July 2, 1968 W. L. HAMMER 3,390,616

FLUID PRESSURE CYLINDERS HAVING LOAD RESPONSIVE PISTON VALVES

Filed Oct. 19, 1965 2 Sheets-Sheet 1

Fig. 1

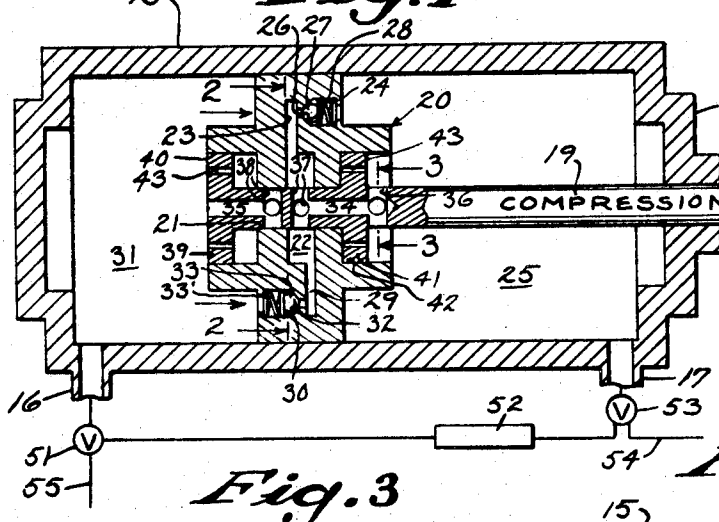


Fig. 2

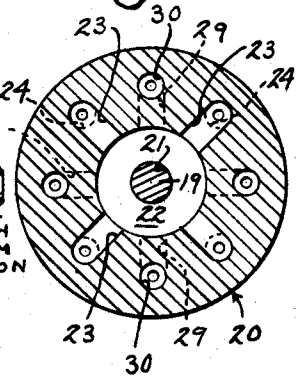


Fig. 3

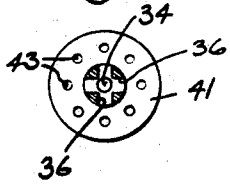


Fig. 4

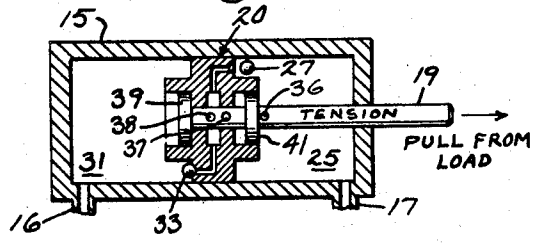


Fig. 5

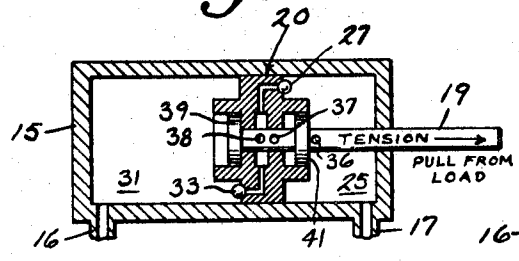


Fig. 6

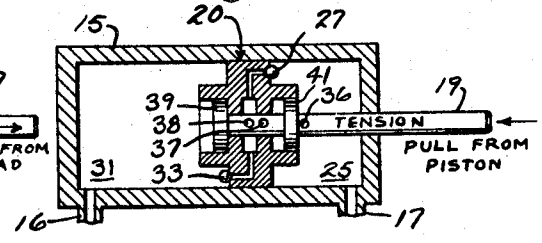


Fig. 7

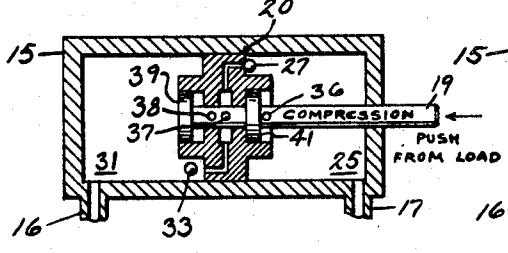
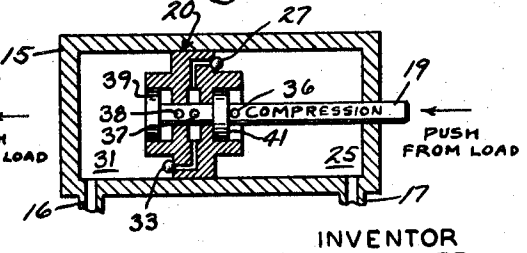


Fig. 8



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FLUID PRESSURE CYLINDERS HAVING LOAD RESPONSIVE PISTON VALVES

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Fig. 9

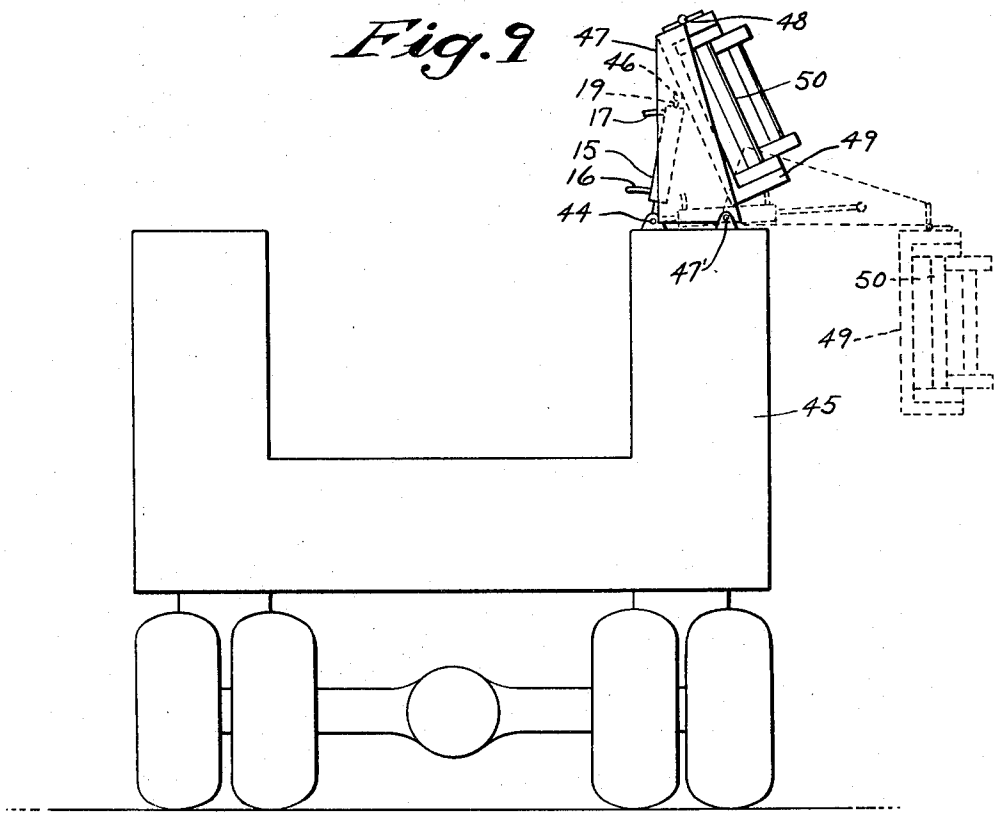
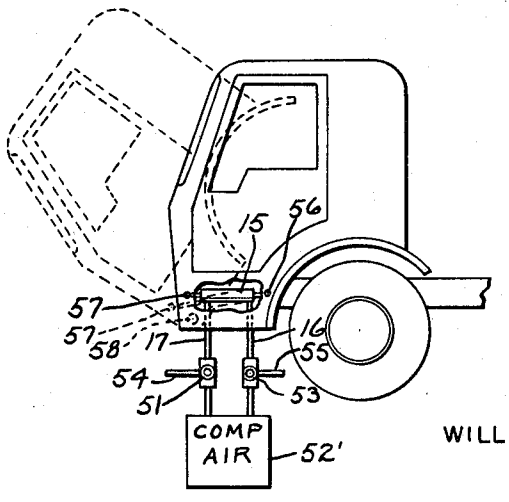


Fig. 10



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FLUID PRESSURE CYLINDERS HAVING LOAD RESPONSIVE PISTON VALVES

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11 Claims. (Cl. 91—422)

ABSTRACT OF THE DISCLOSURE

A double-acting fluid pressure cylinder having a piston operatively connected to a load, there being a chamber on each side of the piston and the piston having a fluid chamber therein with ducts normally closed by check valves leading from each cylinder chamber to the piston chamber, the inner end of the piston rod being slidable in the piston and having a valve-controlled passageway affording communication between one of the cylinder chambers and the piston chamber when the piston rod is in one position of slidable movement, and another valve-controlled passageway affording communication between the other cylinder chamber and the piston chamber when the piston rod is in another position of movement.

This invention relates to improvements in fluid pressure cylinders having load responsive piston valves.

A pneumatic system has many advantages, such as load cushioning. However, such load cushioning becomes a disadvantage when a pneumatic cylinder is operating in connection with an overrunning load. When the load overruns the pneumatic cylinder, as happens after the load passes dead center, the load is acted on by gravity, causing the piston to compress air. Thereafter the cylinder loses control of the load until a balance is obtained. Because of the above problem it has usually been necessary to use hydraulic systems in this type of situation.

It is a general object of the present invention to provide an improved pneumatic cylinder having improved means for preventing uncontrolled load surges when the cylinder is being used with an overrunning load.

A more specific object of the invention is to provide an improved fluid pressure cylinder wherein the piston has a novel valve automatically operable so that it is possible to introduce fluid under pressure into both sides of the cylinder whereby there is flow of fluid under pressure through the piston which flow can be controlled as a function of whether the piston rod is in tension or compression during control of the overrunning load.

A further specific object of the invention is to provide an improved pneumatic cylinder as above described wherein the valve means in the piston includes check valves which enable the cylinder to operate in both directions.

A further object of the invention is to provide an improved pneumatic cylinder as above described wherein a portion of the valve mechanism is embodied in the inner end of the piston rod.

With the above and other objects in view the invention consists of the improved fluid pressure cylinder having a load responsive piston valve, and all of its parts and combinations, as set forth in the claims, and all equivalents thereof.

In the accompanying drawings, illustrating several embodiments of the invention, in which the same reference numerals designate the same parts in all of the views:

FIG. 1 is a longitudinal sectional view through an improved pneumatic cylinder showing the piston at the start of a load controlling movement, with the piston rod under compression as it is being pushed by the piston;

FIG. 2 is a sectional view of the piston taken approximately on the line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken approximately on the line 3—3 of FIG. 1;

FIG. 4 is a partially diagrammatic longitudinal sectional view through the cylinder, showing an advanced position from FIG. 1, in which the piston has been moved to the right and in which the load has just started to overrun the rod to exert a pull thereon so that the rod is now under tension;

FIG. 5 is a view similar to FIG. 4 wherein the piston is still farther advanced as the load continues its pull on the piston rod, the latter being under tension;

FIG. 6 is a view similar to FIG. 5 at the start of a reverse movement after compressed air has been admitted into the right hand chamber so that the pull on the rod is now from the piston, with the rod under tension;

FIG. 7 is a similar view of the return movement showing the piston in an advanced position from FIG. 6, the load having overrun the rod so that the load now exerts a push on the rod and piston with the rod under compression;

FIG. 8 is a similar view showing further return movement, with the push still exerted by the overrunning load and the rod in compression;

FIG. 9 is a partially schematic end view of a utility truck showing the invention applied to a ladder loading mechanism, the dotted lines indicating the position of the parts when the ladder mechanism is lowered; and

FIG. 10 is a partially schematic view showing the cab end of a tilting cab truck, and illustrating the application of the invention to the control of a tiltable cab, the dotted lines indicating the position of the parts when the cab is tilted.

Referring more particularly to the drawings, the numeral 15 designates a suitable pneumatic cylinder having oppositely disposed ports 16 and 17. Suitably guided for sliding movement through the end 18 of the cylinder is a piston rod 19 having its inner end operatively associated with the novel piston 20.

The piston has a central bore 21 for slidably receiving the inner end of the piston rod 19. The bore communicates with an interior chamber 22. The chamber 22 communicates through radial passageways 23 with axially directed bores 24 which are in communication with the right hand chamber 25 of the cylinder. At the inner end of each bore 24 is a valve seat 26 controlled by a valve member, such as the ball 27, which is normally urged into closing position by a light spring 28.

The interior chamber 22 is also connected by spaced radial ducts 29 which alternate with the ducts 23, as shown in FIG. 2, with axial bores 30 communicating with the left hand cylinder chamber 31. At the inner end of each bore 30 is a valve seat 32 controlled by a valve such as the ball 33 which is normally urged to closing position by a light spring 33'.

The inner end of the piston rod is in the form of a spool, specially constructed to coact with the improved piston in forming a spool valve. Such inner end of the

rod has separated but aligned axial passageways 34 and 35. One end of the passageway 34 communicates with radial passageways 36, and the other end communicates with like radial passageways 37. The inner end of the bore 35 connects with radial passageways 38. On the inner end of the piston rod is a rigid thrust collar 39 which is slidable within a cup 40 projecting from the left hand face of the piston. Another thrust collar 41 on the piston rod is slidable in a cup-shaped portion 42 projecting from the right hand face of the piston. The arrangement of the collars 39 and 41 and ports 36, 37 and 38 is such that when the ports 37 are in communication with the interior piston chamber 22 the ports 38 are closed by the adjacent piston wall portions, the ports 36 always being open to the chamber 25. When, however, the piston rod is moved to the right, as in FIG. 4, then the ports 37 are closed and the ports 38 are in communication with the interior piston chamber 22. In the position of FIG. 1 the thrust collar 41 is against the right face of the piston to receive thrust therefrom. When the parts are in the position of FIG. 4 the thrust collar 39 is in contact with the left hand face of the piston. Each of the collars 41 and 39 is provided with air relief ports 43.

OPERATION

In operation, assuming that the valve 51 is set to admit compressed air into the port 16 from a suitable source 52 of compressed air to the left hand chamber 31 of the cylinder, this will cause an increase of air pressure in the chamber 31 from zero to something less than 90 p.s.i., for example, which pressure acts on the left hand face of the piston 20 to cause the piston and piston rod to move toward the right, referring to FIG. 1. For purposes of illustration, the cylinder 15 has been shown in FIG. 9 as pivotally connected at one end, as at 44, to an upper portion of a utility truck 45. The piston rod 19 is pivotally connected as at 46 to a pivot bracket 47, there being a similar bracket spaced forwardly on the truck from the bracket 47, which brackets are pivoted to the truck as at 47'. Pivotally connected as at 48 to the brackets 47 is the upper longitudinal edge of a cradle 49 for a ladder set 50.

As the piston rod 19 moves to the right from the position of FIG. 1, it will act to cause pivoting of the brackets 47 in a clockwise direction about the pivots 47'. During such movement the piston rod 19 is under compression. The check valves 33 are closed because of the pressure in the chamber 31 and the check valves 27 on the other side are also maintained closed. The passageways 38 are closed in the position of FIG. 1 so that the 90 p.s.i. air in the chamber 31 cannot enter the interior chamber 22 of the piston. During such movement the valve 53 is manipulated to cause exhausting through the exhaust line 54 and to shut off communication between the source of compressed air 52 and the port 17. If desired the valve 53 may be in an only partially open position to retard the movement, depending upon requirements.

As soon as the brackets 47 and ladder cradle 49 are over dead center with respect to the pivots 47' gravity will act so that the overrunning load pulls the piston rod 19 in tension, causing the collar 39 on the left hand end of the piston rod to be pulled into contact with the left hand face of the piston 20 so that the load now exerts a pull on the piston. During such shift of the piston rod with respect to the piston the radial ports 37 are now blocked off while the ports 38 are moved into communication with the interior piston chamber 22. 90 p.s.i. air from the left chamber 31 can now pass through the axial bore 35 at the left end of the piston rod, as shown in FIG. 4, through the radial ports 38, into the piston chamber 22, forcing the ball valves 27 to open position to allow 90 p.s.i. air to enter into the right chamber 25. With the valve 53 now turned to a position to close the exhaust port 17, the pressure in said chamber 25 eventually builds up. Force on the piston from differential pressure is now at a minimum and the overrunning load causes the pressure in the right chamber to exceed 90 p.s.i. When this occurs the force in the right hand chamber 25 is such as to close the right hand ball valves 27, as shown in FIG. 5, causing the piston to now brake the load. This action speeds up the compression in the right chamber 25 to more quickly cushion the force of the overrunning load. Thus there is automatic control of the overrunning load inherent in the valve of the piston. During such cushioning action, illustrated in FIG. 5, it is desirable to close the inlet valve 51 as well as the exhaust valve 53. Thereafter it is customary to open the valves 51 and 53 to relieve pressure within the chambers 31 and 25.

After the load has been stopped in the dotted line position of FIG. 9 the ladders are now in a lowered position convenient for use. After the ladders have been used and replaced in the cradle 49 the improved mechanism permits ready return movement. This is accomplished by turning the valve 53 to a position to admit compressed air from the source 52 to the right hand chamber 25, as in FIG. 6, at 90 p.s.i., for example, causing the pressure in the chamber 25 to increase from zero to something less than 90 p.s.i. This increase in air pressure on the right face of the piston 20 causes the piston to move toward the left, with the piston pulling the load to cause a raising of the ladder cradles in FIG. 9. During such movement the piston rod is in tension and the check valves 27 and 33 are maintained in seated position. Also the radial ports 37 are blocked off while the radial ports 38 are in communication with the central chamber. With the three-way valve 51, which controls flow from the port 16 on the left side, in open or partially open position, air will be exhausted through the exhaust line 55.

The air pressure in chamber 25 moves the piston to the left, as indicated in FIG. 7, and as soon as the ladder cradle swings to such a point that the load is over dead center with respect to the pivot 47' of FIG. 9, the load is in overrunning condition and pushes the piston rod in compression, as shown in FIG. 7, shifting the spool valve within the piston to the position shown in FIG. 7. In such position the 90 p.s.i. air in the right chamber 25 can now travel by way of the ports 36, through the axial bore 34 of the piston rod and out of the radial ports 37 into the central chamber 22 of the piston. From this chamber the 90 p.s.i. air will pass out past the opened ball valves 33 into the left chamber 31, causing the pressure to build up in the left chamber and reducing the force on the piston from differential pressure which is now at a minimum. The piston then moves toward the position of FIG. 8, and with the valve 51 now closed or partly closed air pressure in the left section increases to a point in excess of 90 p.s.i. When this occurs all of the check valves in the piston close, as in FIG. 8, and the piston now serves to brake the load. By thereafter closing both of the valves 51 and 53 the load will cushion against the air in the chamber 31, which cushioning action was speeded up by bypassing the high pressure air from the right hand chamber to the left hand chamber. The load will now be returned to the full line position of FIG. 9.

The valves 51 and 53 may be opened and closed either manually or through suitable automatic mechanism depending upon the application to which the device is put.

Referring to FIG. 10, the invention is well adapted to use in controlling the tilting of a tiltable cab on a motor truck. Such trucks commonly have a source of compressed air 52' for supplying compressed air to the air brakes. This same source can be conveniently used in conjunction with one of the pneumatic cylinders 15 of the present invention, which may be pivoted to the frame as at 56 and have its piston rod pivoted to the tilting cab as at 57, the latter being tiltable on the pivot 58.

While only two uses for the invention have been illustrated, it is obvious that the improved fluid pressure cylinder may have use in many other applications where problems of overrunning loads are encountered and is also useful in connection with hydraulic cylinders. It is

also apparent that when used with a pneumatic cylinder the "sponginess" of a pneumatic system is effectively reduced by the bypassing of high pressure air into the exhaust end of the cylinder at the time when the overrunning load takes over to better control such overrunning movement. It is also apparent that the improved piston valve in effect is able to distinguish between a compression and tension load on the piston rod to automatically cause the valve to shift as soon as the overrunning load travels over center, thus quickly cushioning the over center force from the load.

Various changes and modifications may be made without departing from the spirit of the invention and all of such changes are contemplated as may come within the scope of the claims.

What I claim is:

1. In combination with a movable load, means including a fluid pressure cylinder operatively connected to said load for controlling the movement of the same, said cylinder having a piston therein with a piston rod and having a chamber on each side of said piston, means for introducing fluid under pressure into a first one of said chambers to urge said piston and rod in one direction, said piston having a fluid chamber therein with check valve ducts leading to said piston chamber from each cylinder chamber, check valve means normally preventing flow through check valve ducts from one cylinder chamber into said piston chamber, check valve means normally preventing flow through check valve ducts from said other cylinder chamber into said piston chamber, an additional fluid conduit between each cylinder chamber and said piston chamber, and means including valves in said piston controlling flow through said last conduits and responsive to a change from compression to tension on the piston rod as a result of movement of the load to admit said fluid under pressure from one chamber of the cylinder via said piston chamber to the opposite cylinder chamber through the check valve ducts thereof to aid in controlling movement of the load.

2. A device as claimed in claim 1 in which there is exhaust means associated with the other cylinder chamber, and a valve for controlling said exhaust means.

3. A device as claimed in claim 1 in which the cylinder is a pneumatic cylinder and in which the fluid under pressure is compressed air.

4. In combination with a load mounted for movement from a position on one side of dead center to an overrunning position on the other side, means including a fluid pressure cylinder operatively connected to said load for controlling the movement of the same, said cylinder having a piston therein with a piston rod and having a chamber on each side of said piston, means for introducing fluid under pressure into a first one of said chambers to urge said piston and rod in one direction, said piston having a fluid chamber therein with check valve ducts leading to said piston chamber from each cylinder chamber, check valve means normally preventing flow through said check valve ducts from one cylinder chamber into said piston chamber, check valve means normally preventing flow through check valve ducts from said other cylinder chamber into said piston chamber, an additional fluid conduit between each cylinder chamber and said piston chamber, and means including valves in said piston controlling flow through said last conduits and responsive to forces resulting from movement of the load from one side of dead center to the other to admit said fluid under pressure from said first chamber of the cylinder via said piston chamber to the opposite cylinder chamber through the check valve ducts thereof to aid in control of the overrunning load.

5. A device as claimed in claim 3 in which the load is a pivoted ladder loading mechanism.

6. A device as claimed in claim 3 in which the load is a tiltably mounted truck cab.

7. A device as claimed in claim 4 in which the cylinder is a pneumatic cylinder and in which the fluid under pressure is compressed air.

8. In combination with a load mounted for movement from a position on one side of dead center to an overrunning position on the opposite side, means including a fluid pressure cylinder operatively connected to said load for controlling the movement of the same, said cylinder having a piston therein with a piston rod and having a chamber on each side of said piston, means for introducing fluid under pressure into a first one of said chambers to urge said piston and rod in one direction, said piston having a fluid chamber therein with check valve ducts leading to said piston chamber from each cylinder chamber, check valve means normally preventing flow through check valve ducts from one cylinder chamber into said piston chamber, check valve means normally preventing flow through check valve ducts from said other cylinder chamber into said piston chamber, an additional fluid conduit between each cylinder chamber and said piston chamber, a piston rod having its inner end axially slidable in said piston, spaced thrust collars on said rod positioned for alternative engagement with one side of the piston or the other as a result of relative sliding movement between the piston rod and piston, and cooperating valve means in said piston and inner end of the piston rod operative as a result of said relative sliding movement to admit said fluid under pressure from one chamber of the cylinder via said piston chamber to the opposite cylinder chamber through check valve ducts in response to forces on the piston rod resulting from movement of the load from one side of dead center to the other to thereby aid in controlling the overrunning load.

9. The device as claimed in claim 6 in which the valve means is in the form of a spool valve.

10. The device as claimed in claim 8 in which the cylinder is a pneumatic cylinder and in which the fluid under pressure is compressed air.

11. In combination with a load mounted for movement from a position on one side of dead center to an overrunning position on the other side, means including a double-acting pneumatic cylinder operatively connected to said load for controlling the movement of the same, said cylinder having a piston therein with a piston rod and having a chamber on each side of said piston with a gas port in communication with each chamber, said piston having a valve chamber therein, a source of compressed gas, a pneumatic circuit between said source and ports, valve means for controlling the flow of gas from said source into each port, each valve means having a shut-off position and an exhaust position, and means including a valve in said piston controlling flow through the valve chamber in the piston and responsive to forces on said piston rod resulting from movement of the load from one side of dead center to the other to admit compressed gas from one of said chambers of the cylinder to the other chamber, depending upon the direction of operation of the double-acting cylinder, to aid in control of the overrunning load, the inner end of the piston rod being slidable in the piston and the piston including the following:

at least one duct between said piston valve chamber and one of the cylinder chambers;

non-return check valve means controlling said ducts and normally closed as a result of pressure in the adjacent cylinder chamber;

at least one duct between said valve chamber of the piston and the other cylinder chamber;

non-return check valve means controlling said last ducts and normally closed under pressure in the adjacent cylinder chamber;

passageways in the inner end of the piston rod independent of said check valve ducts affording communication between one of the said cylinder chambers and the piston chamber when the rod is in one position of slidable movement with respect to the piston; and

passageways in the inner end of the piston rod independent of said check valve ducts affording communication between the other cylinder chamber and the piston chamber of the piston when the piston rod is in another position of slidable movement with respect to the piston.

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