid in the system. By virtue of this arrangement, in the mode of operation wherein the load is lowered, the descent thereof can be either free or powered depending upon the rate of flow of fluid through the circuit as determined by directional control valve **20**. Valve **10**, therefore, functions independently of the capacity of pump **19** and the magnitude of the mechanical load acting on piston **13** to provide a direct flow path for fluid from the piston end to the rod of cylinder **11**. This regenerative action provided by valve **10** prevents the formation of a vacuum or suction in the rod end of cylinder **11**.

It is therefore apparent that the present invention accomplishes its intended objects. While a single specific embodiment has been described in detail, this has been done by way of illustration without thought of limitation.

I claim:

1. A valve comprising:

a. a housing;

b. a chamber in said housing;

c. first, second and third passages intersecting said chamber for connecting said chamber to corresponding valve ports;

d. metering means in said chamber and comprising a pair of individually biased members movable in response to the flow of fluid, said members normally biased in contact and defining therethrough a path placing said first and second passages in fluid communication with each other and closing said third passage, one of said members moving away from the other member to increase the amount of fluid flow between said first and second passages in response to an increase in the rate of fluid flow in one direction through said chamber, said members moving to open said third passage to said chamber when the fluid flow in another direction through said chamber reaches a predetermined rate, said third passage being opened by an amount depending upon the rate of fluid flow; and

e. check valve means located in said third passage and arranged to permit flow from said third passage to the corresponding port but to prevent flow in the reverse direction.

2. A valve according to claim **1** wherein said chamber is elongated and said passages are axially spaced therealong, and wherein said members of said metering means comprise:

a. a flow controlling member biased in a position normally closing said third passage from said chamber;

b. a flow responsive member axially adjacent said flow controlling member and biased normally in contact with said flow controlling member; and

c. said flow controlling member and said flow responsive member together defining a flow path between said first and second passages and having a constriction therein whereby in response to a flow of fluid from said second passage into said path, a pressure reduction is created in the portion of the path defined by said flow controlling member.

3. A valve according to claim **2** wherein said flow controlling member is generally hollow cylindrical in shape, open at the end axially adjacent said flow responsive member, and having a port in the wall thereof placing the interior of said member in fluid communication with said first passage.

4. A valve according to claim **3** wherein said flow controlling member is provided with an annular shoulder adapted to engage a surface in said chamber for limiting travel of said member in a direction closing said third passage.

5. A valve according to claim **4** wherein a spring is included in said chamber for urging said flow controlling member in contact with said flow responsive member.

6. A valve according to claim **2** wherein said flow responsive member is generally hollow cylindrical in shape and provided with a first opening in the axial end wall which is adjacent said flow controlling member and a second opening in the sidewall thereof positioned so as to place said second passage in fluid communication with the interior of said flow responsive member, the first opening being of smaller area than the second opening.

7. A valve according to claim **6** wherein a portion of said axial end wall is in the path of fluid flowing from said first to said second passages.

8. A valve according to claim **6** wherein a spring is included in said chamber for urging said flow responsive member in contact with said flow controlling member.

9. In combination with the valve defined in claim **1**:

a. an hydraulic cylinder having a piston reciprocable therein;

b. a first conduit connecting the piston end of said hydraulic cylinder with the port communicating with said second valve passage;

c. a second conduit connecting the rod end of said hydraulic cylinder with the port communicating with said third valve passage;

d. a directional flow control valve having an inlet port adapted to be connected to a source of fluid under pressure, an exhaust port adapted to be connected to a reservoir, a pair of motor ports and a movable control element for connecting each of said motor ports to either of said inlet and exhaust ports and for controlling the rate of flow of fluid therethrough;

e. a third conduit connecting one of said motor ports with the port communicating with said first valve passage; and

f. a fourth conduit connecting the other of said motor ports with the port communicating with said third valve passage.

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