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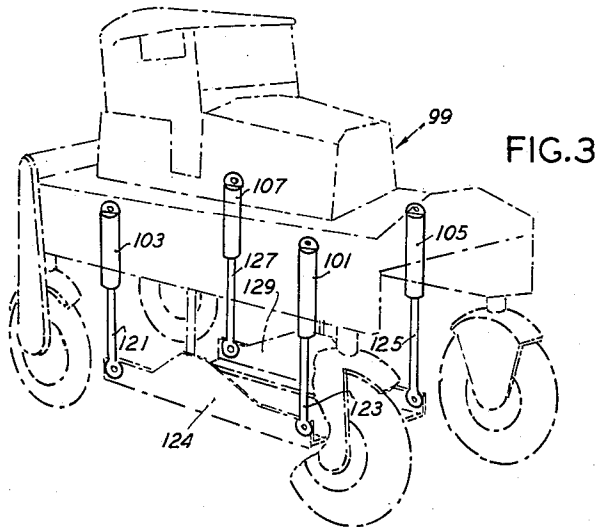
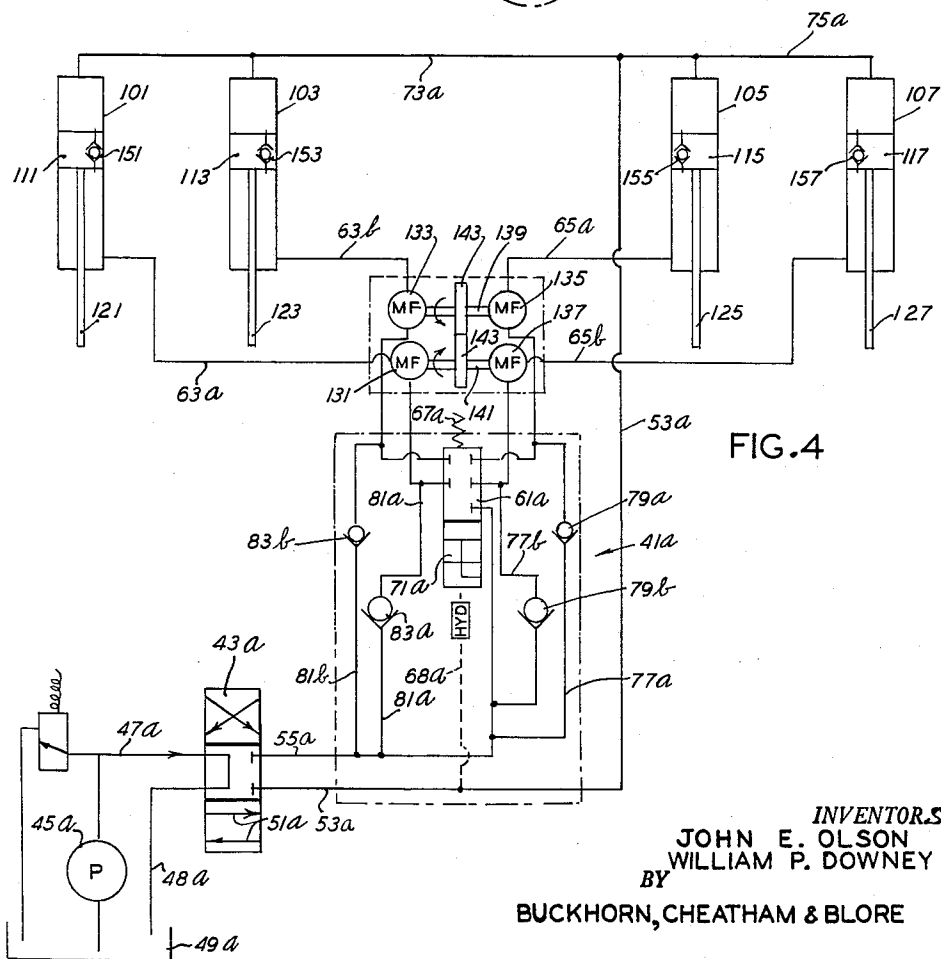
J. E. OLSON ETAL

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FLOW CONTROL SYSTEM FOR LOAD-HANDLING APPARATUS

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INVENTORS
JOHN E. OLSON
WILLIAM P. DOWNEY
BY

BUCKHORN, CHEATHAM & BLORE

ATTORNEYS

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FLOW CONTROL SYSTEM FOR LOAD-HANDLING APPARATUS

John E. Olson and William P. Downey, Portland, Oreg.,
assignors to Hyster Company, Portland, Oreg., a cor-
poration of Nevada

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This invention relates to a load-handling apparatus and particularly to such apparatus having plural hydraulic means for causing movement of certain load-handling parts thereof, wherein the plural hydraulic means is supplied with hydraulic fluid from a common source. Illustrative of such apparatus are industrial lift trucks having a pair of cylinders for tilting the truck mast, and straddle carriers of the type having four cylinders for elevating the load shoes.

When a lift truck is turned, such as when rounding a corner, the load on the forks tends to twist the mast. The two tilt cylinders, which control the position of the mast, permits such twisting when the cylinders are connected to one another, because the fluid from one cylinder can cross over to the other cylinder. That is to say, fluid from the heavily loaded cylinder can flow over to the lightly loaded cylinder. This is undesirable because the twisting which occurs places undue strain on the mast and at times the mast tends to sway dangerously.

In a straddle carrier having hydraulic piston and cylinder means for elevating the load shoes, uneven positioning of the shoes is caused by an unsymmetrical load or by the uneven distribution of a load. That is, after the load has been lifted and the carrier is in condition for travel, the more heavily loaded shoes will tend to descend and the lightly loaded shoes will tend to rise because the fluid from the heavily loaded cylinders will cross over to the lightly loaded cylinders. This creates undesirable stresses in the parts.

A main object of the present invention is to provide a load-handling apparatus of the type under consideration having means for preventing cross over of fluid between the cylinders after the load-handling parts have been moved to their desired positions, yet which means permits the cylinders to be connected together for the ready supply of fluid from a common source.

A more specific object of the invention is to provide a load-handling apparatus of the type just described equipped with a valve means having check valves prohibiting cross over between the cylinders after the positions of the pistons have been set, and yet permitting either set of ends of the cylinders to be supplied with fluid under pressure, and the cylinders to be connected together for the ready supply of fluid from a common source.

Another important object of the invention is to provide a load-handling apparatus of the type under consideration wherein there are valve means operable to prevent cavitation in any of the cylinders, such as when the pistons are being moved in a direction with load assistance.

A further object of the invention is to provide a load-handling apparatus of the type under discussion having flow divider means for causing the equal supply of fluid to the cylinders during movement of the pistons.

Various other objects of the invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a side elevational view in diagrammatic form of a lift truck incorporating the hydraulic circuit of the present invention;

FIG. 2 is an outline of the truck as viewed from above showing schematically the hydraulic circuit;

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FIG. 3 is a diagrammatic view of a straddle carrier embodying the concepts of the present invention; and

FIG. 4 is a diagrammatic view of the hydraulic circuit connecting the various piston and cylinder units together.

Referring to the accompanying drawings and particularly to FIGS. 1 and 2, the lift truck 9 has a mast 13 at its front end pivoted on the body of the truck for movement back and forth from a slightly rearwardly inclined position to a forwardly inclined position shown in dotted lines. A fork carriage 14 is movable along the mast by conventional means not necessary to describe. A pair of tilt cylinders 15 and 17 have pistons 25 and 27 connected by piston rods 35 and 37 to the mast 11.

Hydraulic fluid is supplied to and exhausted from the cylinders by the operation of a pilot operated tilt lock valve 41 and a manually operated directional control valve 43, the latter being supplied with hydraulic fluid under pressure from a pump 45 through a line 47. The directional control valve is a three-position, four-connection valve having a closed center. However, when the directional control valve is in its closed position there is a return line 48 from the pressure line 47 to a sump 49. The directional control valve is actually a spool valve and the symbols shown merely simplify the disclosure of the spool valve. The symbols correspond to the "J.I.C." code.

When the spool member of the valve is shifted to the left a straight-trough portion 51 thereof is placed in alignment with the lines 47 and 48 and with lines 53 and 55 so that fluid under pressure is supplied from line 47 to line 55 and fluid is delivered from the line 53 to the sump 49. On the other hand, when the spool member of the directional control valve is shifted to the right, a reversing portion 57 causes fluid under pressure to be delivered from the line 47 to line 53, and enables fluid to be discharged from line 55 to the line 48 for delivery to the sump 49.

The tilt lock valve 41 is actually a single valve in that all of the valve elements are contained within a single body. However, for convenience, the diagrammatic disclosure more clearly shows the construction and operation of the valve. The line 55 is connected to a pilot-operated spool valve 61, the valve being connected by a line 63 to the cylinder 15 and by a line 65 to the cylinder 17. In the position of the spool member of the valve shown in FIG. 2, the inner ends of the lines 55, 63 and 65 are closed to one another. The spool member of the valve 61 is normally biased by a spring 67 to the position shown in FIG. 2. However, when the line 53 is supplied with fluid pressure, fluid under pressure will be supplied through a pilot line 68 to the right-hand end of the valve 61 to cause a shifting of the spool to the left to position a communicating portion 71 of the spool in alignment with the inner ends of the lines 63, 65 and 55 so that fluid from the lines 63 and 65 may exhaust through the line 55.

At the time that fluid under pressure is supplied to line 53, fluid will also be supplied to the right-hand ends of the cylinders 17 and 15 through branching lines 73 and 75. The line 55 is connected by a branch line 77 containing a check valve 79 to the line 65. The line 55 is also connected by a branch line 81 containing a check valve 83 to the line 63.

It may be assumed that when the pistons 25 and 27 move to the left, they are moving with load assistance, that is, the weight of the load on the forks is urging the pistons to move toward the left, but when the pistons move to the right they are moving with load resistance. The operation of the circuit is as follows. It may be assumed that it is desired to deposit a load and that the mast is in a vertical or slightly rearwardly inclined position. To move the mast forwardly to facilitate depositing the load readily, the pistons 25 and 27 need to be moved to the left. However, they move to the left with

load assistance and thus there is a tendency for cavitation to take place in the right-hand ends of the cylinders. However, cavitation is avoided, as will be now explained.

To cause the pistons 25 and 27 to move to the left, the directional control valve spool member is shifted to the right to place the reversing portion 57 in the center of the valve, therefore supplying fluid under pressure to the pilot line 53 and to the right-hand ends of the cylinders 15 and 17 through the lines 73 and 75. When the spool member of valve 61 shifts to the left under the pressure of the hydraulic fluid supplied from line 53 and the pilot line 63, the inner ends of the lines 63, 65 and 55 are connected together so that fluid from the right-hand ends of the cylinders 15 and 17 can flow into the line 55 and from there through the valve 43 and the line 48 to the sump. However, since the pistons 25 and 27 are already urged toward the left by the load on the forks, there will be a tendency for the pressure within the right-hand ends of the cylinders 15 and 17 to drop and a tendency for cavitation to take place. However, when the pressure does drop this means that the spool member of the pilot operated valve 61 will move to the right under the influence of a spring 67 because the pressure in the line 53 is no longer sufficient to hold the valve member in its left-hand position. By this arrangement, the pressure in the right-hand ends of the cylinders 15 and 17 is controlled so that it cannot drop below a predetermined value. Thus, the pistons 25 and 27 are in effect driven to the left even though they already have a tendency to move to the left with load assistance.

Now it may be assumed that the load has been deposited or placed on the forks and that it is desired to move the forks and the mast in the reverse direction. To do this, the spool member of the directional valve 43 is shifted to the extreme right to place the straight-through portion 51 in the center of the valve so that fluid under pressure is supplied to the line 55, and the line 53 is connected to the sump 49. Since there is no pressure in line 53, the spring 67 will move the spool member of valve 61 to the right to the FIG. 2 position so that the inner ends of the lines 63, 65 and 55 are not communicating with one another. However, the fluid under pressure in line 55 can reach the lines 63 and 65 through the check valves 79 and 83, thus moving the pistons 25 and 27 to the right and forcing fluid in the right-hand ends of the pistons out through the lines 73 and 75 and the line 53 to the sump 49. It will be appreciated that there is just sufficient pressure in the lines 73 and 75 to cause such flow and this pressure is insufficient to operate the pilot operated valve 61.

After the mast has been moved rearwardly to the desired position, the spool member of the directional control valve is moved back to its central position, the position shown in FIG. 2, to hold the mast in the desired position. It may now be assumed that the lift truck is being maneuvered around corners and the like and that the load tends to twist the mast one way or the other. If the lines 63 and 65 were connected to one another, a twisting force on the mast tending to move the piston 25 to the left and the piston 27 to the right would cause a cross over of fluid from the left-hand end of the cylinder 15 to the left-hand end of the cylinder 17 thus enabling the mast to sway or twist. However, the inner ends of the lines 63 and 65 are not connected to one another and the check valves 83 and 79 prevent communication of the lines 63 and 65 through the medium of the branch lines 77 and 81. Thus, twisting or swaying of the mast is not possible.

FIG. 4 shows a basically similar circuit, with several differences to be pointed out, for controlling the supply and exhaust of fluid from the hydraulic piston and cylinder units of the straddle carrier 99, shown in FIG. 3. The straddle carrier is only diagrammatically disclosed and as shown includes four cylinders 101, 103, 105 and 107; the cylinders 101 and 103 having pistons 111 and

113 connected by piston rods 121 and 123 to a shoe 124, whereas the cylinders 105 and 107 have pistons 115 and 117 having piston rods 125 and 127 connected to a shoe 129.

The circuit in FIG. 4 also includes a tilt lock valve 41a and a directional control valve 43a, the latter being connected to a pump 45a by a line 47a, and to a sump 49a by a line 48a. There is a line 55a connecting the directional control valve to a pilot-operated valve 61a.

The lower ends of the cylinders 101 and 103 are connected by lines 63a and 63b through fluid motors 131 and 133 to the valve body of the pilot control valve 61a. The lower ends of the cylinders 105 and 107 are connected by lines 65a and 65b through fluid motors 135 and 137 to the valve body of the pilot-operated valve 61a. A common shaft 139 connects the fluid motors 133 and 135 and a common shaft 141 connects the fluid motors 131 and 135. A pair of gears 143 connects the shafts 141 and 139. Thus all the motors are driven in unison. This provides flow equalization and assures that equal quantities of fluid will be supplied to the four cylinders.

A branch line 81a having a check valve 83a connects the line 55a to the line 63a, and a branch line 81b having a check valve 83b connects the line 55a to the line 65b. Also a branch line 77a having a check valve 79a connects the line 55a to the line 65a, and a branch line 77b having a check valve 79b connects the line 55a to the line 63b.

There is also a line 53a connecting the directional control valve 43a to the upper ends of the cylinders 111 and 113 by means of a line 73a and to the upper ends of the cylinders 105 and 107 by a line 75a. There is also a pilot control line 68a from the line 53a to the pilot-operated valve 61a, the valve having a spring 67a opposing pilot operation. The spool member of the valve has a communicating portion 71a shown in an inactive position in FIG. 4.

Another distinction between the basic arrangement disclosed in FIG. 4 and that shown in FIG. 2 is that in FIG. 4 each of the pistons 111, 113, 115 and 117 is equipped with a double-acting, pin-operated check valve 151 in the case of piston 111, 153 in the case of piston 113, 155 in the case of piston 115, and 157 in the case of piston 117. The type of valve per se is not new and thus is only diagrammatically disclosed. These check valves are opened when the pistons are driven upwardly to the extreme ends of their strokes by the contact of the upper pins with the associated ends of the cylinders to allow all four pistons to assume similar positions. This is required because even though the equal flow means in the form of the motors 131, 133, 135 and 137 are provided, over a considerable period of time, because of leakage and other factors, some inequality in the positions of the pistons 111, 113, 115 and 117 is encountered. Thus, when one piston reaches the end of its stroke prior to the others, flow of fluid through such pistons must be provided if the other pistons are to continue their movement, because the geared pumps continue to supply fluid to all of the cylinders, including, of course, the cylinder containing the one piston first mentioned. The check valve of such one piston provides for such flow.

In operation, it may be assumed that it is desired to lift a load and to do this, the spool member of the valve 43a is moved upwardly, as the parts are shown in FIG. 4 to place straight-through portion 51a of the spool member in the center of the valve to supply fluid under pressure to the line 55a from whence fluid may be supplied through the lines 81a and 81b to the lower ends of the cylinders 101 and 103 and through branch lines 77a and 77b to the lower ends of the cylinders 105 and 107. The check valves 79a, 79b, 83a and 83b of course allow movement of the fluid under pressure to the lower ends of the cylinders because the check valves are upwardly opening as the parts are shown in FIG. 4. The fluid in the upper ends of the

cylinders is pushed through the exhaust lines 73a and 75a and the line 53a to the sump 49a. The fluid motors assure that the pistons of the cylinders move upwardly in unison or substantially in unison.

When it is desired to lower a load, the weight of the load creates a downward force on the pistons and thus the pistons of the cylinders move downwardly with load assistance. This would tend to create cavitation in the upper ends of the cylinders, but again the circuit provided prevents such cavitation because if the pressure in the lines 73a and 75a drops below a predetermined value, this pressure is also effective on line 53a and is insufficient to maintain the spool member 71a in an upward operative position. Thus, this regulates the pressure in the lines 53a, 73a and 75a and prevents cavitation.

After a load is raised and the positions of the load shoes set, unequal loading of the shoes will not result in fluid cross over between the cylinders because at this time the valve 61a will be in its FIG. 4 position. In such position, the lines 63a, 63b, 65a and 65b cannot communicate with one another through the valve 61a and cannot communicate with one another outside of the valve because of the check valves 83a, 83b, 79a and 79b. Thus the shoes will be maintained at the same level despite uneven loading.

In the claims, the term "plurality" means two or more.

Having described the invention in what is considered to be the preferred embodiment thereof, it is desired that it be understood that the invention is not to be limited other than by the provisions of the following claims.

We claim:

1. In a load-handling apparatus, a load-handling means, a plurality of cylinders, a plurality of pistons for said cylinders, each piston being connected to said load-handling means, a source of fluid under pressure, a check valve for each cylinder, means for simultaneously connecting said source to one set of ends of said cylinders through said check valves in the direction of opening movement of said check valves, or for connecting said source simultaneously to the other set of ends of said cylinders, and means by-passing said check valves for exhausting fluid from said one set of ends.

2. In a load-handling apparatus, a load-handling means, a plurality of cylinders, a plurality of pistons for said cylinders, each piston being connected to said load-handling means, a source of fluid under pressure, a check valve for each cylinder, means for simultaneously connecting said source to one set of ends of said cylinders through said check valves in the direction of opening movement of said check valves, or for connecting said source simultaneously to the other set of ends of said cylinders, and means by-passing said check valves for exhausting fluid from said one set of ends, the last-named means including means for preventing the exhaust of fluid from said one set of ends until pressure in the other set of ends of said cylinders has reached a predetermined value.

3. In a load-handling apparatus, a load-handling means, a plurality of cylinders, a plurality of pistons for said cylinders, each piston being connected to said load-handling means, a source of fluid under pressure, a check valve for each cylinder, means for simultaneously connecting said source to one set of ends of said cylinders through said check valves in the direction of opening movement of said check valves, or for connecting said source simultaneously to the other set of ends of said cylinders, and means by-passing said check valves for exhausting fluid from said one set of ends, the last-named means including means for preventing the exhaust of fluid from said one set of ends until pressure in the other set of ends of said cylinders has reached a predetermined value, said preventing means including a pilot-operated valve having a valve member movable under the influence of fluid pressure to a position to connect said one set of ends with a discharge line, said pilot-operated valve

being connected to the other set of ends of said cylinders to be actuated by the pressure therein.

4. In a flow control system for a load-handling apparatus having a plurality of piston and cylinder units, the pistons of which are to be forced away from one set of ends of the cylinders with load assistance or forced away from the opposite set of ends of said cylinders with load resistance, means for connecting either set of ends of said cylinders with a source of fluid under pressure and for exhausting fluid from either set of ends of said cylinders in correlated in-one-end-out-the-other-end manner, said means including valve means responsive to the pressure in said one set of ends for preventing the exhaust of fluid from said other set of ends until a predetermined pressure has been built up in said one set of ends to prevent cavitation in said one set of ends.

5. In a flow control system for a load-handling apparatus having a plurality of piston and cylinder units, the pistons of which are to be forced away from one set of ends of the cylinders with load assistance or forced away from the opposite set of ends of said cylinders with load resistance, means of connecting either set of ends of said cylinders with a source of fluid under pressure and for exhausting fluid from either set of ends of said cylinders in correlated in-one-end-out-the-other-end manner, said means including means for preventing the exhaust of fluid from said other set of ends until a predetermined pressure has been built up in said one set of ends to prevent cavitation in said one set of ends, said preventing means including a pilot-operated valve having a valve member movable under the influence of fluid pressure to a position to connect said other set of ends of said cylinders with a discharge line, said pilot-operated valve being connected to said one set of ends of said cylinders to be actuated by the pressure therein.

6. In a load-handling apparatus of the type set forth in claim 1 in which said check valve and the last-named means prevent cross-over of fluid between said one set of ends in the static condition of said pistons.

7. In a load-handling apparatus of the type set forth in claim 2 in which said check valve and the last-named means prevent cross-over of fluid between said one set of ends in the static condition of said pistons.

8. In a load-handling apparatus of the type set forth in claim 1 in which there are flow regulating means for said cylinders providing for equal flow to and from said one set of ends of said cylinders to provide for equal movement of said pistons despite differences in loading thereof.

9. A load-handling apparatus of the type set forth in claim 4 in which there are flow regulating means for said cylinders providing for equal flow to and from said other set of ends of said cylinders to provide for equal movement of said pistons despite differences in loading thereof.

10. In a straddle carrier, a plurality of vertically mounted cylinders having pistons with depending piston rods, load engaging means connected to said rods, a source of fluid under pressure on said carrier, a check valve for each cylinder, reversing valve means for simultaneously connecting said source to the lower set of ends of said cylinders through said check valves in the direction of opening movement thereof, or for connecting said source simultaneously to the upper set of ends of said cylinders, and means by-passing said check valves for exhausting fluid from said lower set of ends.

11. In a straddle carrier of the type set forth in claim 10, in which the last-named means constitutes valve means responsive to the pressure in said upper set of ends of said cylinders for preventing the exhaust of fluid from said lower set of ends until a predetermined pressure has been built up in said upper set of ends to prevent cavitation in said upper set of ends.

12. In a straddle carrier of the type set forth in claim 11, in which there are flow regulating means for said

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cylinders providing for equal flow to and from said lower set of ends of said cylinders to provide for equal movement of said pistons despite differences in loading thereof.

13. In a straddle carrier having a wheel supported body providing a tunnel-like load space between the wheels of the body for accommodating the load to be handled, a pair of load engaging members at the side of the load space, a pair of vertical double-acting cylinders for each shoe of each load engaging member, means mounting the upper ends of the cylinders on said body, each cylinder having a piston and a rod extending therefrom and projecting from the lower end of said cylinder, means connecting the rods to said shoes, a source of fluid under pressure on said body, a reservoir on said body for said source, a check valve for each cylinder, each check valve being connected to the lower end of its cylinder so as to open toward the cylinder in response to the supply of fluid under pressure from said source, but close in response to pressure from said cylinder, valve means connected to said reservoir and connected between said source and all said check valves, said valve means having independent connections to the upper end of said cylinders and having a first position in which fluid from said source is conducted to said check valves and fluid from the upper ends of said cylinders is exhausted to said reservoir, and a second position in which said source is connected to the upper ends of said cylinders, and other valve means connected between the lower ends of said cylinders and said reservoir independently of said check valve and responsive to a predetermined positive pressure in the upper ends of said cylinders for moving to open positions to place said lower ends in communication with said reservoir.

14. In a straddle carrier having a wheel supported body providing a tunnel-like load space between the wheels of the body for accommodating the load to be handled, a pair of load engaging members at the side

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of the load space, a pair of vertical double-acting cylinders for each shoe of each load engaging member, means mounting the upper ends of the cylinders on said body, each cylinder having a piston and a rod extending therefrom and projecting from the lower end of said cylinder, means connecting the rods to said shoes, a source of fluid under pressure on said body, a reservoir on said body for said source, a check valve for each cylinder, each check valve being connected to the lower end of its cylinder so as to open toward the cylinder in response to the supply of fluid under pressure from said source, but close in response to pressure from said cylinder, valve means connected to said reservoir and connected between said source and all said check valves, said valve means having independent connections to the upper end of said cylinders and having a first position in which fluid from said source is conducted to said check valves and fluid from the upper ends of said cylinders is exhausted to said reservoir, and a second position in which said source is connected to the upper ends of said cylinders, and other means connected between the lower ends of said cylinders and the first mentioned valve means independently of said check valves and responsive to a predetermined positive pressure in the upper ends of said cylinders to move to an open position to place said lower ends of said cylinders in communication with the first mentioned valve means, said first named valve means in its second position placing said other valve means in communication with said reservoir.

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