Oct. 19, 1965 G. J. MARTIN 3,212,523

FLUID SYSTEM AND RELIEF VALVE ASSEMBLY THEREFOR

Filed Sept. 27, 1963

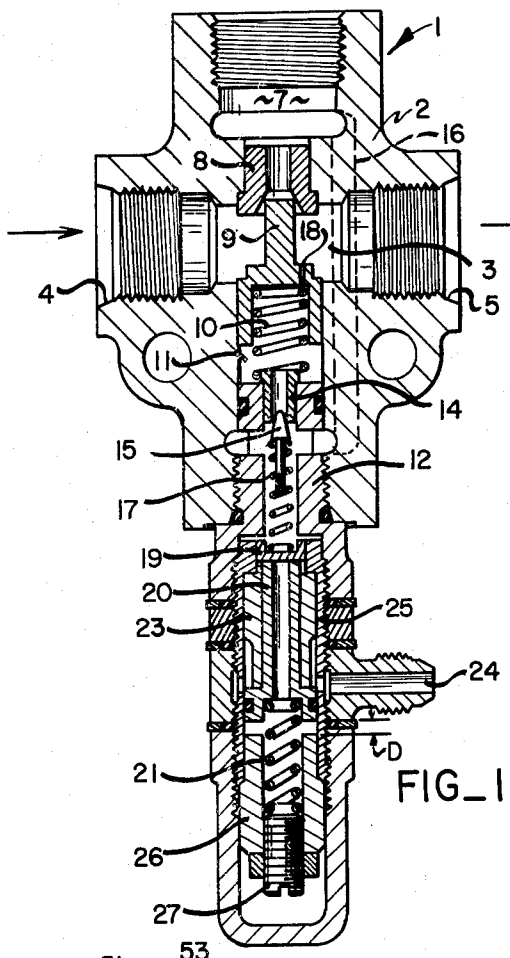


FIG_1

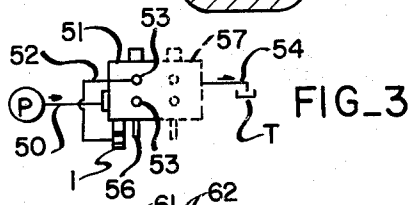


FIG_3

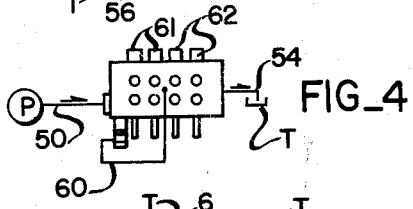


FIG_4

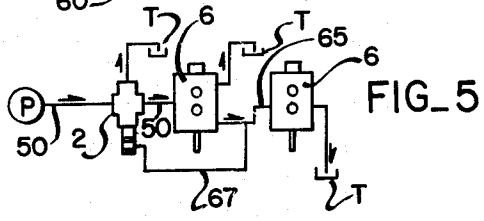


FIG_5

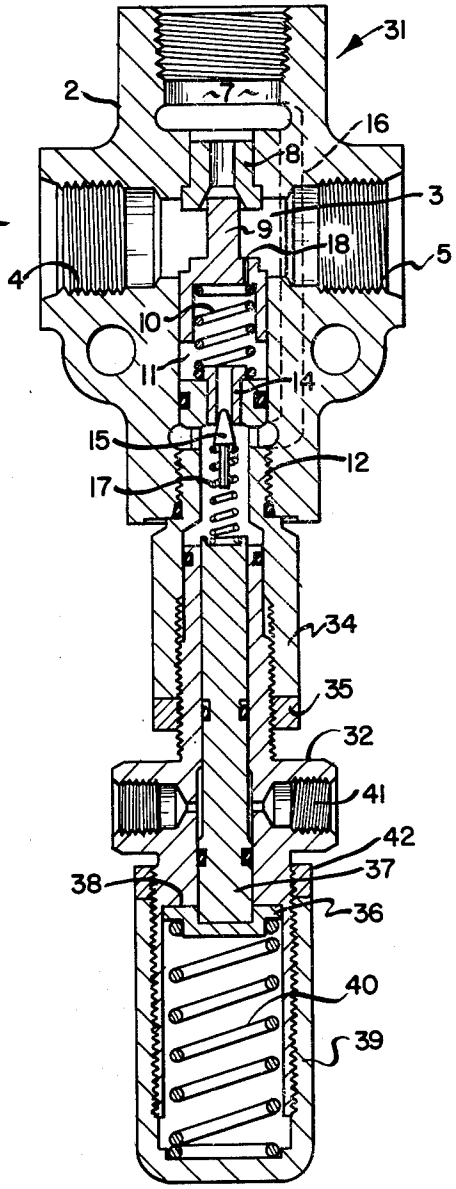


FIG_2

INVENTOR.
GEORGE J. MARTIN
BY
Oberlin, Maky & Donnelly
ATTORNEYS

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FLUID SYSTEM AND RELIEF VALVE ASSEMBLY THEREFOR

George J. Martin, Lyndhurst, Ohio, assignor to Parker-Hannifin Corporation, Cleveland, Ohio, a corporation of Ohio

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14 Claims. (Cl. 137—596.13)

The present invention relates generally as indicated to a fluid system and relief valve assembly therefor and more particularly to a fluid system that comprises a pump, a reservoir, one or more fluid motors, one or more directional control valves for said motor or motors, and a relief valve assembly that has different relief pressures depending on directional control valve actuation.

In fluid systems such as those associated with front end loaders, bulldozers, load handling, and like equipment, it is desired to have available different maximum fluid pressures for actuating one or more fluid motors. For example, in the case of load handling equipment which is provided with a boom extending motor and a boom hoist motor, the former normally would be of the relatively small diameter-long stroke size, whereas the latter would generally be of relatively large diameter-short stroke size. Accordingly in such equipment it may be desired to have available the higher fluid pressure for actuating the boom extending motor.

Accordingly, it is one principal object of this invention to provide a fluid system and relief valve assembly which, in the case of a system including either an open center or closed center directional control valve for a double acting fluid motor, is so arranged that one motor port of the valve is relieved at the normal high pressure setting of the relief valve, whereas the other motor port connected with a control port of the relief valve is relieved at a lower pressure.

It is another object of this invention to provide a fluid system and relief valve therefor which, in the case of an open center system comprising a plurality of directional control valves for corresponding single or double acting fluid motors, is so arranged that the upstream directional control valve or valves nearest the pressure inlet have their motor ports relieved at the normal high pressure setting of the relief valve and the downstream directional control valve or valves have their motor ports relieved at a lower pressure.

It is another object of this invention to provide a fluid system and relief valve therefor in which the latter is provided with means for adjusting the higher relief pressure at which the relief valve will be opened, and the minimum control pressure needed to decrease the relief pressure to a lower value.

It is another object of this invention to provide a fluid system and relief valve therefor in which the latter is provided with means for adjusting the normal high pressure at which the relief valve will be opened and the control pressure at which the relief valve will be actuated to relieve at predetermined lower pressures.

It is still another object of this invention to provide a fluid system and relief valve therefor in which the main relief pressure will continue to be lowered a predetermined amount for each increment of increase of control pressure over and above that required to initially lower the relief pressure from its high setting to a lower setting.

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 drawings

setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

FIG. 1 is a cross-section view of one form of relief valve assembly which may be employed in fluid systems as schematically depicted in FIGS. 3, 4, and 5;

FIG. 2 is a cross-section view similar to FIG. 1 illustrating another form of relief valve assembly usable in the fluid systems of FIGS. 3, 4, and 5; and

FIGS. 3, 4, and 5 are schematic diagrams of fluid systems employing the relief valves of either FIGS. 1 or 2 to provide high and low relief pressures according to how a directional control valve is actuated or according to which of a plurality of directional control valves is actuated.

Refering now more particularly to the drawing, and first to FIG. 1, the relief valve assembly **1** therein comprises a body or housing **2** having a pressure supply passage **3** therethrough terminating at one end in a port **4** to which the pressure delivery port of the pump P (see FIG. 5) is connected and terminating at the other end in a port **5** which connects with the inlet port of a directional control valve **6**, as shown for example, in FIG. 5. Intersecting the through passage **3** is the relief passage **7** leading to a tank T. The relief passage **7** has therein a tubular seat member **8** which is closed by the main relief valve member **9** which is biased by spring **10** and by fluid pressure in the chamber **11** tending to hold said main relief valve member **9** in engagement with the seat member **8**.

A bushing **12** screwed into said body **2** is provided with a tubular seat member **14** for the pilot valve member **15** which, when seated, as shown, closes communication between the chamber **11** and the passage **16** which leads to the tank T via relief passage **7**. The pilot valve member **15** is biased against the seat member **14** by the spring **17** and, as evident, when the fluid pressure in the chamber **11** acting on the exposed area of the pilot valve member **15** overcomes the seating effect of the spring **17**, the pilot valve member **15** will be urged away from seat member **14** to vent the chamber **11** to the tank T. Because the flow capacity of the orifice **18** in the main valve member **9** is less than the flow capacity through the pilot member **14**, the pressure in the chamber **11** will drop with respect to the pressure in the passage **3**, whereby the main valve member **9** will be moved away from the seat member **8** to relieve excess pressure through the relief passage **7**.

In order to provide for relief of a lower pressure in the through passage **3** provision is herein made for partly relaxing the pilot valve spring **17**. This is accomplished by providing a pilot valve spring follower **19** which is engaged by the spring-loaded plunger **20** which, when there is little or no pressure in the control port, is held by spring **21** against the stop sleeve **23** thus to maintain the follower **19** in the position of maximum compression of the pilot valve spring **17**.

When the fluid pressure in the control port **24** is of magnitude sufficient to urge the plunger **20** downwardly against spring **21**, the follower **19** moves downwardly a corresponding distance thereby permitting partial decompression of the pilot valve spring **17**. The control port pressure required to move the plunger **20** downwardly the distance D is usually considerably less than the minimum or low pressure relief setting of the valve **1**.

The low relief pressure setting is adjusted by turning the bushing **25** while the plunger **20** is down against backup member **26** closing gap D, this being done as by loosening the screw **27** which bears on spring **21**. The pressure differential above the desired low setting which is the high pressure setting of the valve **1** is determined by the magnitude of the gap D which is usually

factory pre-set. After making the low pressure setting as aforesaid, the plunger spring **21** is reset by turning screw **27** until the pressure gauge (not shown) in the pressure line from pump P shows no further rise in relief pressure, thus indicating that the plunger **20** has engaged stop sleeve **23** and has moved the distance D away from backup member **26**.

Referring now to FIG. 2, the relief valve assembly **31** there shown may be the same as shown in FIG. 1 insofar as the body **2**, main relief valve member **9**, pilot valve member **15**, etc. are concerned, as evidenced by like reference numerals employed in both FIGS. 1 and 2. A primary difference between the FIGS. 1 and 2 relief valve assemblies **1** and **31** resides in the construction of FIG. 2 in which the high relief pressure setting is made by turning the control port body **32** which is in threaded engagement with the pilot valve bushing **34** and locking it at the desired adjusted position by means of the lock nut **35**. When so turning the control port body **32**, the follower **36** of plunger **37** is held against shoulder **38**.

The cap **39** threaded on body **32** is turned to adjust the follower spring **40** thus to determine what magnitude of fluid pressure in control port **41** will cause downward movement of plunger **37** and consequent partial decompression of pilot valve spring **17**.

Accordingly, with fluid pressure in control port **41** insufficient to move the plunger **37** downwardly against the spring **40**, the parts will be in the position shown in FIG. 2 and a predetermined maximum pressure in the through passage **3** and in the chamber **11** will be relieved when that pressure is sufficient to unseat the pilot valve member **15** thereby creating the unbalance in pressures in the through passage **3** and in the chamber **11** to cause opening movement of the main relief valve member **9**. Assuming now that there is sufficient pressure in control port **41**, to move the plunger **37** downwardly thereby compressing the spring **40**, such downward movement of the plunger **37** will effect relaxation of the pilot valve spring **17** so that the through passage **3** will be relieved at a lower pressure.

By way of example, the high pressure setting through adjustment of the control port body **32** may be anywhere between 500 and 3,000 p.s.i. The compression on the plunger actuator spring **40** is adjusted by turning the spring backup cap **39** in either direction and locking it at adjusted positions by means of the lock nut **42**. The arrangement may be such that the unloading or control pressure may be adjusted between 500 and 2500 p.s.i. pressure and so that the relief pressure will decrease, say, 500 p.s.i. for each 100 p.s.i. increase in control port pressure above the initial setting of the plunger spring **40**.

As an example, if the pilot valve spring **17** is set to relieve the pressure in the through passage **3** at 2000 p.s.i. and the plunger spring **40** is set to permit actuation of the plunger **37** at 1000 p.s.i. control port pressure, a rise in control port pressure to 1100 p.s.i. will permit relief of the passage **3** at 1500 p.s.i. As the control port pressure further increases, each 100 p.s.i. increase will result in a 500 p.s.i. decrease in the pressure at which the main relief valve **9** will relieve the through passage **3**.

Having thus described two embodiments of the relief valve assembly, reference will now be made to the systems shown schematically in FIGS. 3, 4, and 5 illustrating how these relief valves **1** and **31** may be used in fluid systems to provide high and low relief pressures of the system according to which way a particular directional control valve is actuated or which one of a plurality of directional control valves is actuated. Although the relief valves **1** and **31** herein shown are each provided with its own body **2** for connection with the inlet port of a directional control valve housing, it is to be understood that either relief valve assembly may be incorporated in a directional control valve housing in a manner disclosed, for example, in the Patent to George J. Markovich 3,023,584 dated March 6, 1962 and in my copending application Ser. No. 159,413, filed December 14, 1961 now Patent No. 3,160,076 dated Dec. 8, 1964. Such incorporation of the relief valve assembly **1** or **31** as a part of the directional control valve housing is shown herein in FIGS. 3 and 4.

With reference to FIG. 3, the fluid system comprises a pump P having its pressure delivery port connected by conduit **50** to the inlet port of the housing of a directional control valve **51**, a relief valve assembly **1** or **31** in accordance with either FIG. 1 or FIG. 2, having its control port **24** or **41** communicated by way of conduit **52** with one of the two motor ports **53**, **53** of the directional control valve **51**. As aforesaid, the body **2** of the relief valve assembly is herein shown as an integral part of the housing of the directional control valve **51**, whereby the relief passage **7** and the return passage **16** lead to a return port in valve **51** which, in turn, is connected by conduit **54** with the tank T. The control valve **51** shown in FIG. 3 may be of the open center, or closed center type and when it is of the open center type the movable valve member thereof when in a neutral position blocking flow of fluid under pressure from the inlet to both motor ports **53**, **53** permits the pump output to freely flow through a bypass in valve **51** to the return port and tank T. The motor ports **53**, **53** may be connected in well known manner to the opposite ends of a double acting fluid motor, whereby when the valve member **56** is shifted to communicate the fluid pressure inlet with the lower motor port **53** to actuate the motor in one direction, the return pressure in the upper motor port **53** will not be sufficient to overcome the force exerted by the spring **21** or **40** against the plunger **20** or **37** and, therefore, a maximum pressure can be built up in the pressure circuit as determined by the setting of the pilot valve spring **17**. However, when the control valve member **56** is shifted to a position communicating the pressure circuit with the upper motor port **53** to actuate the motor in the opposite direction, the pressure which builds up in the upper motor port **53** will, through the conduit **52**, reach the control port **24** or **41** of the relief valve **1** or **31** and will cause it to be moved downwardly to effect partial decompression of the pilot valve spring **17** with the result that the relief pressure of the pressure circuit will be decreased when the motor is actuated by fluid under pressure in the upper motor port **53**. As shown in dotted lines in FIG. 3, additional one or more directional control valves **57** may be provided to control additional fluid motors and in that case the relief valve **1** or **31** will relieve the pressure circuits at the higher pressure setting of the relief valve, since the relief valve actuating pressure through the control port **24** or **41** will not be sufficient in the case of the other directional control valve or valves **57** to move the plunger **20** or **37** to effect a lower pressure setting of the main relief valve **9**.

FIG. 4 is generally similar to FIG. 3 except that the control port conduit **60** is connected in the bypass circuit of the open center system so that when either of the upstream directional control valves **61** is actuated the relief pressure will be the maximum for which the pilot valve spring **17** has been set and so that when either of the downstream directional control valves **62** is actuated, the bypass line becomes the pressure supply line and consequently pressure builds up in the control port conduit **60** to cause movement of the plunger **20** or **37** that effects partial decompression of the pilot valve spring **17** to thus provide a lower relief pressure in the pressure circuits of the downstream directional control valves **62**.

FIG. 5 illustrates a fluid system utilizing either relief valve assembly **1** or **31** as it is shown in FIG. 1, or FIG. 2 in connection with a plurality of directional control valves **6** that have separate housings and a bypass conduit **65** leading from one valve **6** to the other. Accordingly, when the upstream directional control valve **6** is actuated, the motor connected to the motor ports thereof

is actuated at the maximum pressure for which the pilot valve member **15** is set by spring **17** and when the downstream directional control valve **6** is actuated, the pressure inlet circuit from the pump P through the body **2** of relief valve **1** or **31**, through the bypass of the upstream directional control valve **6**, through bypass conduit **65**, to either motor port of the downstream valve **6** will be decreased by reason of fluid pressure in the control port conduit **67** acting on the plunger **20** or **37** to effect partial decompression of the pilot valve spring **17**.

Although both relief valves **1** and **31** herein disclosed employ pilot operated relief valves, it is to be understood that a conventional spring biased main relief valve member may be provided, and in this case, the backup member for the spring would be the fluid pressure actuated plunger **20** or **37**, also backed up by a spring **21** or **40** to maintain a predetermined compression on the main valve spring for the higher pressure relief setting.

In the case of an arrangement such as shown in FIG. 5 the directional control valves **6**, **6** may be joined together in well-known manner in parallel or series-parallel and in either event, the actuation of the upstream valve **6** provides for the higher relief pressure; and the actuation of the downstream valve **6** provides for the lower relief pressure. In a parallel circuit simultaneous actuation of the valves **6**, **6** results in the lower relief pressures at the inlet and this is true even though the valve member of the upstream valve **6** is in a metering position. In the series-parallel circuit when both valves **6**, **6** are simultaneously actuated the higher relief pressure setting is in effect for the upstream valve **6** with no pressure available at the downstream valve **6**, and when the upstream valve **6** is in a metering position while the downstream valve **6** is actuated, the lower relief pressure setting will be in effect.

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. In combination, a directional control valve assembly having an inlet port for fluid communication with a pump and providing two pressure circuits from said inlet port for fluid motor actuation; valve means in said assembly selecting either one of said circuits for motor actuation; a relief valve having a relief port in fluid communication with said inlet port and a control port in fluid communication with but one pressure circuit, said relief valve comprising a movable relief valve member therein, spring means biasing said relief valve member to a position closing said relief port, and a fluid pressure actuated means bearing on said spring means in a direction for yieldably holding said relief valve member in a position closing said relief port, said fluid pressure actuated means being exposed to fluid under pressure in said control port and movable thereby to decrease the spring bias on said relief valve member whereby the latter opens said relief port to said inlet port at a lower fluid pressure when said one circuit is selected for motor actuation than when the other circuit is selected for motor actuation.

2. The combination of claim **1** wherein said directional control valve assembly comprises a four-way valve having a pair of motor ports constituting said pressure circuits for actuation of a double acting fluid motor.

3. The combination of claim **1** wherein said directional control valve assembly comprises at least two valves with passages thereto constituting said pressure circuits for actuation of a corresponding number of fluid motors.

4. In combination, a directional control valve assembly having an inlet port for fluid communication with a pump and providing two pressure circuits from said inlet port for fluid motor actuation; valve means in said assembly selecting either one of said circuits for motor actuation; a relief valve having a relief port in fluid communication with said inlet port and a control port in fluid communication with but one pressure circuit; said relief valve comprising a movable relief valve member therein, spring means biasing said relief valve member to a position closing said relief port, a fluid pressure actuated member exposed to fluid under pressure in said control port, and another spring means biasing said fluid pressure actuated member in a direction bearing on said spring means for holding said relief valve member in a position closing said relief port when said other circuit is selected for motor actuation, said another spring means yielding under the influence of fluid pressure in said control port acting on said fluid pressure actuated member to permit movement of the latter to decrease the spring bias on said relief valve member, whereby said relief valve member opens said relief port to said inlet port at a lower fluid pressure when said one circuit is selected for motor actuation than when the other circuit is selected for motor actuation.

5. The combination of claim **4** wherein stop means are provided in said relief valve for engagement by said fluid pressure actuated member to determine the maximum relief pressure when said other circuit is selected for motor actuation.

6. The combination of claim **5** wherein additional stop means are provided in said relief valve for engagement by said fluid pressure actuated member to determine the minimum relief pressure when said one circuit is selected for motor actuation.

7. The combination of claim **5** wherein said another spring means yields in proportion to the increase in fluid pressure in said control port when said one circuit is selected for motor actuation thus to proportionately decrease the bias of said first-mentioned spring means on said relief valve member.

8. The combination of claim **5** wherein means are provided for adjustment of the bias of said first-mentioned and another spring means on said relief valve and fluid pressure actuated members respectively.

9. A relief valve comprising a housing having an inlet port for connection with a fluid pressure source and a relief port for connection with a fluid reservoir; a relief valve member movable in said housing to open and close fluid communication between said inlet port and relief port according to the magnitude of fluid pressure in two fluid circuits with which said inlet port is selectively adapted to be communicated; spring means biasing said member to a position closing such communication between said ports; a fluid pressure actuated member bearing on said spring means; said housing having a control port for connection with one fluid pressure circuit; said fluid pressure actuated member being exposed to fluid pressure in said control port and movable thereby to decrease the spring bias on said relief valve member; another spring means biasing said fluid pressure actuated member in a direction to increase the bias of said first-mentioned spring means on said relief valve member when the other circuit is selected whereby fluid pressure in said control port acting on said fluid pressure actuated member is insufficient to move the latter against said another spring means; said relief valve member thus opening fluid communication between said inlet port and relief port at a lower pressure when said one circuit is selected than when the other circuit is selected.

10. The relief valve of claim **9** wherein stop means are provided in said housing for engagement by said fluid pressure actuated member to determine the maximum relief pressure when said other circuit is selected.

11. The relief valve of claim **9** wherein stop means are provided in said housing for engagement by said fluid pressure actuated member to determine the minimum relief pressure when said one circuit is selected.

12. The relief valve of claim **9** wherein said another spring means yields in proportion to the increase in pres-

sure in said control port when said one circuit is selected thus to proportionately decrease the bias of said first-mentioned spring means on said relief valve member.

13. The relief valve of claim **9** wherein means are provided for adjustment of the bias of said first-mentioned and another spring means on said relief valve and fluid pressure actuated members respectively.

14. The relief valve of claim **9** wherein stop means are provided in said housing for engagement by said fluid pressure actuated member to determine the minimum and maximum relief pressures when said one or other circuit is selected.

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M. CARY NELSON, *Primary Examiner.*

MARTIN P. SCHWADRON, *Examiner.*