# United States Patent [19]

**Jackoboice et al.**

[11] **3,818,936**

[45] **June 25, 1974**


[54] **HYDRAULIC CONTROL VALVE**


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[73] Assignee: **Monarch Road Machinery Company,** Grand Rapids, Mich.



[22] Filed: **June 15, 1972**

[21] Appl. No.: **262,988**

[52] **U.S. Cl.** ..... **137/596.12,** 137/270, 91/420

[51] **Int. Cl.** ..... **F15b 11/08**

[58] **Field of Search** ..... 137/596.12, 596.2, 270, 137/271, 269.5, 87, 106, 269; 91/420; 251/366, 367



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,717,652 | 9/1955 | Nichols | 91/420 X |
| 2,720,755 | 10/1955 | Gardiner | 91/420 X |
| 3,145,734 | 8/1964 | Lee et al. | 91/420 |
| 3,164,171 | 1/1965 | Hasbany | 137/596.12 |
| 3,272,085 | 9/1966 | Hajma | 137/596.2 X |
| 3,576,192 | 11/1969 | Wood | 91/420 X |
| 3,722,543 | 3/1973 | Tennis | 137/271 X |



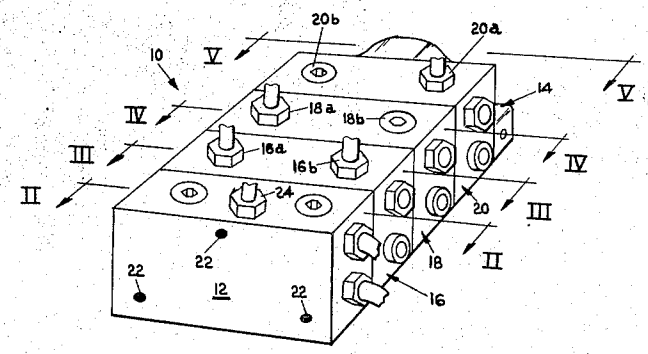
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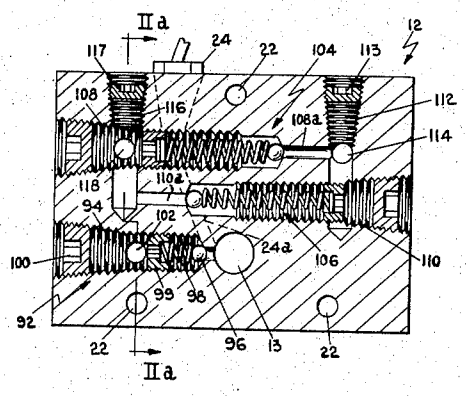


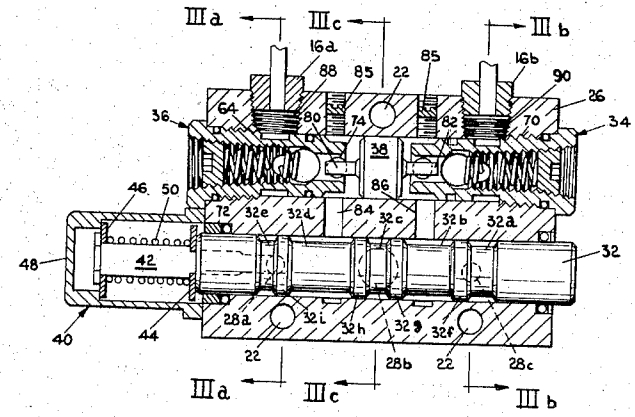
[57] **ABSTRACT**

A fluid control valve assembly having a movable primary valve member, preferably a spool valve, for primary control of inlet fluid under pressure, and at least one secondary valve, preferably a ball-type check valve, which receives the fluid from the primary valve to directly control the operation of connected apparatus such as a power cylinder. The control valve assembly further includes a movable actuator such as a free piston which receives fluid controlled by the primary valve and is moved thereby to open the check valve even though the latter may then be under fluid pressure normally sufficient to hold it closed.


**22 Claims, 13 Drawing Figures**



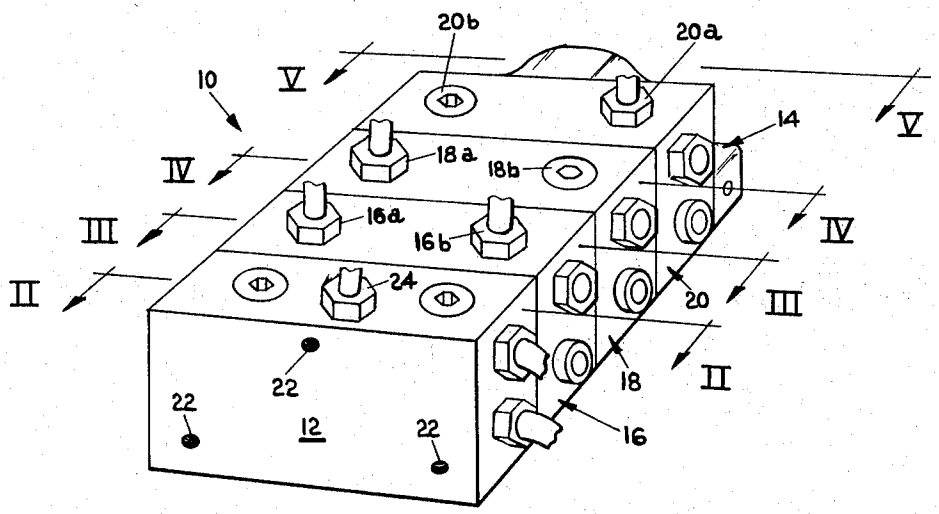



FIG. 1

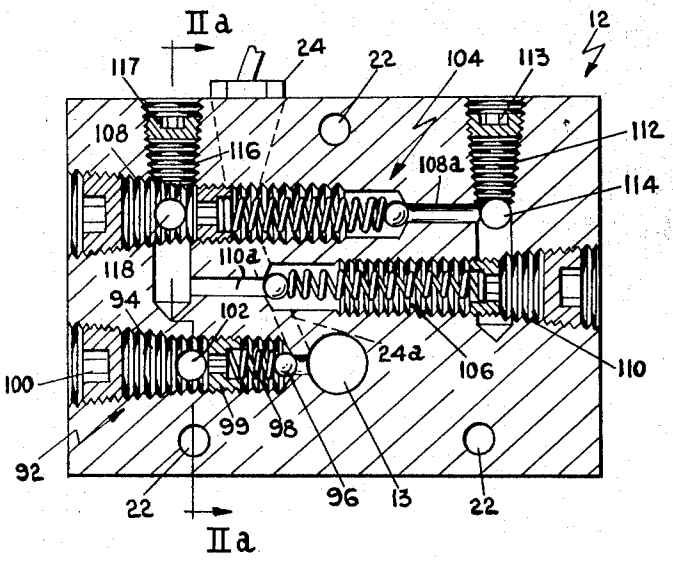



FIG. 2

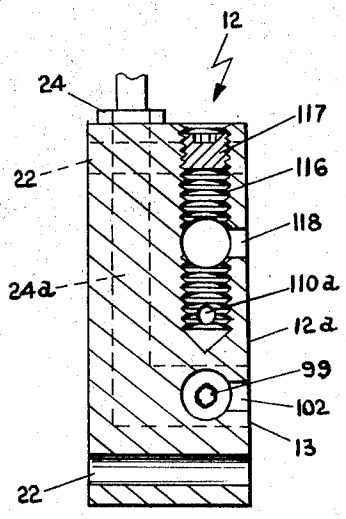



FIG. 2a

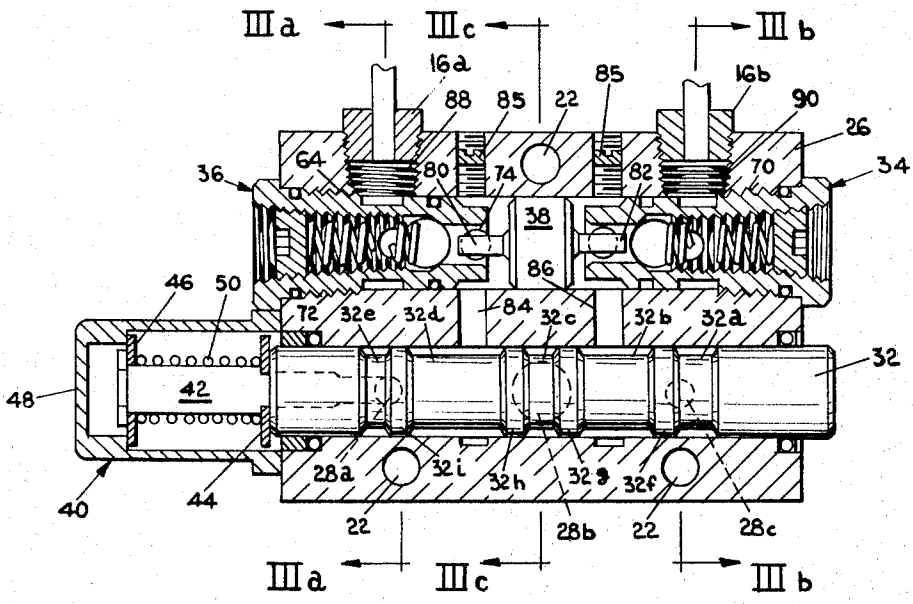



FIG. 3

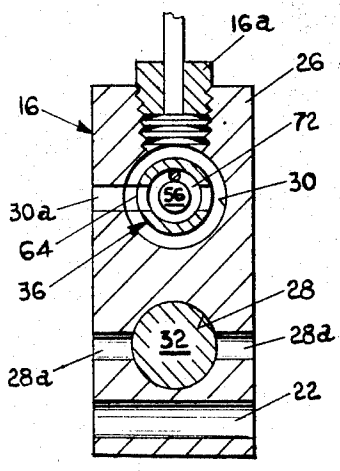



FIG. 3a

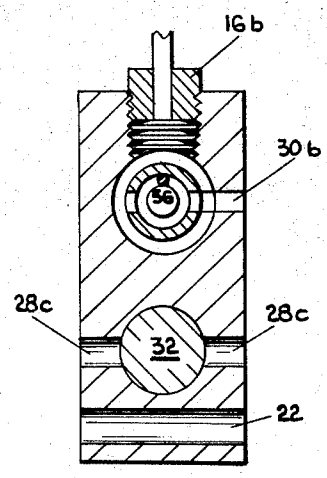



FIG. 3b

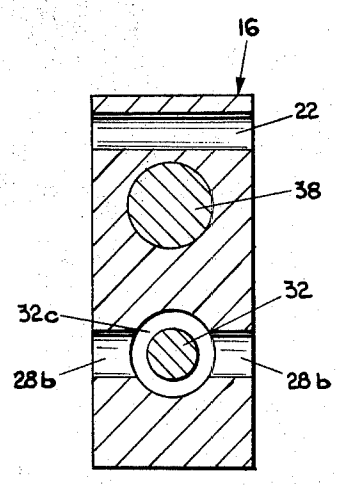



FIG. 3c

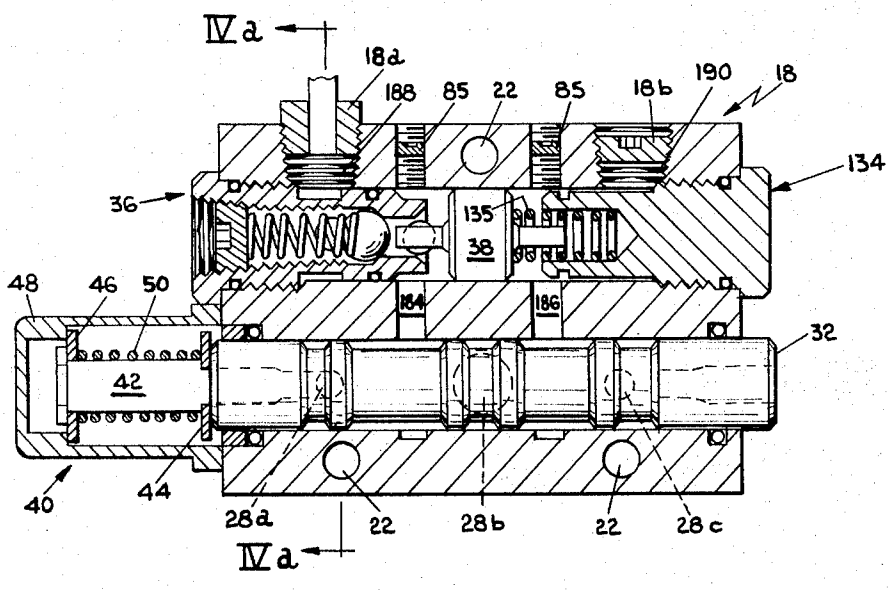

IV a
18d
188
85
22
85
18b
190
18
134
36
135
38
48
46
50
184
186
32
42
40
44
28a
22
28b
22
28c
IV a

FIG. 4

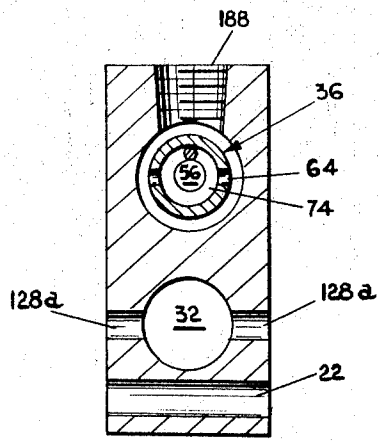

188
36
64
56
74
128a
32
128a
22

FIG. 4a

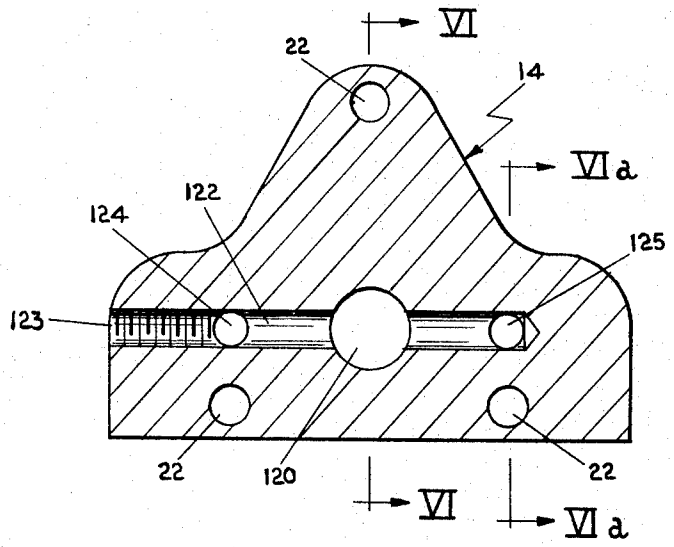



FIG. 5

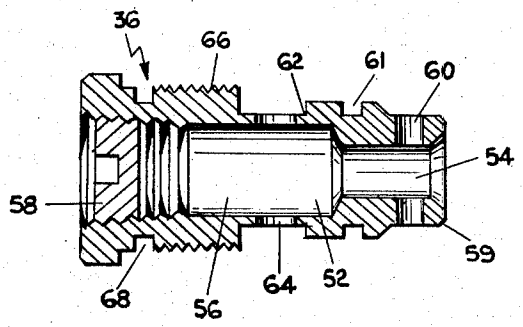



FIG. 7

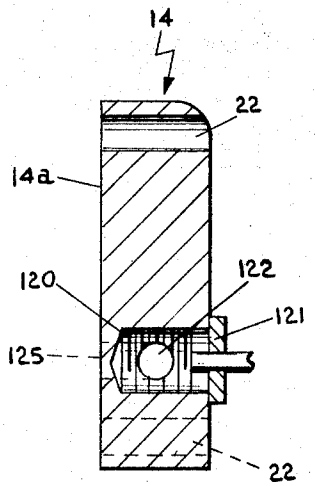



FIG. 6

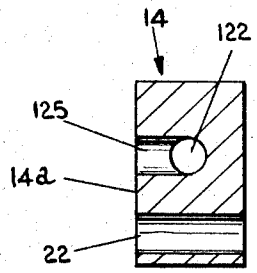



FIG. 6a

# HYDRAULIC CONTROL VALVE

## BACKGROUND OF THE PRESENT INVENTION

This invention relates to fluid control valves, and more particularly to hydraulic control valves of the general type used in a multitude of applications involving hydraulic actuators or motors, including specifically hydraulic power cylinders.

In the past, a number of different types of control valves have been used relatively extensively to control the actuation of hydraulic devices such as power cylinders, in a wide variety of applications. For example, spool valves are often used in such systems, typically through manual actuation by control cables or the like, and usually in a manner such that movement of the spool to a predetermined position couples pressurized fluid directly to the power cylinder, through outlet ports and interconnected pressure lines. Also, rotary-disc or sliding-plate valves have been used which basically operate on the principle of shifting relatively-slidable parts into alignment wherein orifices or passages come into registry and permit fluid flow.

Precise control of hydraulic motors or power cylinders is a very definite concern in many, or even most, instances, particularly since the hydraulic devices being controlled are frequently in a position to cause serious property damage or grave personal injury if controlled imperfectly. Relying strictly upon spool valves or relative sliding valve elements for control in such instances often leads to unsatisfactory results, since normal manufacturing tolerances usually require sealing means of various types in order to prevent characteristic leakage and resulting loss of complete control; however, it is commonly known that sealing means are subject to wear and fatigue, and also are subject to abrupt and usually unexpected failure. Of course, resorting to extremely small manufacturing tolerances sufficient to preclude any substantial need for seals is in most instances prohibitively expensive.

A further consideration of prior devices involves the means for actuating or operating the control valve. That is, there is an increasing requirement and desire for electrical pushbutton operation, typically through pushbutton-controlled solenoids which are used to actually move the control element of the valve. In the case of spool valves of the type typically used heretofore, fingertip control of this type has not been a practical reality, particularly where safe, positive, and accurate control is required, as is normally the case, since the requisite accuracy and reliability of the solenoid plunger throw has not, as a practical matter, been realized.

## SUMMARY OF THE PRESENT INVENTION

The present invention marks an advance in control valves of the general type referred to above, amounting to a new concept in the structural nature and mode of operation of such control valves. In accordance with the invention, a new valve concept is provided by which a spool may be used as a primary control element in a manner not requiring extreme accuracy in machining tolerances, and yet in a valve having extremely accurate control functions and, at the same time, having complete reliability and safety of operation. Additionally, the control valve in accordance with the invention can readily be actuated by pushbutton-controlled solenoids or the like, as well as manually and by other conventional means, without loss of control accuracy or reliability.



In accomplishing the foregoing objectives, the invention provides a control valve which uses a spool-type valve element not as the sole control element, but only as a primary such element, as a result of which the accuracy of the machining tolerances need not be more than routine, and certainly not extreme. In combination with such a primary control element, the valve of the present invention also includes one or more secondary control elements which are used to control fluid flow to and from the primary control element. Most preferably, the secondary control elements comprise ball-type check valves which are opened by pressurized fluid directed thereto from the primary control element, and which are closed by pressurized fluid in an opposite direction; however, the invention also provides a movable, freely-mounted actuator for the secondary control elements, which is moved in response to pressurized fluid from the primary control element to open a secondary control element which would normally be closed as a function of fluid pressure at the latter, to provide controlled pressure return. The aforesaid actuator can be operated directly as a consequence of, and in conjunction with, fluid pressure directed to one secondary control element which serves to open the latter for passage therethrough, such that the fluid pressure causes the actuator to open another secondary control element which would normally be closed. Furthermore, "dummy" or non-operating secondary control element bodies are provided in accordance with the invention, for substitution in place of actual such control elements, to achieve "float" operation of hydraulically controlled apparatus and machinery such as, for example, a snowplow blade or the like.

The foregoing major objectives of the invention and the advantages provided thereby, together with other related objectives and advantages, will become more apparent from a consideration of the following more detailed specification, together with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a frontal perspective view of a control valve in accordance with the invention, showing an illustrative assembly of valve component parts;

FIG. 2 is a sectional side elevational view taken through the plane II—II of FIG. 1;

FIG. 2*a* is a sectional end elevational view taken through the plane 11*a*—11*a* of FIG. 2;

FIG. 3 is a sectional side elevational view taken through the plane III—III of FIG. 1;

FIG. 3*a* is a sectional end elevation taken through the plane III*a* —III*a* of FIG. 3;

FIG. 3*b* is a sectional end elevation taken through the plane III*b*—III*b* of FIG. 3;

FIG. 3*c* is a sectional end elevation taken through the plane III*c* —III*c* of FIG. 3;

FIG. 4 is a sectional side elevational view taken through the plane IV—IV of FIG. 1;

FIG. 4*a* is a sectional end elevational view taken through the plane IV*a*—IV*a* of FIG. 4;

FIG. 5 is a sectional side elevational view taken through the plane V—V of FIG. 1;

FIG. 6 is a sectional end elevational view taken through the plane VI—VI of FIG. 5; and

FIG. 6*a* is a sectional elevation similar to FIG. 6 but taken through the plane VI*a*—VI*a* of FIG. 5; and

FIG. 7 is a central sectional plan view of the secondary valve element shown in FIGS. 3 and 4.

## DESCRIPTION OF A PREFERRED EMBODIMENT

Referring first to FIG. 1, the preferred form of the overall control valve assembly 10 of the invention is a layered or laminar assembly which basically includes an inlet end plate or pressure plate 12 on one end and a return end plate or pressure plate 14 on the other end, with a plurality of control valve units 16, 18 and 20 disposed therebetween. The entire assembly is securely fastened together, as for example by the use of through-bolts which extend from end plate 12 to end plate 14, through apertures 22 in both end plates and in the control valve units disposed therebetween. While in a broad sense layered-type valve assemblies have been used in the past with different valve organizations, a layered construction of this type is definitely an advantage in the practice of the present invention, and as such should be considered as a feature thereof.

With respect to the overall basic assembly 10, it should be pointed out that inlet fluid under pressure from an appropriate pump is coupled to the inlet end plate 12 at a line fitting 24, and that each of the control valve units 16, 18 and 20 includes at least one fluid outlet through which fluid (which can include actuating fluid or return fluid) is directed by the operation of the particular valve unit involved. In the drawings, the fluid outlets for valve unit 16 are designated 16*a* and 16*b*, while that for valve unit 18 is designated 18*a* and that for valve unit 20 is designated 20*a*. As illustrated, valve units 18 and 20 have but one such outlet, whereas valve unit 16 has two; however, valve units 18 and 20 may also have two outlets, as will be described in more detail hereinafter, and in FIG. 1 the ports through which such additional outlets may be connected are closed by hex-socket plugs designated 18*b* and 20*b*, respectively.

The basic nature of the control valve units 16, 18 and 20 can best be understood by first referring to FIGS. 3, 3*a*, 3*b*, and 3*c*, which illustrate details of valve unit 16 (valve units 18 and 20 being for the most part structurally the same as unit 16).

As illustrated in FIG. 3, valve unit 16 includes a generally rectangular valve body 26 having a pair of spaced, generally parallel transverse bores, the lower one of which is designated 28 and the upper one of which is designated 30. A spool valve element 32 is disposed in a lower bore 28, and a check valve assembly 34 or 36 is disposed in each of the opposite ends of the upper bore 30. Also, between the check valves 34 and 36, an actuator means 38, in the nature of a free piston or plunger, is disposed within the upper bore 30. The arrangement for the spool 32 which is illustrated includes a spring-biased spool-centering means 40, and in this configuration the end of the spool shown at the right in the drawings will customarily be fitted to receive a connector (not specifically illustrated) by which the spool may be coupled to a solenoid actuator, such coupling and solenoid being conventional insofar as the invention is concerned.

As illustrated, the spool-centering means 40 comprises a shoulder bolt 42 which is threaded into a tapped hole in the end of the spool and which is telescoped through a washer-like spring retainer element 44. Bolt 42 slidably passes through a second spring retainer element 46 whose perimeter seats against a shoulder formed inside a tubular thimble-like cover 48, there being a coil spring 50 telescoped over the exposed shank of bolt 42, between retainers 44 and 46. As will be seen, this arrangement will serve to center the spool 32 whenever the same has first been pushed or pulled in either lateral direction and the pulling or pushing force, as provided by a solenoid actuator, is subsequently released.

In addition to the transverse passages 22 through valve body 16 for the aforementioned through bolts which hold the assembly together, the valve body also defines three parallel and mutually spaced transverse passages 28*a*, 28*b* and 28*c* (FIGS. 3, 3*a* and 3*c*), all of which extend directly through the valve body and communicate with the passage 28 thereof in which the spool 32 is disposed. It will be observed that spool 32 defines spaced areas of reduced circumference 32*a*, 32*b*, 32*c*, 32*d* and 32*e*, referred to as reliefs or grooves, which alternate with areas of unreduced circumference referred to as lands, designated 32*f*, 32*g*, 32*h*, and 32*i*. As illustrated, in the centered position of spool 32 (shown in FIG. 3), the central passage 28*b* is disposed centrally of relief 32*c*, and is of a diameter such that both of the lands 32*g* and 32*h* are partially registered with the sides of this passage, but the passage does not extend laterally the full width of either such land. Somewhat similarly, the passages 28*a* and 28*c* are in alignment with relief grooves 32*e* and 32*a*, respectively, and partially in alignment with lands 32*i* and 32*f*, respectively, without communication with relief grooves 32*b* and 32*d*. With this arrangement, it may be seen that a limited excursion of the spool in either direction will place its groove 32*b* or 32*d* in communication with central passage 28*b*, although the latter is of sufficient diameter to always bridge one of the lands 32*g* or 32*h*, so that the central groove portion 32*c* of the spool will always be in flow communication with passage 28*b*. Upon such an excursion of the spool, one or the other of the lands 32*f* or 32*i* will be moved in a direction sure that the one reset or groove portion 32*b* or 32*d* which is not placed in flow communication with passage 28*b* will be placed in communication with its respective passage 28*a* or 28*c*.

The check valves 34 and 36 disposed at opposite ends of the upper bore 30 are identical in nature, and each is thus illustrated in detail by the showing of valve 36 in FIG. 7. Each such check valve has a valve body of generally tubular construction, with a hollow interior defining a frusto-conical seat 52 disposed between an open-ended passage 54 communicating through the inner end of the valve body and a central passage 56 which extends through the opposite end of the valve body, the latter passage being internally threaded at its end extremity to receive a plug 58 which acts both as a closure for the passage and also as a spring retainer and spring tension-adjustment. Along its outer periphery, the body of valve 36 defines an annular relief 59 at the inner part of the body, with diametrically opposed apertures 60 which communicate with the chamber or passage 54, as well as defining a circumferential groove 61 for an O-ring or like seal, an annular relief

62 having a pair of diametrically opposed apertures 64 communicating with the interior of passage 56, a threaded outer peripheral portion 66 which threads into the control valve body 16, and a second circumferential groove 68 for receiving an O-ring, or like sealing member. Passage 56 contains a ball-type valve element 70 (FIG. 3) and a biasing spring 72 which bears against ball 70 and against the inner end of retainer 58, to force the ball against seat 52 with a predetermined, and variable pressure. As may be observed, when the ball 70 is not forced against seat 52, there is a path for fluid flow between passage 54, which opens outwardly at the inner end of valve 36 through the open end of the passage and through the apertures 60, past the seat 52 to the chamber 56, and laterally thereof through the apertures 64.

As stated above, the actuator or piston plunger 38 is disposed generally centrally within the upper bore 30, between check valves 34 and 36. Actuator 38 has a circularly cylindrical center section and a pair of oppositely-directed projecting cylindrical end extremities 80, 82, each of which aligns axially with the end passage 54 of the respective check valve disposed adjacent thereto, and upon sufficient movement in either lateral direction of the actuator 38, one or the other such projecting end extremity will enter the associated passage 54 in the check valve and unseat the ball 70, under conditions described more fully hereinafter.

Control valve unit 16, in addition to the internal passages and bores already described, also includes a pair of vertically-disposed interior passages 84 and 86 (FIG. 3) which communicate between the lower bore 28 in which the spool 32 is disposed and the upper bore 30, generally in alignment with the circumferentially relieved portions 59 of the respective check valves 34 and 36, at a position with respect to the latter which affords flow communication to the end passages 54 thereof. In actual practice, both of the vertical interior passages 84 and 86 are preferably formed by drilling downwardly into the valve unit 16 from its upper surface, and then sealing the upper extremities of such passages, which are normally not used, by threading the same and inserting appropriate pipe plugs 85. The valve unit 16 also includes vertical passages 88 and 90 (FIGS. 3, 3*a* and 3*b*) which are threaded to receive the fittings 16*a* and 16*b* referred to above, and which communicate with the annular relief portion 62 of each of the check valves, for flow communication to or from the interior passage 56 of the check valves, through the apertures 64 which communicate therewith. Further, valve unit 16 has a pair of spaced passages 30*a* and 30*b* (FIGS. 3, 3*a* and 3*b*) which extend orthogonally of both bore 30 and the passages 88 and 90 described above, through the side of the valve body, with passage 30*a* communicating with passage 88 at relief 62 of check valve 36 and passage 30*b* communicating with passage 90 at the same part of check valve 34.

The control valve unit 18 is illustrated in detail in FIG. 4, and is much like valve unit 16, as well as being directly analogous to the valve unit 20, except with respect to the relative lateral positioning of certain parts, as will be noted. Referring to FIG. 4, it may be seen that the valve unit 18 has a valve body essentially the same as that described above in connection with valve unit 16, including a pair of elongated generally parallel bores for a spool 32 and check valves of the type designated 36, i.e., the same kind of check valves used in the valve unit 16. Valve unit 18 also has the same spaced transverse lower passages 28*a*, 28*b* and 28*c* as unit 16, but valve unit 18 demonstrates, however, a further feature in accordance with the invention not present in valve unit 16, comprising a blank or dummy valve body 134 having basically the same outer configuration, and the same overall dimensions, as check valves 34 and 36. The blank or dummy valve body 134 is threadably interchangeable with either check valve 34 or 36, but includes no internal flow passages and no ball valve. Instead, the dummy valve 134 merely includes an axial bore or recess in its inner end for retaining a biasing spring 135, which bottoms in such bore and, at its other end, bears against the actuator piston 38, at least to the extent that it will return the latter to a centered position. With no flow passage through the dummy valve 134, the vertical passage 190 of valve unit 18 (corresponding to the passage 90 of valve unit 16) is closed by the plug 18*b* mentioned previously, as opposed to receiving a fitting and a line such as are shown at 18*a*, in vertical passage 188. A further difference in valve unit 18 when compared to valve unit 16 is the fact that whereas the latter has a lateral passage 30*a* extending through the side of the valve body and opening outwardly thereof, in registration with the openings 64 of check valve 36, valve unit 18 has no such passage laterally from bore 30 and, hence, fluid transfer from the check valve 36 of valve unit 18 is restricted to the vertical passages 188 or 184. Valve unit 20 is, in essence, the same as valve unit 18, except that the check valve 36 and the dummy valve 134 have been reversed in position, which is freely and readily done in accordance with the invention to change the functional characteristics of a particular valve unit. In this case, the position of plug 18*b* is reversed with that of the line fitting 18*a*.

The inlet end plate 12 noted in connection with FIG. 1 is illustrated in detail in FIGS. 2 and 2*a*. As already indicated, this end plate receives a line fitting 24 connected to the pump or other source of pressurized fluid. One of the primary functions of end plate 12 is to supply pressurized fluid to the other units of the valve assembly, and this is accomplished by an angular passage 24*a* which extends downwardly and laterally from fitting 24 to communicate through an aperture 13 in the rear or interior side 12*a* of the end plate which faces valve unit 16 and which is in direct registry with the central inlet pressure passage 28*b* of such valve unit.

In addition to merely supply inlet fluid pressure, end plate 12 also provides pressure regulation or relief features. One such feature involves the inlet pressure from the pump, such that the actual pressure of fluid passing outwardly through aperture 13 to the different valve units is regulated so that it does not exceed a predetermined maximum amount. This is accomplished by a relief valve means 92 (FIG. 2) disposed within a passage 94 which intersects the lower portion of inlet passage 24*a* and which is thus in flow communication with the fluid being admitted to the valve assembly at the point of admission. Relief valve means 92 comprises a ball 96 and a spring 98 which normally forces the ball against a seat to close the passage 94 from communication with inlet passage 24*a*. The end of spring 98 opposite ball 96 abutts and bears against a spring retainer 99 which has an axial flow passage and which is threaded into passage 94 so that it can be adjusted to vary the compressive force with which the spring bears against ball 96.

Passage 94 is closed by a pipe plug fitting 100 threaded into its outer end. The pressure plate 12 has a passage 102 (FIG. 2*a*), disposed normal to and intersecting passage 94, passage 102 communicating through the rear face 12*a* of the pressure plate and positioned in registration with the return passage 28*c* of the first valve unit 16 (FIG. 3 and 3*b*). Accordingly, ball 96 will be unseated by inlet fluid pressures exceeding a predetermined and variable maximum, to bleed off excess pressure through chamber 94 and passage 102, in a manner described further hereinafter.

Pressure plate 12 also includes a crossover relief feature, which is provided by a pair of relief valves 104 and 106 disposed in parallel spaced passages 108 and 110, respectively, which extend laterally into pressure plate 12 from opposite sides thereof. In fact, the passages 108 and 110 are, or can be, in full communication with one another; that is, the inner end extremity 108*a* of passage 108 intersects a downward vertical passage 112 whose outer end is closed by a threaded plug 113. Further, a passage 114 extending into the rear face 12*a* of the pressure plate 12 intersects both passages 112 and 108*a*. Passage 114 is positioned for registry with passage 30*a* of valve unit 16. Further, vertical passage 112 continues downward far enough to intersect the passage 110 in which relief valve 106 is disposed, such intersection being on the opposite side of the ball in this relief valve from the forward extension 110*a* of passage 110.

The arrangement of passages with respect to relief valve 104 and its passage 108 is similar to those just discussed above in connection with check valve 106 and passage 110. That is, a downwardly-oriented passage 116 closed by a threaded plug 117 intersects passage 108, and both such passages are also intersected by a lateral passage 118 (FIG. 2*a*) which, like the passage 114 mentioned above, extends outwardly through the rear face 12*a* or pressure plate 12. Vertical passage 116 continues downward to intersect the extending portion 110*a* of passage 110. Lateral passage 118 is disposed for registration with the lateral passage 30*b* (FIG. 3*b*).

The rear or return pressure plate 14 is shown in detail in FIGS. 5 and 6. This member closes the rearward end of the valve assembly and includes openings 22 for the through-bolts mentioned previously, as well as including certain fluid flow passages. The latter include a central fluid outlet passage 120 which extends into this plate from its outer side and which is threaded to receive a line fixture 121 (FIG. 6) for mounting a fluid line by which fluid may be returned to the reservoir. Also, end plate 14 has a laterally-extending passage 122 which intersects passage 120, the open end extremity of passage 122 being closed by a threaded plug 123 (FIG. 5). Passage 122, in turn is intersected by a pair of orthoganal passages 124 and 125 which communicate through the interior side 114*a* of end plate 14 (i.e., that side which abuts valve unit 20). Passages 124 and 125 are positioned for registry with the return passages 28*a* and 28*c* of the various valve units 16, 18, and 20, to receive fluid flow therefrom.

## OPERATION

Fluid under pressure from the pump enters the valve assembly 10 through line fitting 24 in pressure plate 12, and is communicated through the passage 13 of the latter to the centrally-disposed transverse passages 28*b* in each of the various control valve units 16, 18 and 20. The level of pressure actually admitted to the valve units is controlled by the setting of relief valve 92 (FIG. 2) contained by pressure plate 12, with any overpressures unseating the ball 96 of the latter valve and passing through passage 102 of end plate 12 to the return passages 28*c* of the various control valve units which, like the passages 28*a* thereof, are all mutually in registration in the assembled valve unit and which communicate with the passages 125 and 124 respectively, of the rear end plate 14 (FIG. 5), to ultimately connect with the return passage 120 of the latter.

In the centered position of the spool 32 (FIGS. 3 and 4) none of the valve units conduct fluid through any of the secondary check valve means such as 34 or 36 of control unit 16; however, it may be seen that if the spool 32 of valve unit 16 is moved to the right as seen in the figures, inlet pressure from passage 28*b* will communicate over the circumferentially relieved portion 32*d* of the spool and into the vertical passage 84 of this valve unit, the annular land 32*i* of the spool moving to the right to prevent flow of such fluid through return passage 28*a*. At the same time, such spool movement places return passage 28*c* in flow communication with relief portion 32*b* of the spool, so that return passage 28*c* then communicates with vertical passage 86. This causes the presence of pressurized fluid at the inlet to check valve 36, and also places this fluid pressure against the left side of actuator piston 38, causing the latter to move to the right.

Fluid pressure at the inlet side of check valve 36 unseats ball 70, moving the latter to the left against the pressure of spring 72, and allowing fluid flow outwardly through fitting 16*a* and, at the same time, providing pressurized fluid in passage 30*a* of valve unit 16 (FIG. 3*a*). The latter fluid pressure is, therefore, communicated through passage 114 of pressure plate 12, such that any subsequent overpressures beyond the setting of relief valve 104 will unseat the ball thereof and allow the excess pressure to relieve through passage 118 to passage 30*b* of valve unit 16 and into check valve 34, on the spring side of the ball thereof. Normally, however, fluid will merely pass outwardly through fitting 16*a* to actuate a connected power cylinder or other fluid apparatus. In the case of a double-acting or two single-acting hydraulic cylinders, the side thereof opposite the piston from that receiving pressurized fluid will be connected to fitting 16*b*, and hence fluid may return from such power cylinder through fitting 16*b* and into check valve 34.

Normally, one would expect that fluid from fitting 16*b* or passage 30*b* would be trapped at check valve 34, since this valve would normally be closed under these conditions of back pressure; however, the piston actuator 38 has moved to the right and its projecting portion 82 has forced ball 70 of check valve 34 off its seat, thereby allowing return through check valve 34, passage 86, and passage 28*c*, to the end pressure plate 14, where the same may pass through passages 124 and 122, to the outlet 120, and from there to the return side of the reservoir.

When, under the foregoing conditions, the remote power cylinder has been extended the desired amount, the spool is released and will automatically center, as a result of the operation of spring 50 and its associated members, as discussed above. Centering of the spool 32 removes the pressure from passage 84 and the inlet of

check valve **36**, whereupon the ball **70** of the latter will seat and, with the consequent establishment of balanced forced conditions within the upper bore **30** of the control valve unit, the actuator piston **38** will center, and check valve **34** will also close. Thus, the remote power cylinder is effectively locked in the desired position of adjustment to provide extremely safe and reliable operation. However, whenever any undesired extreme sudden force is applied to the power cylinder, as for example when the same is used to angularly position a snowplow blade and the blade while plowing suddenly strikes a fixed or substantially immovable object, the power cylinder can yield and allow the blade to shift under the impact rather than cause structural damage, since regardless of the direction of the force, the overpressure in one side or the other of the cylinder will be communicated to the interior of either check valve **34** or **36** and, through passage **30***a* or **30***b*, to the inlet pressure plate **12**, causing relief through relief valve **104** or **106**, as the case may be.

In many instances, it is desired to have a "float" position or mode of operation for the device powered by the remote power cylinder or other fluid apparatus connected to the valve assembly. In such cases, valve units of the type shown at **18** and **20** may be used. In these valve units, one of the check valves **34** or **36** is replaced by the dummy valve **134** illustrated in FIG. **4** and described above. In this configuration, the valve unit will, upon movement of the spool toward the right as shown in the drawings, operate partially in the same manner as discussed above in connection with valve unit **16**. That is, under these conditions pressurized fluid from the central passage **28***b* will be permitted to flow upwardly through passage **184**, opening check valve **36** and flowing or acting out of the valve unit through fitting **18***a*. At the same time, the actuator member **38** will be moved toward the right by this fluid pressure but, since there is no check valve in the right side of the valve unit, the actuator cannot open a path for return fluid flow downwardly through passage **186** and through the spool relief to relief passage **28***c*. Instead, the passage in the control valve corresponding to passage **190** of control valve unit **18** is not used, and the side of the hydraulic device opposite that powered from pressure through fitting **18***a* is merely left open to the pump return or to atmospheric pressure, as the case may be. Thus, in the case of a snowplow blade, for example, which is raised by fluid pressure from fitting **18***a*, once the spool valve has been returned to its centered position at a desired extent of blade elevation, check valve **36** will hold the blade at this position and will not permit lowering of the blade, unless the spool valve is moved to the left to permit relief of the actuating pressure through check valve **36**, passage **184** and passage **28***a*, in normal lowering procedure. However, the blade will under these conditions be permitted to "float," i.e., it can follow the ground contour with respect to further elevation over higher territory and subsequent return toward, or to, the initial point of elevation as determined by the initial operation of spool valve **32**. Under these conditions, the ultimate lowering of the blade is caused by gravity acting upon the weight of the blade itself, when the fluid pressure from fitting **18***a* is relieved. Such a "float" mode of operation is a most desirable feature, and like the operation of control unit **16** discussed above, operation of the unit **18** can also very readily and accurately be accomplished by pushbutton solenoid operation.

In accordance with the invention, then, a layered or sandwich-structure valve can be assembled from the two types of end plates **12** and **14**, with practically any desired assortment of control units **16**, **18**, or **20** to satisfy particular requirements. In fact, such a valve assembly can be modified at any desired time after initial assembly to incorporate either a greater or lesser number of the valve units, and each valve unit can, of course, be modified at any time by interchanging the check valves **34** or **36** with a dummy check valve **134** and, of course, using a plug **18***b* with the dummy check valve instead of using a fitting corresponding to that shown at **18***a*.

In the layered valve assembly of the invention, valve units of the type shown at **16** in FIG. **3** can be stacked laterally in multiples, one against the other, just as the valve units **18** and **20** may be, although when the valve units **16** are so stacked the passages **30***a*, **30***b* in those units after the first will not communicate with the inlet end plate **12** so as to have the crossover relief feature described above, unless of course the passages **30***a*, **30***b* are extended all of the way through the valve body **16**, so that one such body communicates with another. While this may be desired at times, it will not normally be desired since this will place the interior portions of the check valves in different valve units in flow communication with one another, and will in effect place the outlet lines from such check valves in parallel flow condition. Of course, it is possible to alternately place inlet end plates **12** between each pair of adjacent valve units of the type designated **16** and, in this manner, afford crossover relief to each such unit.

It is entirely conceivable that upon examining the foregoing disclosure, those skilled in the art may devise embodiments of the concept involved which different somewhat from the embodiment shown and described herein, or may make various changes in structural details to the present embodiment. Consequently, all such changed embodiments or variations in structure which utilize the concepts of the invention and clearly incorporate the spirit thereof are to be considered as within the scope of the claims appended herebelow, unless these claims by their language specifically state otherwise.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

**1.** A fluid control valve, comprising: a valve body having inlet and outlet pressure ports, return ports, and internal passages interconnecting said ports; a movable primary valve member disposed within said body between said inlet and return ports and movable to control fluid flow through the same and from such ports to certain of said passages; a pair of check valves removably mountable in said body, each between at least one of said internal passages and at least one of said outlet ports, said check valves each having a closure member and means biasing the same toward a closed position against the flow path from said passages to said one outlet port; and an actuator means exposed to pressure from fluid in other internal passages and movable in response to such fluid pressure to open said check valve closure members to permit reverse flow therethrough; each of said check valves in said pair disposed in flow communication between different internal passages

and outlet ports, and a dummy structure having a size and shape which at least in part corresponds to that of at least one of said check valve bodies and interchangeably mountable therewith, said dummy structure including biasing means for moving said actuator member.

**2.** The valve of claim **1,** wherein each of said check valves is disposed generally adjacent said actuator means and each is openable by the latter.

**3.** The valve of claim **2,** wherein said check valves in said pair thereof are disposed opposite one another for opposite opening operation upon oppositely directed movement of said actuator means.

**4.** The valve of claim **1,** wherein each of said check valves has a body having substantially the same size and shape as the body of the other such valve, said bodies being interchangeable.

**5.** The valve of claim **1,** wherein said primary valve member comprises a spool valve.

**6.** The valve of claim **5,** including means for centering said spool in the absence of displacement forces applied thereto.

**7.** The valve of claim **1,** including means for returning said actuator member to a neutral position, wherein said check valve is not actuated open by said member, upon removal of said fluid pressure.

**8.** The valve of claim **1,** including means for returning said actuator member to a centered position generally intermediate the allowable movement of such member in the absence of fluid pressure applied to said member.

**9.** The valve of claim **8,** wherein said primary valve member comprises a spool valve.

**10.** The valve of claim **9,** including means for centering said spool in the absence of displacement forces applied thereto.

**11.** A fluid control valve, comprising in combination: a layered, stacked valve body structure comprising at least two separate and distinct component control valve assemblies connected together in mating juxtaposition; each of said component control valve assemblies including a valve body having openings therein which register with those of the other such body, providing fluid transfer conduits from one body to the other; said two said component valve assemblies each having an inlet for fluid under pressure, an internal passage and a primary internal valve element for opening and closing a transfer path between said inlet and said internal passage; each component valve assembly further having a secondary valve means, for opening a fluid path from said internal passage to an outlet passage of such valve assembly in response to fluid pressure present in such internal passage resulting from the operation of said primary valve element and exceeding a predetermined fluid pressure at said outlet, and for closing said fluid path in response to fluid pressure at said outlet passage which is in excess of a predetermined fluid pressure at said internal passage; a pressure plate member also joined in juxtaposition to one of said component valve assemblies and having openings disposed in registration with certain of the said openings of such component valve assembly which register with like openings of the other of said assemblies for fluid transfer between the pressure plate member and said one component valve assembly, said pressure plate member including a bypass valve means in communication with at least one of said openings disposed in registration with said valve assembly openings, for bypassing fluid pressures from the latter which exceed a predetermined value; said one component valve assembly having said primary valve element including a pair of internal passages and a pair of outlet passages, and said primary valve element being movable to open and close a fluid flow path through either of such internal passages; said secondary valve means of such component valve assembly having means for opening and closing a fluid path to either of said outlet passages from a respective one of said internal passages under the stated fluid pressure conditions.

**12.** The valve of claim **11,** wherein each of a plurality of said component valve assemblies includes said internal passages, said outlet passages and said secondary valve means.

**13.** The valve of claim **12,** wherein each of a plurality of said component valve assemblies includes means defining an inlet passage, and includes a primary internal valve element for opening and closing a transfer path between such inlet passage and at least one of said internal passages.

**14.** The valve of claim **13,** wherein said means defining said inlet passages of said plurality of component valve assemblies comprises at least one of said registering valve body openings.

**15.** A fluid control valve assembly, comprising in combination: a valve body having first and second internal chambers, an inlet passage communicating through part of said body to said first chamber; an outlet passage communicating through part of said body to said second chamber, and an internal passage; a spool valve movably disposed in said first chamber and having recessed portions for opening a fluid flow path from said inlet passage to said internal passage; check valve means disposed in said second chamber for opening a flow path from said internal passage to said outlet passage in response to fluid pressure at the former exceeding a predetermined pressure at the latter and for closing such flow path under opposite pressure conditions; said body having a chamber for an actuator member generally adjacent said check valve means and an internal passage from said first chamber to said actuator chamber; an actuator member disposed in said actuator chamber for movement in response to fluid pressure in such internal chamber; said actuator having a portion engageable with said check valve means to open the same in response to said actuator movement thereby relieving fluid pressure from said outlet through said check valve despite the existence of said opposite pressure conditions; said second internal chamber having a pair of second chamber portions, with a separate internal passage from said first chamber to each such chamber portion, and with an outlet passage for each such chamber portion; said spool having recessed portions for opening a flow path to either of said internal passages and to the respective second chamber portion communicating therewith; a check valve means disposed in each of said second chamber portions for opening and closing a fluid flow path from the respective separate internal passages to the respective outlet passages of such chamber portions; and said actuator chamber disposed between said second chamber portions, with said actuator member being movable toward either of said check valve means and being engageable with either of the same to open either to produce said fluid pressure relief; and a dummy check valve having

means for interchangeable mounting of the same with one or the other of said check valve means; said dummy check valve having a configuration such that when so mounted the flow path through that check valve position is continuously closed.

**16.** The valve of claim **15,** wherein said pair of second chamber portions comprise a bore through part of said valve body, said check valve means disposed in opposite sides of such bore.

**17.** The valve of claim **16,** wherein said check valve means each include a body having means for removably mounting same within said bore.

**18.** The valve of claim **16,** wherein said actuator chamber comprises a further part of said bore, said actuator member being disposed within said bore between said check valve means.

**19.** The valve of claim **15,** wherein said dummy check valve includes means for biasing said actuator member toward a centered position.

**20.** A fluid control valve, comprising: a valve body having inlet and outlet pressure ports, return ports, and internal passages interconnecting said ports; a movable primary valve member disposed within said body between said inlet and return ports and movable to control fluid flow through the same and from such ports to certain of said passages; a pair of check valves mounted in said body, each between at least one of said internal passages and at least one of said outlet ports, said check valves each having a closure member and means biasing the same toward a closed position against the flow path from said passages to said one outlet port; an actuator means exposed to pressure from fluid in other internal passages and means being movable in response to such fluid pressure to open said check valve closure members to permit reverse flow therethrough; and fluid pressure by-pass means coupled to said body and having passages in flow communication with said inlet and return ports and passages in flow communication between at least certain of said internal passages; said by-pass means including pressure-responsive valve means in different ones of said passage for causing fluid flow from said inlet to said return ports and from one to another of said internal passages in response to predetermining pressure differential conditions occurring therebetween, to thereby relieve such conditions.

**21.** The valve of claim **20,** wherein said pressure by-pass means is disposed within a pressure block member which is connected to said valve body.

**22.** The valve of claim **20,** wherein said pressure by-pass means includes adjustable means for varying the pressure level at which said relieving takes place.

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