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FLOW CONTROL VALVE FOR FLUID MOTORS AND THE LIKE

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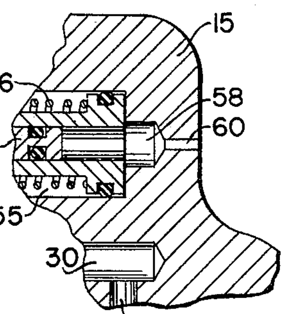
Fig. 3



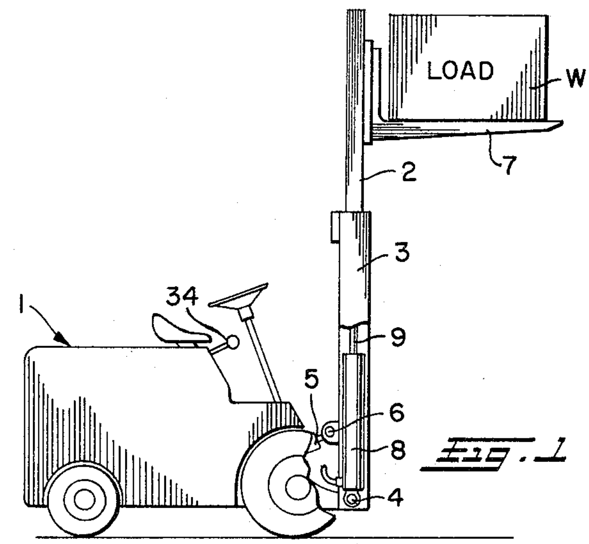


Fig. 1

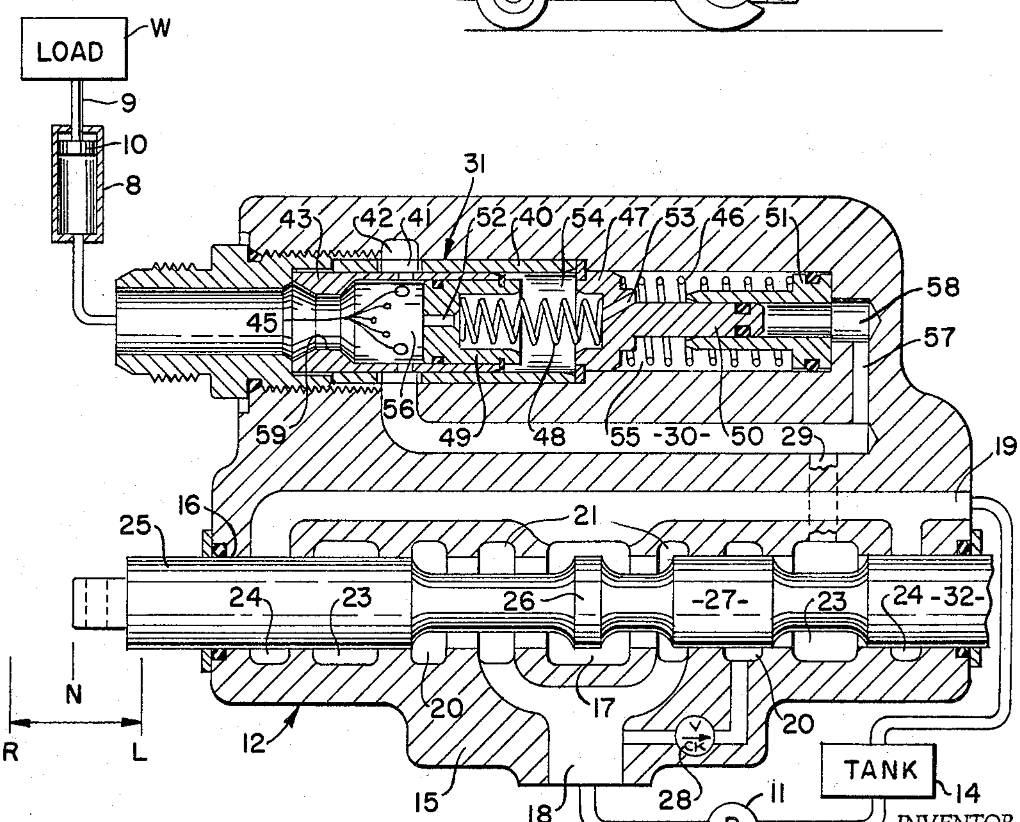


Fig. 2

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FLOW CONTROL VALVE FOR FLUID MOTORS AND THE LIKE

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The present invention relates generally as indicated to a flow control valve for fluid motors and the like and more particularly to a flow control valve which is pressure sensitive, i.e., when the fluid pressure increases, the rate of flow of fluid through the flow control valve decreases.

In the case of a fork lift truck, for example, it is conventional practice to employ a single acting hydraulic motor which, when fluid under pressure is conducted thereto, is operative to raise the lifting fork and a load thereon and which, when the fluid therefrom is permitted to drain into a tank, the lifting fork and load thereon descends. If such lifting fork has a heavy load thereon and is allowed to descend at too rapid a rate, the lift truck will be subject to severe shock load and, in fact, may be tipped when the lifting fork and load is suddenly stopped during descent or at the end of the stroke.

Accordingly, it is a principal object of this invention to provide a flow control valve which is sensitive to fluid pressure to permit rapid descent of a piston in a cylinder under light load and to permit progressively decreased rate of descent of the piston as the load is progressively increased. Thus, in the case of a fork lift truck, for example, the lift fork when empty, or lightly loaded, will descend at a rapid rate, as desired, when the directional control valve is operated to permit such descent. On the other hand, when the lift fork has a heavy load thereon, and the directional control valve is operated to permit lowering thereof, the present flow control valve will automatically restrict the flow according to the magnitude of the load.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

FIG. 1 is a side elevation view partly in cross-section illustrating a typical fork lift truck employing a single acting fluid motor for raising and lowering the lifting fork thereof;

FIG. 2 is a cross-section view through a flow control valve embodying the present invention, said flow control valve being shown in association with a directional control valve for a single acting cylinder, said directional control valve being here shown by way of example as a three-way spool-type valve; and

FIG. 3 is a fragmentary cross-section view of a modified form of flow control valve.

Referring now in detail to the drawing; and first to FIG. 1, the reference numeral 1 denotes a fork lift truck to the lower front portion of which a telescoping mast structure 2–3 is pivotally mounted at 4. Said mast structure 2–3 is adapted to be tilted back about pivot 4 as by a double acting fluid motor 5 pivotally connected to the

mast structure at 6 and pivotally connected at its other end (not shown) to the truck frame.

As aforesaid, the mast structure 2–3 herein is of telescoped form including a lower section 3 in which the upper section 2 is vertically slidably guided and, in turn, the lifting fork 7 is vertically slidably guided in said upper section 2. Mounted on the pivot 4 is the single-acting cylinder 8 having its piston rod 9 linked by chains or the like, not shown, to cause vertical movement of the upper mast section 2 with respect to the lower mast section 3 and upward movement of the lifting fork 7 with respect to the upper mast section 2. When the piston 10 (see FIG. 2) moves down in the cylinder 8, the upper section 2 moves down into telescoped relation within the lower section 3 of the mast structure and then the lifting fork 7 moves down with respect to both sections 2 and 3 for placing the load W on the floor F. This is schematically shown in FIG. 2 wherein the load W is lifted by admitting fluid under pressure from pump 11 via the directional control valve 12 into the lower end of the cylinder 8, and the load W is permitted to descend when the fluid in the cylinder 8 is allowed to escape into the reservoir or tank 14, via the directional control valve 12.

Referring now in detail to FIG. 2, there is provided a housing 15 which has a bore 16 therethrough intersected by a bypass passage 17 which at one end communicates with the inlet port 18 and which at the other end communicates with tank port 19, by a pair of pressure feed passages 20, 20 which straddle the branches 21, 21 of the bypass passage, by a pair of motor passages 23, 23, and by a pair of return passages 24, 24 which lead to the aforesaid tank port 19.

Reciprocable in said bore 16 is a three-way valve spool 25 and it can be seen that when said spool 25 is in the neutral position N as shown in FIG. 2, the pump 11 will freely circulate fluid through the bypass passage 21–17 into the tank 14. When the spool 25 is shifted to raise position R, the bypass passage 21–17 will be closed by the lands 26 and 27, and fluid communication will be opened between the right pressure feed and motor passages 20 and 23, whereby fluid under pressure delivered by the pump 11 into the inlet port 18 will flow through the check valve 28 into the right pressure feed passage 20 and thence to the right motor passage 23 wherefrom the fluid under pressure flows through the passages 29 and 30 and through the flow control valve 31 into the lower end of the cylinder 8 thus to act on the piston 10 to raise the same and the load W thereon.

When the spool 25 is shifted to the lower position L, the bypass passage 21–17 remains open, and fluid communication is established between the right motor passage 23 and the right return passage 24, whereby the load W on the piston 10 will displace the liquid in the cylinder 8 through the flow control valve 31 and passages 30 and 29 into the tank 14 via the right motor and return passages 23 and 24 and tank port 19. When the spool is in neutral position N, the lands 27 and 32 thereof block communication of the right motor passage 23 with the adjacent pressure feed and return passages 20 and 24, whereby fluid is trapped in the cylinder 8 so that the piston 10 and load W thereon are locked in raised position.

In FIG. 1, the operating lever 34 will be operatively connected with the spool 25 to shift it to its various positions aforesaid and it is understood that the valve housing 15 may have another spool therein for controlling the mast tilt cylinder 5. Furthermore, while not shown herein, the spool 25 may have associated therewith the usual spring centering mechanism which automatically returns the spool to the "N" position upon release of the control lever 34, and it is further contemplated that suitable detent mechanisms may be employed to yieldably retain the spool **25** in either or both the "R" and "L" positions, whereby the operator may manipulate the lever **34** to the desired position and use both hands for driving the truck while the load W is being raised or lowered.

The flow control valve **31** herein comprises a sleeve member **40** having passages **41** through the wall thereof which register with the annular passage **42** in the housing **15**. Reciprocable in said sleeve member **40** is the flow control member **43** which has a plurality of apertures **45** of varying sizes therethrough which, as can be seen, when the flow control member **43** moves to the right as viewed in FIG. 2, the largest apertures **45** will progressively be covered by the right edges of the passages **41** of the sleeve member **40** to decrease the aggregate flow capacity through apertures **45**. As the member **43** continues to move to the right the second largest, then the third largest, etc., apertures **45** will progressively be covered until only the smallest apertures **45** will remain uncovered for most restricted flow. The member **43** is capable of movement to the right even to the extent where the smallest apertures **45** are covered by the right edges of the sleeve passages **41**, whereby exhaust flow from the cylinder **8** under extremely heavy load may be substantially completely blocked except for leakage around the sleeve member **40** and through the sliding fit between the flow control member **43** and sleeve **40**.

The flow control member **43** is biased to its full open position, as shown in FIG. 2, by the spring **46** which bears on the member **47**, and said plunger member **47**, in turn, bears on flow control member **43** through spring **48** and plug member **49**. Said plunger member **47** has a plunger stem **50** which is axially slidably sealed in cylinder member **51**. The plug and plunger members **49** and **47** have pressure equalizing orifices **52** and **53** therethrough so that the fluid pressures in the chambers **54** and **55** will be equal to that in the chamber **56** in the flow control member **43**. The housing **15** has a passage **57** leading from passage **30** to chamber **58** so that fluid pressure may act on the end of plunger stem **50**.

When the spool **25** is in the neutral position N, the flow control member **43** will be in the position shown in FIG. 2 regardless of the load W on the piston **10**, since in that condition of the spool **25**, the pressures are equalized on both sides of the plunger stem **50** in the chambers **56**, **54** and **55** and in the passages **30** and **57** and chamber **58**. However, when the spool **25** is shifted to the lower position L, the communication of the motor passage **23** with the right return passage **24** results in a pressure drop in the passages **29**, **30** and **57** and in chamber **58** leading to the plunger stem **50**, whereupon the higher pressure in the chambers **56**, **54**, and **55** acting on the area of said plunger stem **50** will cause the flow control member **43** to move to the right compressing spring **46** thus to decrease the flow rate through the apertures **45**. The greater the load W, the greater the pressure differential acting on plunger stem **50** due to decreasing flow capacity through apertures **45** and thus as the load W is increased, the rate of descent thereof is decreased.

When the load W on the piston **10** is a minimum, that is, the weight of the lifting fork **7** and of the upper mast section **2**, the bias of the spring **46** is preferably such that the plunger stem **50** will not move toward the right under the influence of the relatively small fluid pressure differential in the chambers **56** and **58**.

Assuming now that the lifting fork **7** has a maximum load W thereon for which the equipment is designed, such that, for example, there is built up a pressure of 1000 p.s.i. on the liquid in the lower end of the cylinder **8**. So long as the spool **25** is in its neutral position N such 1000 p.s.i. pressure is prevalent throughout the system from cylinder **8** to motor passage **23**, and thus all of the parts of the flow control assembly will remain as shown in FIG. 2. However, when the spool **25** is shifted to lower position L, the pressure in the chamber **58** will drop substantially whereupon the pressure in the chambers **56**, **54**, and **55** acting on the area of the plunger stem **50** will compress the spring **46** to permit movement of flow control member **43** to the right to decrease the flow capacity through the apertures **45** to the desired extent so that the lifting fork **7** and its load W will descend at the desired rate so as not to shock the equipment or to tip it over when the fork **7** reaches its lowest point, or when the spool **25** is shifted back to neutral position N. Similarly, when the fork **7** has a load W thereon between minimum and maximum, the resulting pressure differential in the chambers **56** and **58** will compress the spring **46** to less extent with the result that the flow control member **43** will move to the right to permit flow through apertures **45** at a desired rate which will be less than the maximum rate (with no load on fork **7**) but greater than the minimum rate (with maximum load W on fork **7**).

When the spool **25** is shifted to raise position R, the motor passage **23** is communicated with the feed passage **20** whereupon fluid under pressure flows through passages **29** and **30**, and apertures **45** to the lower end of cylinder **8** to raise the load W. In that case, the pressure in chamber **58** is greater than in chambers **56**, **54**, and **55** due to pressure drop in passage **30** and apertures **45** and thus the flow control member **43** will be held in FIG. 2 position by spring **46** and by the higher fluid pressure in chamber **58** acting on the end of the plunger stem **50**. The pressure drop across passage **59** also aids in maintaining flow control member **43** in its maximum flow position.

With further reference to the flow control member **43**, and plunger member **47**, they are, in effect, integral, but because of the provision of the equalizing orifice **52** of smaller size than the equalizing orifice **53**, the chamber **54** becomes a dashpot or cushioning chamber to minimize the effect of shock loads in the system. For example, when the spool **25** is shifted from lower position L to neutral position N the load W will be suddenly stopped and its inertia will cause shock pressure in the system, but because of the orifice **52** the pressure in the chamber **54** cannot be instantly increased and thus plug member **49** may move slightly to the right compressing spring **48** to isolate the shock from plunger member **47**. Moreover, if the load W is a very heavy one, only the smallest apertures **45** will be open to dissipate shock pressures in the downstream passages **30**, **29**, and **57**.

When the load W is at rest with the spool **25** in the neutral position N, pressure in the system due to the load W will be equalized and the flow control elements, that is, the flow control member **43**, the plug member **49**, the plunger member **47** and the cylinder member **51** will be in the positions shown in FIG. 2. Now, if the spool **25** is shifted to raise position R, the pressure in the system will have to increase to a value greater than that due to the load W in order to overcome the inertia of the load W and to raise the load. As the pressure supplied by the pump **11** flows into the system through the inlet port **18**, check valve **28**, pressure feed passage **20**, and motor passage **23**, the increasing fluid pressure may tend to actuate the cylinder member **51** toward the left against the spring **46** to displace the fluid in the chamber **55** through the equalizing orifice **53** into the chamber **54** and the build-up of pressure in the chamber **54** (due to smaller orifice **52**) resists the opposing pressure in chamber **56** so as to avoid pulsating or fluttering movement of the flow control member **43**. Here again the chamber **54** (and also chamber **55**) acts as a cushioning chamber or dashpot.

In the modification illustrated in FIG. 3, the chamber **58** is vented to the atmosphere by passage **60** instead of being communicated with passages **29** and **30** by way of passage **57** as in FIG. 2. Accordingly, static fluid pressure in chambers **56**, **54**, and **55** will move plunger stem **50** to the right against spring **46** a distance proportional to the magnitude of the pressure, thus correspondingly relaxing the spring **48**. When the spool **25** is shifted to lower position L with a heavy load W on piston **10** even a very small pressure drop across passage **59** will move the members **43** and **49** against relaxed spring **48** to effect substantial restriction of flow by apertures **45**. On the other hand if there is a light load W, the spring **46** will not be further compressed at all or only very slightly whereby even a substantial pressure drop across passage **59** will not move the member **43** appreciably against spring **48** to flow restricting position and thus the light load W can descend rapidly. In this FIG. 3 embodiment, the spring **46** is sufficiently strong so as not to require assistance of fluid pressure in chamber **58** as is the case in FIG. 2 wherein fluid pressure has access to chamber **58** through passage **57**. Accordingly, when spool **25** is shifted to raise position R, the pressure drop across passage **59** and the force of spring **48** will urge the sleeve **43** toward the left for full flow through apertures **45** even though high pressure due to heavy load W holds the plunger **47** at its rightward actuated position.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A flow control valve comprising a housing having a passage therethrough, a flow control sleeve means having an aperture through the wall thereof disposed in said housing for movement in one direction from a position whereat said aperture is in direct open alignment with said passage to effect a progressive closing of said aperture as said aperture is moved out of alignment with said passage, means within said housing defining a chamber having restricted fluid communication with fluid pressure upstream of said aperture, a fluid pressure actuated plunger in said housing having its respective ends exposed to fluid pressure downstream of said aperture via a branch passage leading to one end of said plunger and to fluid pressure in said chamber, and spring means biasing said plunger and sleeve means in a direction maintaining said aperture in such direct open alignment with said passage, said chamber constituting a cushioning chamber to resist sudden changes in fluid pressure therein.

2. A flow control valve comprising a housing having a passage therethrough, and a flow control member movable in said housing to vary the rate of flow of fluid through said passage, said flow control member comprising a plunger means having a portion thereof exposed to fluid pressure on the upstream side thereof for actuation thereby, sleeve means axially reciprocable in a bore in said housing and having apertures through the wall thereof, first spring means biasing said plunger means in opposition to such fluid pressure for yieldably maintaining said sleeve means in a position whereat said apertures are in full fluid communication with said passage, said sleeve means also having a portion thereof exposed to fluid pressure on the upstream side thereof for actuation thereby in one direction during actuation of said plunger means by increasing fluid pressure to cause a progressive closing of said apertures for reduced fluid communication between said apertures and passage, and a second spring means between said plunger means and sleeve means for exerting decreasing resistance to movement of said sleeve means in such one direction as said plunger means is thus actuated by increasing fluid pressure.

3. The valve of claim **2** wherein said plunger means has another portion opposite said first mentioned portion vented to the atmosphere.

4. The valve of claim **2** wherein said plunger means has another portion opposite said first mentioned portion exposed to fluid pressure downstream of said apertures via a branch passage leading to one end of said plunger means.

5. The valve assembly of claim **2** further comprising a plug member disposed in said bore between said sleeve means and plunger means, said plug member being maintained in engagement with said sleeve means by said second spring means and defining with said plunger means and the wall of said bore a chamber having restricted fluid communication with the fluid pressure on the upstream side thereof to minimize the effect of shock loads on said plunger means.

6. A flow control valve comprising a housing having a passage therethrough, a flow control sleeve axially slidably received in a bore in said housing and having apertures through the wall thereof, a plunger and plug member disposed in said bore with said plug member located between said sleeve and plunger, said plug member and plunger defining with the wall of said bore a first chamber having restricted fluid communication with fluid pressure upstream of said apertures, spring means engaging said plunger for biasing said plunger and thus said sleeve in a direction maintaining said apertures in substantially full fluid communication with said passage, said plunger also defining with the wall of said bore a second chamber having restricted fluid communication with said first chamber, said plunger having a stem portion projecting into said second chamber, and means for isolating the outer end of said stem portion from the fluid pressure in said second chamber so as to provide a larger area on said plunger exposed to fluid pressure in said first chamber than in said second chamber, whereby there is a progressive movement of said plunger and thus said sleeve in the opposite direction for effecting a progressive reduction in fluid communication between said passage and apertures as the fluid pressure upstream of said apertures is increased.

7. The valve of claim **6** wherein said outer end of said stem portion is exposed to the atmosphere.

8. The valve of claim **6** wherein said outer end of said stem portion is exposed to fluid pressure downstream of said apertures via a branch passage leading to said outer end of said stem portion.

9. The valve of claim **8** wherein said means for isolating the outer end of said stem portion from the fluid pressure in said second chamber comprises a cylinder member disposed in said bore for receipt of said stem portion, and there is a greater fluid restriction between said first chamber and the fluid pressure upstream of said apertures than between said first and second chambers, whereby any increase in the fluid pressure in said second chamber will be resisted by the opposing pressure in said first chamber so as to avoid fluttering of said flow control sleeve.

10. A valve assembly for actuation of a fluid motor comprising a housing having an inlet port for connection with a fluid pressure source, a motor port for connection with a fluid motor, and a return port for connection with a fluid reservoir; a directional control valve member movable in said housing from a neutral position blocking fluid communication between said motor port and said inlet and return ports to operating positions selectively communicating said motor port with said inlet port or said return port; and a flow control valve contained within said housing for varying the rate of flow of fluid from said motor port to said return port when said valve member is in that operating position, said flow control valve comprising a plunger means having a portion thereof exposed to fluid pressure on the motor port side thereof for actuation thereby, a sleeve means axially reciprocable in a bore in said housing and having apertures through the wall thereof, first spring means biasing said plunger means in opposition to such motor port fluid pressure for yieldably maintaining said sleeve means in a position whereat said apertures are in full fluid communication with said motor port, said sleeve means also having a portion thereof exposed to fluid pressure on the motor port side thereof and actuated thereby in one direction during actuation of said plunger means by increasing fluid pressure in said motor port to cause a progressive closing of said apertures for reduced fluid communication between said apertures and motor port, and a second spring means between said plunger means and sleeve means for exerting decreasing resistance to movement of said sleeve means in such one direction by flow of fluid therethrough as said plunger means is thus actuated by increasing fluid pressure.

11. The valve assembly of claim **10** further comprising a plug member disposed in said bore between said sleeve means and plunger means, said plug member being maintained in engagement with said sleeve means by said second spring means and defining with said plunger means and the wall of said bore a chamber having restricted fluid communication with fluid pressure in said motor port to minimize the effect of shock loads on said plunger means.

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