Dec. 23, 1941. C. B. LIVERS 2,267,284

BY-PASS VALVE

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FIG. 1.

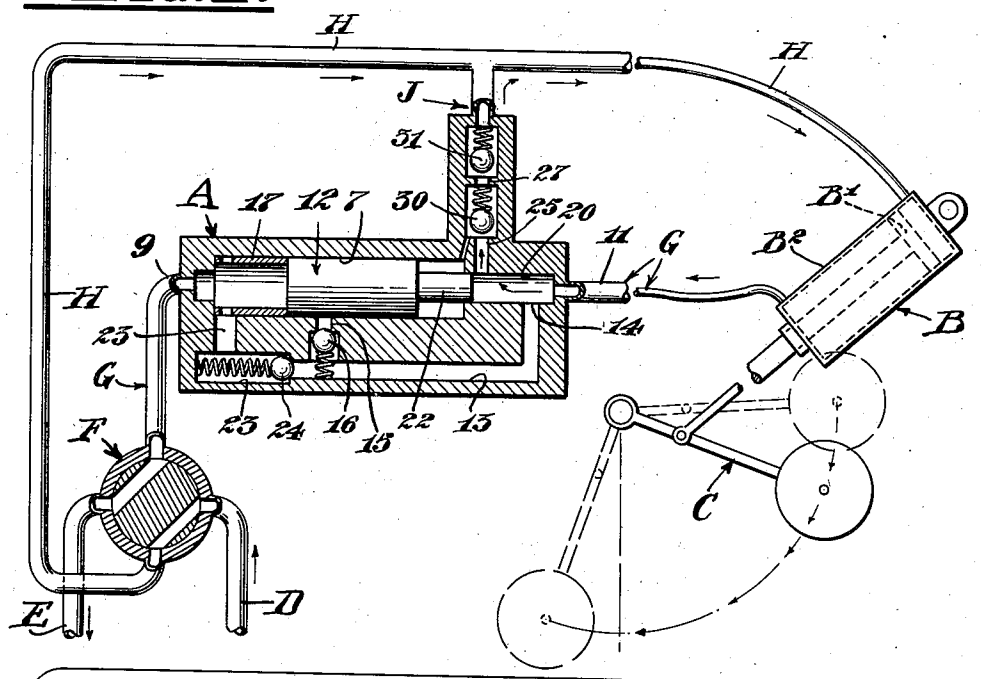

FIG. 2.

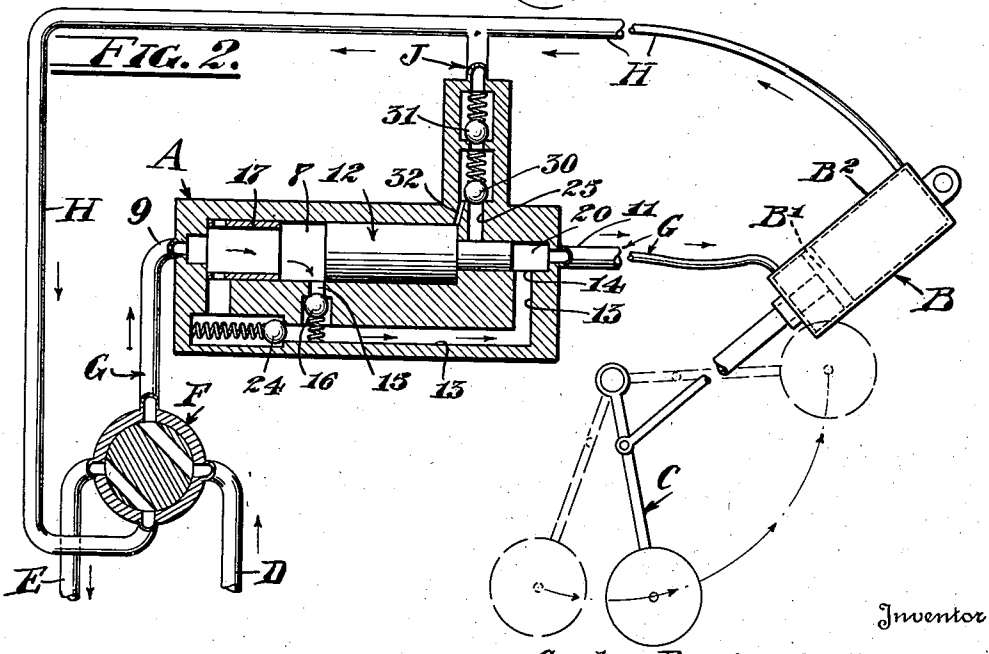

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FIG. 3.

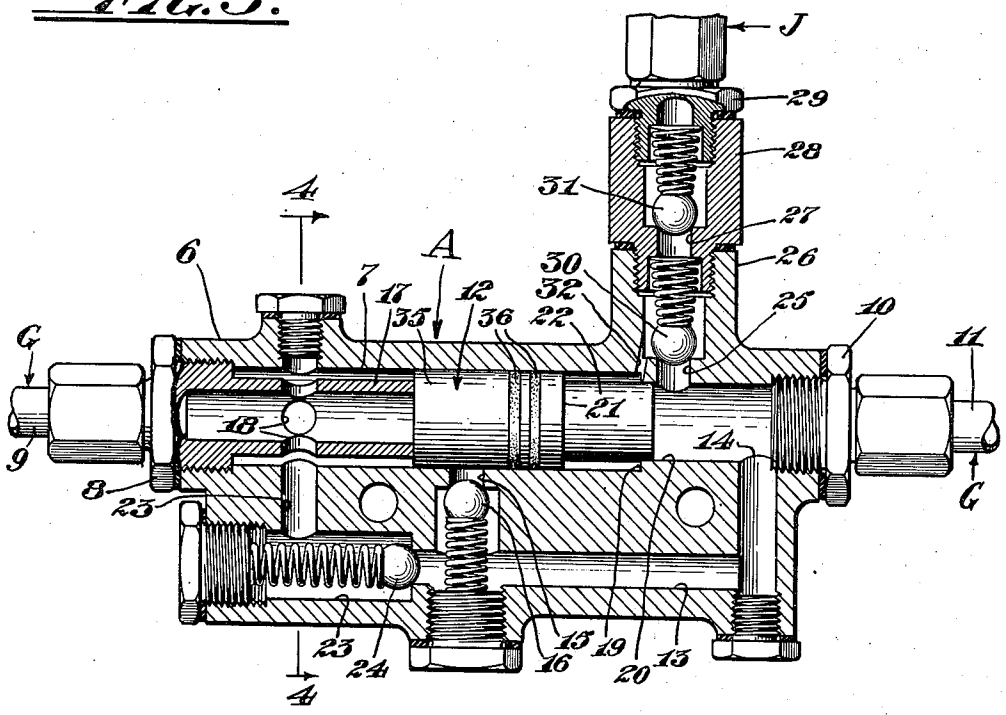


FIG. 4.

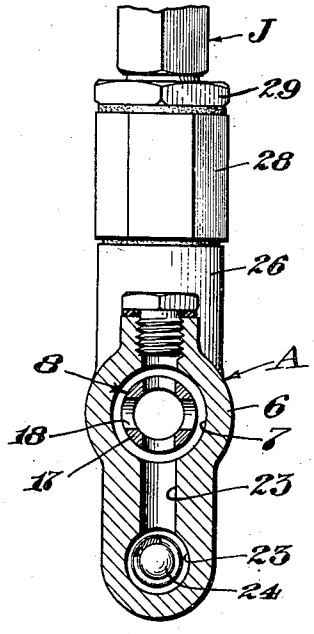
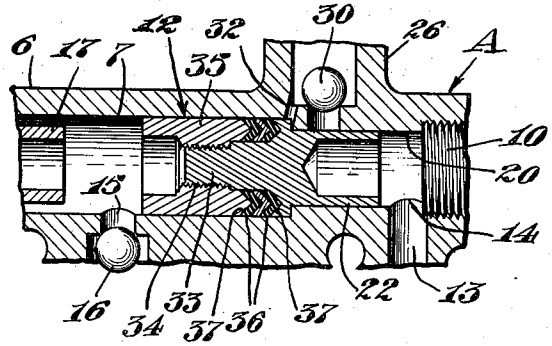


FIG. 5.



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BY-PASS VALVE

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8 Claims. (Cl. 121—38)

This invention relates to valves for controlling hydraulic jacks or motors such as are used for actuating or controlling the operation of the landing gear and other component mechanisms of an airplane.

In hydraulic systems where fluid is admitted to a jack or the like for raising a mechanism which is subject to gravitation when released or where the jack is required to move a spring loaded mechanism against the action of the spring, the return action may become more rapid than the lifting or spring compressing action because the force of gravity or the expansion action of the spring as the case may be, may expel the fluid from the jack faster than the pumping system can supply fluid thereto. As an example, the retractable landing gear of an airplane is retracted by forcing high pressure fluid beneath the piston of the jack therefor, but when this gear is to be extended into position of use, pressure fluid is applied to the top of the piston and the latches holding the gear are released responsive to initial movement of the jack as is now the general practice, whereupon the gear will gravitate toward its extended position. In so gravitating the volumetric capacity above the piston is increased at a rate greater than the pump is able to fill it and by the time the gear reaches the limits of its gravitational movement or in other words is substantially extended, the jack cylinder is almost entirely evacuated. Before the gear can reach the fully extended position in which it is automatically latched in place, the pump must fill this space and hydraulically effect the final movement of the gear.

The time required to fill this space and operate the jack depends on the size of the cylinder and the capacity of the pump and in some installations this time delay is so great as to prove objectionable if not dangerous.

In consideration of the objections hereinbefore noted it is the primary purpose of my invention to provide a novel and highly efficient by-pass valve for eliminating such objections and insuring an instantaneous and reliable extension of the landing gear into position of use.

More specifically it is an object of my invention to provide a by-pass valve which will direct the return fluid to the pump pressure side of the piston to thereby relieve the pump of the task of delivering the full volume required. This short-circuiting or by-passing of the fluid from one end of the cylinder to the other prevents the formation of a cavity in the cylinder and keeps the cylinder full of fluid so that the pump will take hold immediately the gear gravitates to a point where gravity is of no more assistance and pressure fluid is required to dispose the gear in fully extended position ready for use. Thus it is apparent that by reason of the use of my by-pass valve the pumping system is not required in the lowering or extension operation of the landing gear to deliver appreciably more fluid to the jack cylinder than is represented by the displacement of the piston rod therein.

A further purpose of my invention is to provide a by-pass valve such as described which may be readily and inexpensively produced as an exceptionally light and compact unit of simple design and in which access to parts is readily had and possibility of failure of operation is minimized.

With the foregoing objects in view together with such other objects and advantages as may subsequently appear, the invention is carried into effect as illustrated by way of example in the accompanying drawings, in which:

Fig. 1 represents a schematic view of a hydraulic circuit and equipment including a by-pass valve of my invention, as when employed for operating the landing gear of an airplane, the valve being shown in the position assumed when the gear is being extended or lowered;

Fig. 2 is a schematic view similar to Fig. 1 showing the by-pass valve and its related elements as when the landing gear is being retracted;

Fig. 3 is a longitudinal sectional view of a by-pass valve embodying my invention;

Fig. 4 is an enlarged cross sectional view taken on the line 4—4 of Fig. 3;

Fig. 5 is a fragmentary sectional view particularly showing the detailed construction of the piston-valve of the by-pass valve unit.

Referring to the drawings more specifically, particularly Figs. 1 and 2, A designates a by-pass valve embodying my invention as when set up for operating a hydraulic jack B which is connected to and adapted to effect the extension and retraction of the landing gear C of an airplane. As here provided pressure and return lines D and E lead from a hydraulic pump unit not shown to a 4-way control valve F which through lines G and H provides for selective delivery of high pressure to opposite ends of the jack B also the return of fluid to the pump unit. My by-pass valve is series connected in line G and by means of a by-pass line J is connected with the line H.

The function of the by-pass valve is to by-pass

return fluid on the down or extension stroke of the jack piston B1, from the lower or return end of the cylinder B2 to the upper or pump pressure end of said cylinder, whereby to relieve the pump of having to supply the full volume of fluid necessary to fill said upper or pump pressure end of the cylinder. It should be noted that inasmuch as the extension of the landing gear is largely effected by force of gravity, the piston of the jack tends to expel the fluid faster than the pump can supply pressure fluid above the piston but that my by-pass valve will automatically by-pass this expelled fluid into the upper end of the jack and thereby prevent any objectionable operation or operation failure which would obviously attend such a disproportionate flow of fluids.

Referring now to Fig. 3, it is seen that the by-pass valve A includes an elongated body 6 having a main passage or bore 7 extending therethrough and connected at one end by means of a fitting 8 with a section 9 of the line G leading from the 4-way valve F. A fitting 10 connects the other end of the passage 7 with a section 11 of line G leading to the lower end of the jack cylinder B2.

The passage 7 is partitioned or divided between its ends by means of a reciprocable piston-valve 12 around which fluid is by-passed through a passage 13. A port 14 communicates one end of passage 13 with the main passage 7 at a point beyond the range of travel of the piston-valve and adjacent the fitting 10, whereas the other end of passage 13 is communicated with the main passage 7 through a port 15 which is adapted to be opened and closed by the piston-valve. A spring loaded check valve 16 in the passage 13 seats against the port 15 to prevent back-flow of fluid from passage 13 into passage 7.

The piston-valve is limited as to travel in one direction by means of a tubular stop 17 carried by the fitting 8 as an extension thereof. This stop is circumferentially spaced from the wall of the passage 7 and at its inner end which is disposed to engage the piston-valve, is fully open. Between its ends the stop is formed with openings 18 which with said circumferential spacing and open end provide for full flow of fluid through said stop and said passage.

When the piston-valve is engaged with the stop the port 15 is closed but when the piston-valve is moved in a direction away from the stop it will open said port. This movement of the piston in a direction away from the stop is limited by means of an annular stop shoulder 19 formed by reducing the right end 20 of the passage 7 adjacent the fitting 10, which shoulder is adapted to engage a similar shoulder 21 formed by reducing the right end 22 of the piston valve.

In a relief or return passage 23 which leads from passage 13 to a point in passage 7 adjacent the fitting 8, a spring loaded relief valve 24 is arranged to open and allow return fluid to flow from passage 13 into passage 7 and thence out through fitting 8 and line G back to the low pressure side of the pump unit, not shown, only when certain high pressures are developed during final movement of the landing gear into operative position as will be hereinafter more fully described. The operating pressure in the passage 7 and passage 23 holds the valve 24 seated when the port 15 is open and the jack is being operated to retract the landing gear as shown in Fig. 2.

For the purpose of by-passing fluid from one end of the jack cylinder B2 to the other, my improved by-pass valve is provided with port 25 in the reduced end 20 of the passage 7, which port is adapted to be opened and closed by the reduced end 22 of the piston-valve. Leading from the port 25 through a boss or extension 26 on the body 6 is a passage 27 connected through fittings 28 and 29 with the fluid line H. These connections between the valve A and line H provide the aforesaid by-pass fluid line J. In the boss 26 and fitting 28 are outwardly opening spring check valves 30 and 31 respectively for controlling the by-passing of fluid through lines J and H into the upper end of the jack cylinder B2.

In order to relieve fluid trapped in the annular space defined between reduced end 22 of the piston and the surrounding wall of said passage, a passage 32 is formed to by-pass fluid from said space, past the check valve 30 and into the passage 27 above said check valve.

The piston-valve 12 as best shown in Fig. 5 may be sectionally constructed with the reduced end 22 being one part and having a threaded shank 33 screwed into a threaded bore 34 in the other part or body portion 35. Packing rings 36 of angular cross section are clamped between similarly shaped annular shoulder portions 37 on the two sections of the piston-valve. The outer ends of the piston valve are bored out or recessed to reduce weight.

In the operation of my by-pass valve, assuming it is employed in a hydraulic system as shown in Figs. 1 and 2 and the landing gear is to be lowered into position of use, the 4-way control valve F is moved into the position shown in Fig. 1 and pressure fluid from the pump not shown, is effective in line D, past valve F, line H and the upper end of the jack cylinder B2 above the piston B1 therein, to move the piston downwardly. Upon initial movement of the piston a latch means not shown, but which is commonly known in the art, automatically releases the landing gear for gravitational movement toward its position of use. However it should be noted that with the valve F set in a neutral position the system will be fluid locked whereby to hold the landing gear against movement out of either retracted or extended position.

As the jack piston descends the fluid in the lower end of the cylinder is expelled through the section 11 of line G into the reduced end 20 of the passage 7 and thereby forces the piston-valve 12 to the left, into position shown in Fig. 1. In this position the piston-valve has opened port 25 and closes port 15 whereupon the return fluid opens the check valves 30 and 31 and passes through lines J and H into the upper end of the cylinder. This by-passing of the return fluid takes place due to the fact that the relief or return valve 24 is set to open under higher pressure than is developed in the return side of the system during gravitational movement of the landing gear, whereas the two check valves 30 and 31 will open responsive to the return fluid during such gravitational movement.

In installations which do not have by-pass provisions such as are afforded by my valve, the descent of the jack piston becomes so rapid during the gravitational movement of the landing gear that the volumetric capacity of the portion of the jack cylinder above the piston increases at a greater rate than the rate of delivery of pressure fluid from the pump to the jack. In consequence, the upper part of the cylinder may be evacuated by the time the landing gear has

reached the end of its gravitational movement and therefore an appreciable lapse of time may take place before the pump can deliver sufficient fluid to actuate the jack as is then necessary to complete the extension of the landing gear into position of use. This time delay is objectionable if not on some occasions decidedly dangerous, as it is highly important that landing gear be positively extended into position for use immediately the 4-way valve is set in position to extend the gear.

In instances when my by-pass valve is used, as soon as the landing gear has completed its gravitational movement, the by-pass valve A, having by-passed fluid from the lower to the upper end of the jack during such gravitational movement, the pump is immediately effective to deliver high pressure fluid through line H to the jack for completing the extension movement of the gear into position of use. While the jack is being fluid operated to complete the extension of the landing gear as above stated the pressure in line H and above the check valves 30 and 31 holds said valves seated inasmuch as such pressure has by that time exceeded the return pressure in the reduced end 20 of the passage 7.

Return fluid however does at this time build up a pressure in passage 13 sufficient to open the relief valve 24 whereby the return fluid will return to the pump unit not shown, through passages 23 and 7, fitting 8, section 9 of line G, valve F and thence to said pump unit through return line E.

In retracting the landing gear the 4-way valve F is set as shown in Fig. 2 and the pump pressure is effective through line D, valve F, section 9 of line G, fitting 8, stop 17, port 15, open check valve 16, passage 13, port 14, section 11 of line G, and lower end of jack cylinder B2, whereby to raise piston B1 and lift the landing gear. The return fluid passes freely from the upper end of the jack through line H, valve F, and line E to the pump not shown. As soon as the pressure fluid is introduced into passage 7 through fitting 8, the piston then being positioned to the left as shown in Fig. 1, is immediately shifted to the right into the position shown in Fig. 2, and opens port 15 wherefor the flow of pressure fluid takes place in the manner next above noted.

It will now be seen that the by-pass valve of my invention will provide the advantages hereinbefore pointed out, in a particularly reliable and highly efficacious manner by reason of the particular construction, relative arrangement, association and combination of the parts thereof as described in the accompanying drawings and as set forth in the foregoing specification.

Furthermore it should be noted that my by-pass valve may be readily incorporated in various hydraulic systems whereby by-passing requirements such as hereinbefore described are essential and that said valve will improve and render more effective and reliable hydraulic systems of the character described.

It should be noted that the piston-valve in having differential end areas is held in extreme right hand position while the pressure fluid passes through the valve unit for retracting the landing gear. Furthermore it should be noted that by having the two check valves 30 and 31 in line, the trapped fluid will pass around the check valve 30 through relief passage 32 without unseating it, but will unseat the outer valve 32 and enter the line H, then acting as a return line.

While I have shown and described a specific embodiment of my invention I do not limit myself to the exact details of construction set forth, and the invention embraces such changes, modifications and equivalents of the parts and their formation and arrangement as come within the purview of the appended claims.

I claim:

1. In a valve for by-passing fluid from the return side to the pressure side of a hydraulic system having fluid lines leading from a pump to opposite ends of a hydraulic cylinder, a valve body having a main passage provided with connection means at spaced points in and for connecting said passage in series with one of said fluid lines, a piston valve reciprocable in said passage responsive to fluid pressure, said main passage having a port which is opened and closed by said piston-valve, and a second port which is beyond the reach of said piston-valve, a second passage in said body between said ports for by-passing fluid around said piston-valve, a spring loaded check valve in the second passage set to open only responsive to fluid pressure when the first named port is opened, a third port in that portion of the main passage on one side of the piston with which portion the second port communicates and into which fluid is returned through said one fluid line from one end of the cylinder, said third port being closed by the piston-valve when the latter is in position to open the first named port and being opened when the first named port is closed, a connection means whereby the third port may be connected with the other fluid line leading to the other end of the cylinder, a second spring loaded check valve in said connecting means opening only responsive to pressure of the return fluid in said portion of the main passage, a third passage in said body for conducting return fluid from the second passage into that part of the main passage on the other side of the piston-valve, and a third spring loaded check valve for opening said third passage only responsive to a greater pressure of the return fluid than that required to open the second check valve.

2. The invention as set forth in claim 1 wherein said piston-valve has a reduced end for controlling said third port, and said portion of the main passage is correspondingly reduced and receives the reduced end of the piston-valve.

3. The invention as set forth in claim 1 wherein said piston-valve has a reduced end for controlling said third port, and said portion of the main passage is correspondingly reduced and receives the reduced end of the piston-valve, the reductions of the piston-valve and main passage defining stop shoulders for limiting the movement of the piston-valve in one direction to a position in which the reduced end thereof is spaced from the second port and the adjacent end of the main passage.

4. The invention as set forth in claim 1 wherein said piston-valve has a reduced end for controlling said third port and said portion of the main passage is correspondingly reduced and receives the reduced end of the piston-valve, the reductions of the piston-valve and main passage defining stop shoulders for limiting the movement of the piston-valve in one direction to a position in which the reduced end thereof is spaced from the second port and the adjacent end of the main passage, and a tubular stop member in said passage for limiting the movement of the piston-valve in the other direction to a position spaced inwardly from the other end of said main pas-

sage and in which the first named port is closed and the third port is open, said tubular stop being open for the passage of fluid therethrough and also circumferentially spaced from said passage.

5. The invention as set forth in claim 1 wherein said piston-valve has a reduced end for controlling said third port, and said portion of the main passage is correspondingly reduced and receives the reduced end of the piston-valve, said body having a relief passage for conducting fluid trapped in the annular space between the reduced part of the piston valve and the adjacent unreduced part of the main passage into the second named connection means without unseating the second check valve, and a fourth spring loaded check valve in said last named connection means set to open only responsive to the pressure of said trapped fluid and the pressure of the return fluid by-passed through said second check valve.

6. The invention as set forth in claim 1 wherein said piston-valve has a reduced end for controlling said third port and said portion of the main passage is correspondingly reduced and receives the reduced end of the piston-valve, the reductions of the piston-valve and main passage defining stop shoulders for limiting the movement of the piston-valve in one direction to a position in which the reduced end thereof is spaced from the second port and the adjacent end of the main passage, said body having a relief passage for conducting fluid trapped in the annular space between the reduced part of the piston-valve and the adjacent unreduced part of the main passage into the second named connection, means without unseating the second check valve, and a fourth spring loaded check valve in said last named connection means set to open only responsive to the pressure of said trapped fluid and the pressure of the return fluid by-passed through said second check valve.

7. In a hydraulic by-pass valve, a valve body having a main passage therein, connection means for connecting said passage in series with a hydraulic fluid line for conducting pressure fluid to and returning it from one end of a hydraulic cylinder, a by-pass connection means adapted for connecting said main passage with another fluid line which is employed in delivering fluid to and returning it from the other end of the hydraulic cylinder, a check valve means mounted in said by-pass connection means for connecting the by-pass connection means with said main passage only when the return fluid which has entered the main passage from said one end of the cylinder reaches a predetermined pressure above the check valve seating pressure derived from the second named fluid line, said body having a relief passage for conducting return fluid away from said by-pass connection while the first named check valve means is seated, another check valve means in said relief passage for opening said passage only when the pressure of the return fluid in said main passage exceeds the pressure required to open the first named check valve means and when the seating pressure on the latter exceeds the pressure of said return fluid, and fluid responsive means in said valve body including a member for shutting off communication of the main passage with the by-pass connection means and the check valve means in the latter when pressure fluid passes through said main passage for delivery to said one end of said cylinder.

8. In a hydraulic by-pass valve, a valve body having a fluid passageway, connecting means adapted for coupling said passageway in series with a fluid line which is employed for conducting pressure fluid to and returning fluid from one end of a hydraulic cylinder, a by-pass connection means adapted for coupling said passageway with another fluid line which is employed for conducting pressure fluid to and returning fluid from the other end of said cylinder, a check valve means tending to seat responsive to pressure of fluid in the by-pass connection means derived from the second named fluid line and opening said by-pass connection means only when the return fluid in the main passageway from said one end of the cylinder reaches a pressure greater than the pressure of the fluid tending to seat said valve means, said body having a relief passage affording the discharge of return fluid from the valve body, and a relief check valve for opening said relief passage only when the return fluid pressure in said passageway exceeds the pressure required to open the by-pass check valve means and the seating pressure against the latter exceeds the pressure of said return fluid, and fluid responsive means embodied in said valve body for shutting off communication of said passageway with the by-pass connection means when pressure fluid passes through said passageway for delivery to said one end of said cylinder, which fluid responsive means communicates said passageway with said by-pass connection means when the return fluid enters said passageway.

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