

[54] CONTROL VALVE

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[51] Int. Cl. F16k 11/07, F16k 11/10

[58] Field of Search 137/596, 596.12, 599.13

[56] References Cited

UNITED STATES PATENTS

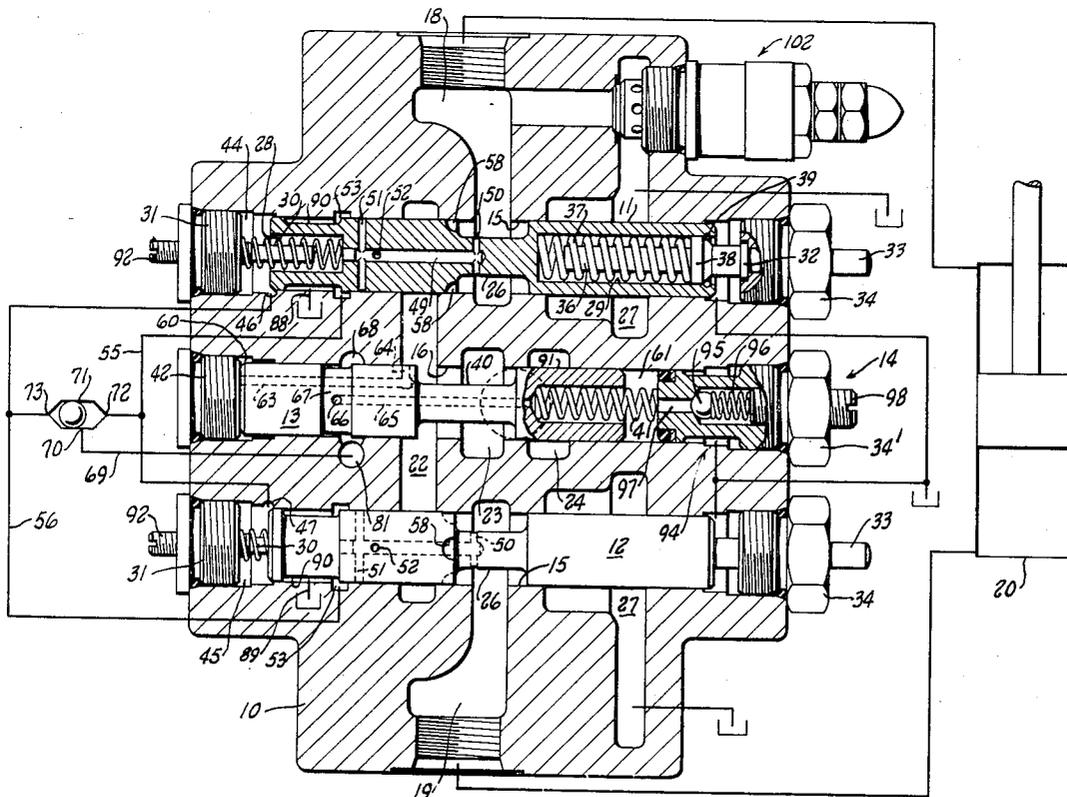
3,133,559	5/1964	Tennis.....	137/596
3,464,443	9/1969	Tennis.....	137/596.12

Primary Examiner—Henry T. Klinksiek
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[57] ABSTRACT

A sectional control valve having a pressure compensating valve to control fluid flow to each of a pair of service passages which provide for connection of the valve with the opposite sides of a reversible fluid motor. A separate valve spool for each service passage is movable to feed and vent positions to communicate its service passage with either pressure fluid supply or return passage means. Each valve spool is automatically actuated to its vent position by a hydraulic actuator that is energized by pressure fluid flowing to the service passage governed by the other valve spool, in the feed position of the latter. Grooves in the opposite faces of the valve section provide portions of the control passages for the hydraulic actuators associated with the valve spools and the compensating valve plunger.

22 Claims, 7 Drawing Figures



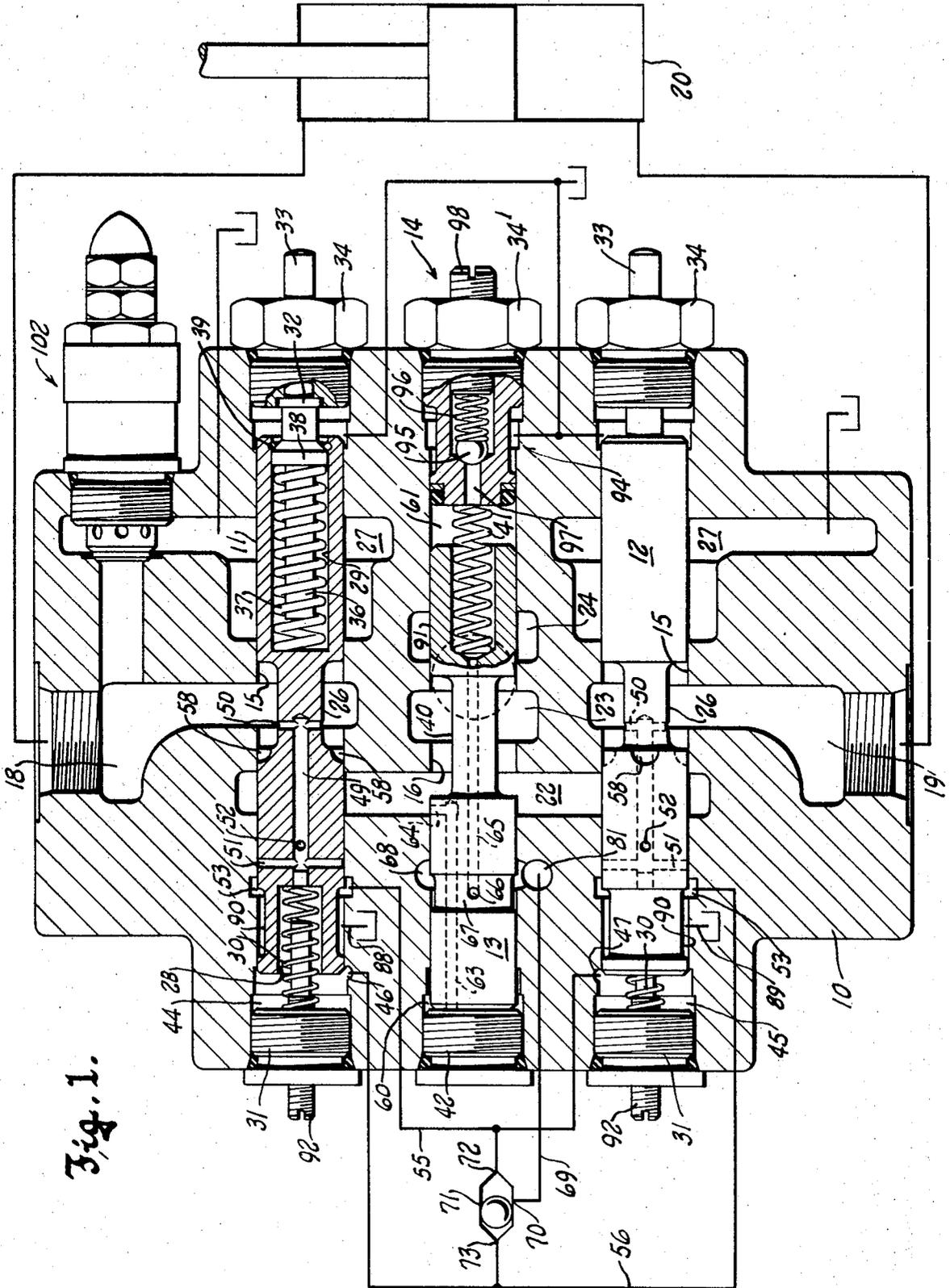
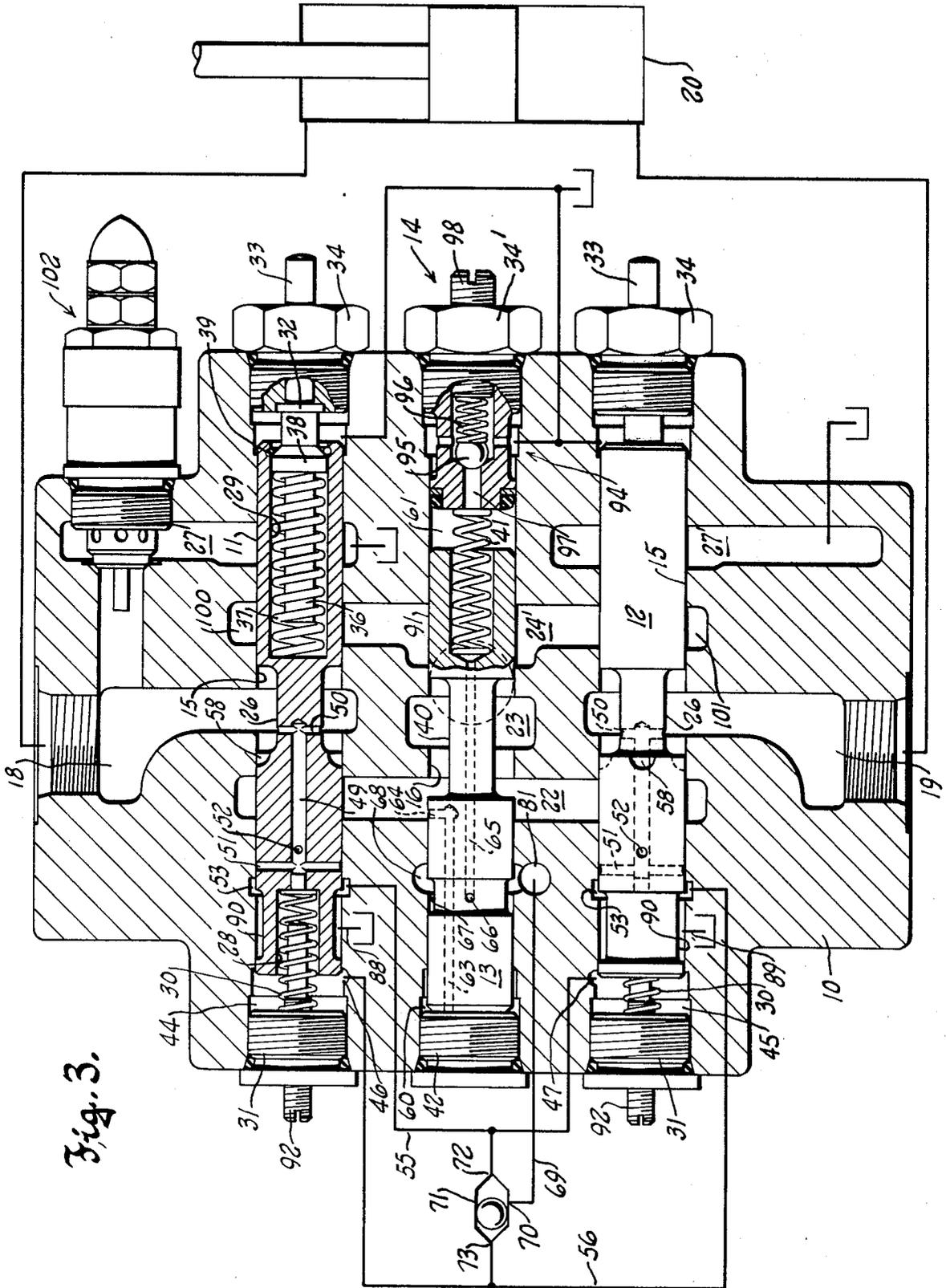
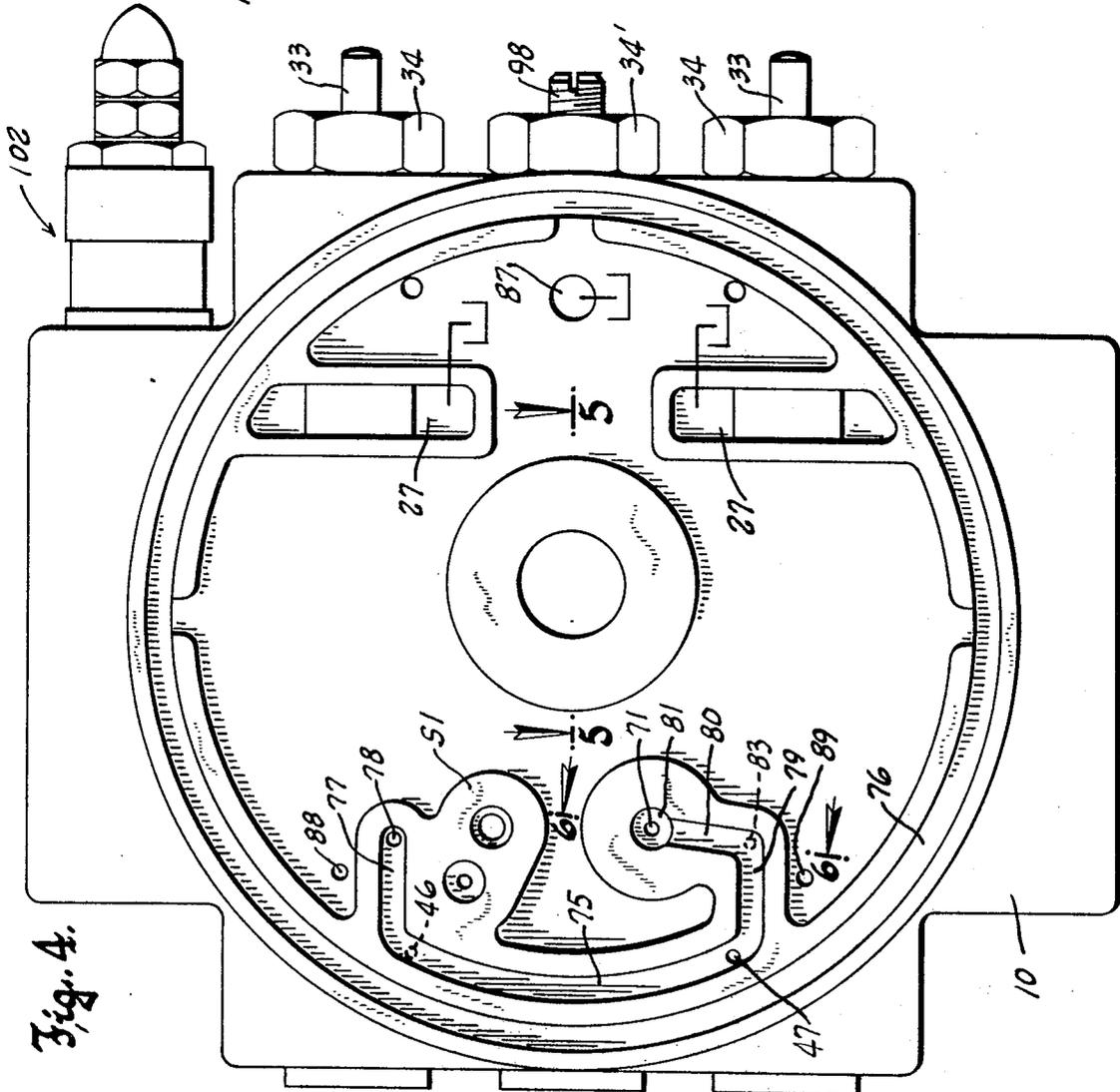
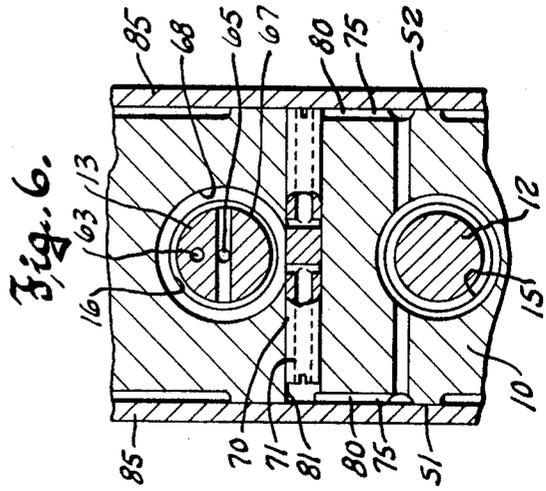
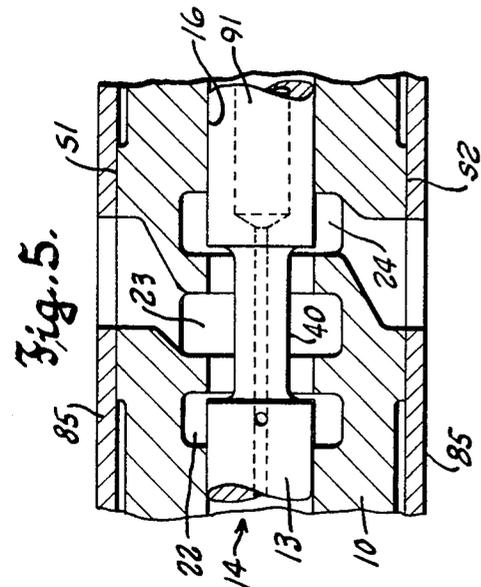


Fig. 1.





CONTROL VALVE

This invention relates to fluid pressure operated systems having one or more double acting cylinders or other reversible fluid motors, and it has more particular reference to control valves for governing the operation of such motors.

Most conventional control valves that are provided with a pair of service passages, for connection with the opposite sides of a reversible fluid motor, are characterized by a single axially shiftable spool type valve element to selectively communicate either of the service passages with a pressure fluid supply passage and the other service passage with a fluid return passage. In contrast, the control valve of this invention features a pair of valve spools which operate to govern operation of a reversible fluid motor. One spool is provided for each service passage and controls fluid flow to and from only one port of the reversible fluid motor.

In that respect, therefore, the control valve of this invention follows the so called divided or split spool concept of the Tennis U.S. Pat. No. 3,464,443, dated Sept. 2, 1969; and it is a general object of the invention to provide a split spool valve which is for simpler than that of the Tennis patent but performs equally as well.

One of the main advantages of the control valve of Tennis U.S. Pat. No. 3,464,443 is that it relieves the operator of the valve of the excessive effort ordinarily required to shift valve spools when those spools are of the large diameter necessary in a conventional high rate of flow valve. It achieves this advantage because its control spools are pilot actuated by small valves in which flow rates are not a consideration; one such pilot valve being required for each pair of spools that govern fluid flow to and from a double acting cylinder or other reversible fluid motor.

One of the main objectives of this invention is to provide a split spool type valve such as described, having valve spools which can be shifted with such little effort as to make possible their operation without pilot valves. Needless to say, the valves can thus be made and sold at far less cost, and they can even be actuated electromagnetically by an operator at a remote location, if desired.

In a more specific sense, it is a purpose of this invention to provide a control valve of the split spool type, wherein the valve spools can be operated with exceptionally low effort due in part to their short length and in part to the virtual elimination of axial momentum or jet forces thereon incidental to flow of fluid at high pressure past the lands thereon during operation of the valve.

In this respect, it is a further object of this invention to provide a split spool valve such as described, which embodies a pressure compensating valve mechanism to assure flow of pressure fluid to the governed motor at a constant rate as determined by the adjustment of the feed position of the valve spool governing flow of supply fluid to the motor.

Another object of the invention resides in the provision of a pilotless split spool control valve of the type having a pair of service passages for connection with the opposite sides of a reversible fluid motor and a valve spool for each such passage actuatable to a feed position at which it diverts supply fluid to its service passage, and wherein the other valve spool is then automatically actuated to a vent position connecting its service passage with a return passage.

In this respect, it is a more specific object of the invention to provide for automatic shifting of either spool of a split spool valve to its vent position by a hydraulic actuator energized in consequence of actuation of the other spool to its feed position, by pressure fluid then flowing to the service passage associated with said other spool.

Still another object of the invention resides in the provision of a split spool type valve of sectional construction, wherein portions of the control passages essential to operation of the compensating valve and for energization of said hydraulic operators are provided by grooves in the faces of the valve section.

With these observations and objectives in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings, which exemplify the invention, it being understood that changes may be made in the specific apparatus disclosed herein without departing from the essentials of the invention set forth in the appended claims.

The accompanying drawings illustrate three complete examples of the embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIG. 1 is a sectional view of a split spool type control valve unit embodying this invention;

FIG. 2 is a view similar to FIG. 1 but showing the valve spools in an operating position;

FIG. 3 is a view diagrammatically illustrating how the valve can be converted for series circuit operation;

FIG. 4 is a face view of the unit seen in FIGS. 1, 2 and 3;

FIG. 5 is a detail sectional view taken on the line 5—5 in FIG. 4;

FIG. 6 is a sectional view taken on the line 6—6 in FIG. 4; and

FIG. 7 is a view similar to FIG. 1 but illustrating a simplified version of the valve suitable for use in situations wherein the pressure compensating feature is not essential.

Referring now more particularly to the accompanying drawings, the numeral 10 generally designates the substantially flat valve housing or body of one control section for a sectional valve which may comprise two or more such control sections secured together in flatwise superimposed relation. Mounted in the body are two valve spools 11 and 12, and the valve plunger 13 of a pressure compensating valve mechanism 14. The valve spools are axially slidably received in bores 15 which are spaced equal distances to opposite sides of and parallel to a central bore 16 containing the plunger 13 of the pressure compensating valve mechanism 14. Plugs are threaded into the opposite ends of the bores to close the same.

A first service passage 18 opens to the exterior of the body from the bore containing the valve spool 11, and a second service passage 19 similarly opens to the exterior of the body from the bore containing the valve spool 12. Hence, there is a valve spool for each service passage, and each spool is adapted to control fluid flow to and from one port of a reversible fluid motor such as the double acting hydraulic cylinder 20.

The body is provided with pressure fluid supply means comprising a feeder passage 22 which intersects all three bores 15 and 16, and a carryover supply passageway having upstream and downstream branches 23 and 24 which intersect the bore 16 at axially spaced locations. The upstream branch 23 of the carryover passage opens to one face of the body while the downstream branch 24 opens to the opposite face of the body. Hence, pump fluid entering the upstream branch 23 of the supply passageway normally can flow through the downstream branch 24 to the upstream branch of a downstream control section to make supply fluid available to the service passages in said downstream section under the control of the valve spools therein.

Each valve spool 11,12 has a centrally located circumferential groove 26 therein to provide for communicating its service passage with the feeder passage 22 or with an exhaust passage 27 for said service passage. It is movable to the left of its neutral position shown to a feed position (18,19) which its groove 26 communicates the associated service passage (18,19) with the feeder passage 22. Similarly, each spool can be moved to the right of its neutral position to a vent position at which its groove 26 communicates the associated service passage with its exhaust passage 27. In the neutral positions of the spools, the lands at opposite axial sides of their grooves 26 close off the service passages from both the feeder and exhaust passages.

Each valve spool has an axial well 28 therein which opens to the left hand end of the spool, and a somewhat deeper axial well 29 therein which opens to the opposite end of the spool. A substantially light coil spring 30 confined between the bottom of the well 28 and the adjacent plug 31 yieldingly holds the spool in its neutral position. The neutral position of each spool is defined by the engagement of a flange 32 on a valve actuating stem 33 with the plug 34 closing the right hand end of its bore 15. The stem has an outer portion which projects through a suitable axial hole in the plug 34 to be accessible at the exterior thereof. An inner portion 36 of the stem projects into the well 29 to be encircled by a substantially strong coil spring 37 confined between the bottom of the well and an enlargement 38 on the stem which provides a seat for the spring. A snap ring 39 in the mouth of the well is engaged by the outer side of the spring seat enlargement to hold the actuating stem against axial movement outwardly of the well 29.

With the construction described, a push on the exposed portion of the actuating stem of either valve spool 11,12 is transmitted through the spring 37 thereof to the spool to move the same to its feed position at which its service passage is communicated with the feeder passage portion 22 of the supply passageway. It should be here observed that the feeder passage 22 intersects the bore 16 containing the pressure compensating plunger 13 at a location to the left of the upstream branch 23 of the carryover supply passage, so that the latter is situated intermediate its downstream branch 24 and the feeder passage 22. Pressure fluid in the inlet branch 23 of the carryover supply passage flows to either service passage 18,19 in the feed position of its valve spool 11,12, as long as the plunger 13 of the pressure compensating valve 14 is in a position at which a circumferential groove 40 in its

exterior communicates the feeder passage 22 with the upstream or inlet branch 23 of the carryover supply passage. A spring 41 acting upon the plunger 13 urges the same toward one limit of motion defined by the engagement of its left hand end with a stop provided by the adjacent plug 42.

A hydraulic operator is provided for each valve spool 11,12, to actuate the same to its vent position. For this purpose, those portions of the bores 15 which are inwardly adjacent to the plugs 31 provide actuating cylinders 44 and 45 in which the left hand ends of the valve spools 11,12, respectively, operate as pistons. Hence, the spools will be actuated to their vent positions in consequence of flow of pressure fluid into their respective actuating cylinders 44,45, via ports 46 and 47, respectively, for said cylinders.

According to this invention, each valve spool will be hydraulically actuated to its vent position as a consequence of actuation of its companion spool to its feed position. This is to say that if one valve spool, 11 for example, is moved to the left of neutral to a feed position seen in FIG. 2, the other valve spool 12 will be actuated to its vent position in consequence of diversion of pressure fluid to its actuating cylinder 45 from the service passage 18 governed by the valve spool 11.

For the above purpose, each valve spool is provided with an axial passage 49 one end of which communicates with a crossbore 50 that opens to the circumferential groove 26 in the spool, and the other end of which communicates with axially adjacent crossbores 51 and 52 in the spool near the bottom of the well 28 therein. One or the other of the crossbores 51 or 52 will always be brought into register with an enlargement 53 of the bore 15 when the valve spool is shifted to the left to a feed position communicating its service passage with the feeder passage 22.

FIGS. 1 and 2 diagrammatically illustrate how each valve spool is adapted to serve as a pilot valve which is operable upon shifting of the spool to its feed position to effect energization of the hydraulic actuator for the other spool and consequent actuation of the latter to its vent position. To achieve this feature of the invention, the enlargement 53 of the bore containing valve spool 11 is communicated by a control passage 55 with the port 47 of actuating cylinder 45; while the enlargement 53 of the bore containing valve spool 12 is communicated by a control passage 56 with the port 46 of cylinder 44.

In operation, if the piston rod of the work cylinder 20 is to be retracted, spool 11 is pushed in to a feed position at which pressure fluid flows to the rod end of the work cylinder from the inlet branch 23 of the supply passage via the feeder passage 22, the groove 26 in spool 11 and its bore 15, and service passage 18. At the same time, pressure fluid diverted to the service passage 18 will flow into crossbore 50 in spool 11 and through its axial passage 49 and crossbore 51 or 52 to the enlargement 53 of the bore containing spool 11, from whence it flows to the actuating cylinder 45 for spool 12 via control line 55. The pressure fluid then flowing into cylinder 45 effects shifting of valve spool 12 to its vent position at which pressure fluid expelled from the contracting end of the work cylinder and returned to service passage 19 can flow to the exhaust passage 27 through the groove 26 in spool 12, and the bore in which said spool operates.

Similarly, the valve spool 11 will be hydraulically actuated to its vent position by pressure fluid diverted into its actuating cylinder 44 in consequence of actuation of the other valve spool 12 to its feed position effecting extension of the piston rod of the work cylinder 20.

Each service passage 18,19 is supplied with pressure fluid from the feeder passage 22 in the feed position of its valve spool through an orifice whose size and flow restricting effect depends upon the distance the spool is displaced from neutral. For example, the orifice will have maximum size and least restricting effect upon fluid flow to either service passage when the associated valve spool is shifted to a full feed position of engagement with the stop provided by the plug 31 closing the bore in which the spool operates. The orifice will be smaller and have more limiting effect on fluid flowing to the service passage when the associated valve spool is shifted to a feed position short of the full feed position described, to meter fluid flow to the service passage.

In the present case, throttle notches 58 in the ends of the spool lands at the left hand end of the grooves 26 facilitate metering of fluid flow to the service passages; and the notches in each spool can be said to provide an orifice through which fluid flows to the associated service passage in any of a number of metering positions of the valve spool short of its full feed position.

Whenever pressure fluid flows through such an orifice from the feeder passage to one or the other of the service passages, there will be a pressure drop across the orifice. This pressure drop or differential is sensed by the plunger 13 of the pressure compensating valve mechanism 14, which functions to regulate flow to the feeder passage 22 in accordance with variations in said pressure drop or differential.

For that purpose, the pressure of fluid in the feeder passage 22 is caused to exert force upon the left hand end of the compensating plunger 13, while the higher of the pressures obtaining in the service passages is caused to exert force upon the right hand end of the compensating plunger.

The left hand end of the plunger 13 operates in a pressure chamber 60 defined by that portion of its bore 16 inwardly adjacent to the plug 42; while the opposite end of the bore 16 which is closed by the plug 34' provides a pressure chamber 61 in which the adjacent end of the compensating plunger operates.

The pressure chamber 60 is at all times subjected to the pressure of supply fluid obtaining in the feeder passage 22 through an axial passageway 63 that opens to the chamber 60 at one end. The other end of the passageway 63 opens laterally as at 64 to the exterior of the plunger land at the left of its groove 40, at a location such as to be in communication with the feeder passage in any position of the compensating plunger.

A second axial passageway 65 in the plunger 13 opens at one end to the pressure chamber 61 containing the other end portion of the plunger. The opposite end of the passageway 65 opens radially outwardly as at 66 to a shallow circumferential groove 67 in the compensating plunger located substantially medially between its groove 40 and the left hand extremity of the plunger. The groove 67 registers with an enlargement 68 of the bore 16 in all axial positions of the compensating plunger.

The enlargement 68 has been shown by way of illustration as connected by a control passage 69 with the side port 70 of a shuttle valve 71. The end ports 72 and 73 of the shuttle valve are connected with the enlargements 53 of the bores for valve spools 11 and 12 by means of the control passages 55 and 56, respectively, described earlier. The purpose of the shuttle valve, of course, is to assure subjection of the spring end of the compensating plunger to the pressure of fluid in whichever service passage is communicated with the supply passage by its valve spool and thus has the higher pressure.

One of the features of the control valve of this invention resides in forming portions of the above described passages as grooves in the opposite faces of the valve section, to thereby reduce the number of drilling operations necessary for the production of said passages.

Thus, for example, the opposite finished surfaces S1 and S2 of the body are provided with identical grooves 75 at a location inwardly of the circular groove 76 for the "O" ring employed in sealing the joint between valve housings. A substantial length of each groove 75 is concentric to the "O" ring groove, but one end portion has a branch 77 which extends inwardly away from it to intersect a hole 78 drilled into the housing from its surface S1 and normal thereto. The hole 78 opens to the enlargement 53 of the bore containing valve spool 11.

The other end portion of the groove 75 in one face of the body intersects the hole 47 which extends inwardly from the surface S1 into the operating cylinder 45 for the valve spool 12, and defines the port for said cylinder. Hence, the grooved portions 75 and 77 in said one face of the body, along with holes 47 and 78, provide the control line 55 diagrammatically illustrated in FIGS. 1 and 2.

Leading from its intersection with the port forming hole 47, each groove 75 has a branch 79 which extends inwardly a short distance away from the "O" ring groove 76 and which joins with another branch 80 that extends a short distance toward the first mentioned branch 77 of the groove. The branch 80 terminates at the mouth of a bore 81 that extends all the way through the housing normal to its surfaces S1 and S2. The shuttle valve 71 is mounted in the bore 81, and the junction of said bore with the grooved portion 80 in surface S1 of the housing provides the end port of the shuttle valve diagrammatically seen in FIGS. 1 and 2. The other end port 73 of the shuttle valve is provided by the junction between the opposite end of bore 81 and the end of the branch 80 of the groove 75 in the opposite surface S2 of the housing. At a location medially of its ends, the bore 81 is communicated with the enlargement 68 of bore 16 housing the compensating plunger, to thus provide the side port 70 of the shuttle valve.

Drilled into the housing from its other surface S2 is a first hole 83 which opens to the enlargement 53 of the bore containing the valve spool 12. This hole opens to the groove 75 in body surface S2 at a location at the junction between groove branches 79 and 80. The port 46 of actuating cylinder 44 for valve spool 11 is formed as a drilled hole which opens to the groove 75 in surface S2 adjacent to its junction with the branch 77 thereof. Hence, the grooved portions 75 and 79 in surface S2 of the housing together with holes 46 and 83,

define the control line 56 diagrammatically seen in FIGS. 1 and 2.

Because of the grooves 75 a thin flat plate 85 is confined between the valve housings in a stack thereof, as seen in FIGS. 5 and 6, to isolate the grooves in each valve section from those of an adjoining section in the stack. These plates, of course, bear flatwise against the "O" rings in grooves 76 to seal the joint between the various valve sections in the stack.

The particular sealing expedient for the junctions between valve sections follows the teachings of Tennis U.S. Pat. No. 3,133,559, in that finished surfaces having face to face engagement with the separation plates 85 surround the mouths of all high pressure passages that open to the opposite sides of the housing, while all other areas of those faces inwardly of the "O" ring groove 76 are depressed and maintained at reservoir pressure. For that purpose, the housing for each valve section of a stack thereof is provided with a hole 87 which opens to the depressed area in each face of the housing, and which is connectable to the reservoir of the system at one end of the stack of valve sections to assure that the depressed areas will be maintained at reservoir pressure.

It should also be observed that there are two more holes 88 and 89 which are drilled into the housing from one of the low pressure depressed areas thereof, to the bores 15 at locations such as to communicate with circumferential grooves 90 in the left hand end portions of the valve spools 11 and 12, respectively, in said bores. These grooves 90 serve to vent the enlargements 53 of the bores 15 in the neutral positions of the valve spools therein. As a result, the pressure fluid in the hydraulic actuating cylinders 44 or 45 can be expelled therefrom to one or the other of the venting ports 88, 89 via the control line 56 or 55 connecting therewith during initial actuation of either valve spool to its feed position. After only slight motion of either valve spool toward its feed position, the circumferential groove 90 therein communicates its hydraulic actuator cylinder with the vent hole 88 or 89, leading to the bore containing the actuated valve spool, to then establish a more direct exhaust path for fluid expelled from the actuating cylinder.

The operation of the valve mechanism described is believed to be obvious from the above. However, it should be noted that the particular compensating plunger 13 shown adapts the control valve for series-parallel or conventional operation. This results from the fact that the land 91 thereon to the right of its groove 40 is able to close off communication between the upstream and downstream branches 23 and 24 of the carryover supply passage in its valve section if pressure in the service passage to which supply fluid is flowing rises to a high value and the load demand for pressure fluid is relatively great.

At times when one or the other of the valve spools is in a feed position such as seen in FIG. 2, permitting a metered amount of supply fluid to flow to its service passage from the feeder passage 22, the compensating plunger will ordinarily occupy a position at which its groove 40 allows some of the fluid in the upstream supply passage branch 23 to flow to the downstream branch 24, in bypass relation to the feeder passage 22.

If the load on the governed cylinder should vary, of course, the compensating plunger 13 will be caused to shift in the direction to restore the desired differential in pressure between fluid in the feeder passage and that in whichever service passage is communicated therewith. For example, the plunger will be shifted to the left to increase the flow of supply fluid to the feeder passage if the pressure of fluid in the service passage fed therefrom rises. It will be shifted to the right to decrease flow to the feeder passage if there is a pressure drop in the service passage in communication therewith.

The construction described lends itself exceptionally well to the provision of an adjustable spool stop 92 for one, or for both valve spools. The stop 92 for spool 11 is threaded into the plug 31 closing the left hand end of its bore, and its inner end projects into the well 28 in the spool for engagement with the bottom of the well. With the stop adjusted as shown, the spool 11 can be shifted to its full feed position without interference from the stop. If the stop is turned inwardly on its threaded connection with the plug 31, however, it will limit the distance the valve spool 11 can be shifted in the feed direction an extent depending upon the adjustment of the stop. This, of course, helps to establish a metering position of the spool to which it can be repeatedly shifted each time its service passage is to be communicated with the feeder passage 22.

Another feature of the control valve of this invention resides in the provision of a high pressure relief valve mechanism 94 for the pressure chamber 61 at the spring end of the pressure compensating plunger 13, by which sequential operation of a plurality of hydraulic cylinders can be achieved. The mechanism 94 comprises a valve element 95 which is normally held engaged with a valve seat by a spring 96, to close a venting passage 97 for the pressure chamber 61. A screw 98 threaded into the plug 34' provides for adjustment of the spring force tending to hold the valve element 95 seated.

The valve element is held in closed position by its spring during all normal operation of the governed cylinder. It will be unseated whenever the pressure of supply fluid in either service passage rises to an abnormally high value. Such an abnormally high pressure, for example, can be produced when the piston rod in work cylinder 20 reaches the end of its extension (or retraction) stroke. At that time, the pressure in the expanding end of the cylinder rises abruptly to an abnormally high value, which pressure will also be manifested in the pressure chamber 61 of the compensating valve 14. The valve element 95 will be then unseated to vent chamber 61 and cause the compensating plunger 13 to be shifted to the right by the pressure of supply fluid in the chamber 60 at the opposite end of the plunger.

In the series-parallel valve shown, the compensating plunger 13 can occupy a full flow position preventing bypass of supply fluid to the outlet branch 24 of the supply passage whenever one of the valve spools is in a full feed position. Under such conditions, when the piston rod of the work cylinder then reaches the end of its stroke, the abrupt rise in pressure in the cylinder effects unseating of the valve element 95 to thereby vent the chamber 61. The compensating plunger 13 will then be propelled to the right to allow pressure fluid in

the upstream branch of the supply passage to flow to the downstream branch 24 thereof, from whence it can enter the upstream branch of the supply passage in the next valve section for sequential operation of a fluid motor governed by the valve spools therein.

FIG. 3 illustrates how a substantially minor alteration in the coring of the housing converts it for series circuit operation. As therein seen, the downstream branch 24' of the carryover supply passage in the housing has opposite lateral extensions 100,101 which intersect the bores 15 for both valve spools 11 and 12, respectively. These extensions are separate from the exhaust passages 27' and join with the bores 15 at locations intermediate their zones of communication with the associated service passages 18,19 and the exhaust passages 27'.

When either valve spool 11, 12 is in its "vent" position displaced to the right of its neutral position shown, the central groove 26 in the spool effects communication of the associated service passage with the downstream branch 24' of the carryover supply passage through one or the other of the extensions 100,101 thereof. Accordingly, the fluid expelled from a first hydraulic work cylinder is made available for operation of a second work cylinder governed by the valve spools in a downstream valve section.

In the series valve shown in FIG. 3, however, the valve spools never communicate the service passages with the exhaust passages 27', as they did in the series-parallel valve of the first described embodiment of the invention. One or both of the exhaust passages 27 or 27' however, can be communicated with the associated service passage through a combination high pressure relief and void control valve 102 of a type such as disclosed in Tennis U.S. Pat. No. 3,164,166.

The control valve shown in FIG. 7 is like that of FIG. 1 except that it has no compensating valve mechanism. Hence, it is useful in situations where accurate or precise speed control is not essential.

Again in this case, either valve spool 11 or 12 is automatically hydraulically actuated to its vent position in consequence of actuation of the other valve spool to its feed position. For that purpose, the hydraulic actuator (44,45) for each spool is supplied with pressure fluid as before, from the bore enlargement 53 associated with the other valve spool at the time the latter is shifted to a feed position. The control passages 55' and 56' diagrammatically shown in FIG. 7 provide for such energization of the hydraulic actuators 44,45.

In this embodiment of the invention, however, an unloading valve 105 is employed to divert pump fluid away from the feeder passage 22 and bypass it to the reservoir when both valve spools are in their neutral positions. The unloading valve is of conventional design, having a pressure chamber which, when vented through a passageway 106 leading serially through the bores 15 for both valve spools, effects opening of the unloading valve and return of the pump output to the reservoir. Shifting of either valve spool to a feed position closes off the venting passage and effects closure of the unloading valve in the usual way.

While series and series-parallel valve arrangements have been disclosed herein, it is believed to be apparent that the control valve of this invention could easily be modified for parallel operation, which would involve

the employment of a compensating plunger having a circumferential groove 40 therein long enough to at all times assure communication between the upstream and downstream branches of the carryover supply passage in the valve housing.

From the foregoing, it is believed to be apparent to those skilled in the art that this invention provides a simplified version of the so-called split spool valve, which nevertheless achieves all of the objectives set forth hereinabove.

I claim:

1. A control valve having pressure fluid supply and return passage means and a pair of service passages for connection with the opposite sides of a reversible fluid motor, characterized by:

A. a first valve spool movable to a feed position communicating one of said service passages with the supply passage means;

B. a second valve spool movable to a vent position communicating the other service passage with the return passage means;

C. actuating means for said second valve spool operable when energized to shift said spool to its vent position;

D. and means controlled by said first valve spool and rendered operative thereby in the feed position thereof to effect energization of the actuating means for said second valve spool.

2. The control valve of claim 1, further characterized by:

A. each valve spool being movable to such feed and vent positions and having actuating means for shifting the same to its vent position;

B. and means controlled by each valve spool and rendered operative thereby upon movement thereof to its feed position to effect energization of the actuating means for the other valve spool.

3. A control valve having pressure fluid supply and return passage means and a pair of service passages for connection with the opposite sides of a reversible fluid motor, characterized by:

A. a first valve spool movable to a feed position communicating one of said service passages with the supply passage means;

B. a second valve spool movable to a vent position communicating the other service passage with the return passage means;

C. fluid pressure actuating means for said second spool, having a cylinder into which pressure fluid can flow to effect actuation of said second spool to its vent position;

D. and means controlled by said first valve spool and rendered operative thereby in the feed position thereof to effect communication of the supply passage means with the cylinder of said actuating means.

4. The control valve of claim 3, wherein:

A. pressure fluid flows from the supply passage means to said one service passage through an orifice whose size and flow limiting effect is determined by the position of said first valve spool;

B. and further characterized by a pressure compensating valve operable to regulate flow of pressure fluid to said one service passage in accordance with variations in the pressure drop across said orifice.

5. The control valve of claim 3, further characterized by:
- A. each of said spools being movable to feed and vent positions to provide for communication of its associated service passage with either the supply or the return passage means;
 - B. a pair of said fluid pressure actuating means, one for each valve spool;
 - C. and means controlled by each spool and rendered operative thereby in the feed position thereof to effect communication of the supply passage means with the cylinder for the other spool.
6. The control valve of claim 5, wherein pressure fluid flows to each service passage through an orifice whose size and flow limiting effect is determined by the setting of the associated valve spool in the feed position thereof; and further characterized by a pressure compensating valve operable to regulate the flow of pressure fluid to each of said orifices in accordance with variations in the pressure drop thereacross.
7. The control valve of claim 5, further characterized by:
- A. feeder passage means to communicate the supply passage means with each service passage in the feed position of its valve spool;
 - B. means on each valve spool to provide an orifice through which fluid flows from the feeder passage to the associated service passage in an amount determinable by the adjustment of the feed position of the valve spool;
 - C. and a pressure compensating valve operable in the feed position of each spool to regulate fluid flow to the service passage thereof in accordance with variations in the pressure drop across the orifice through which fluid passes to said service passage.
8. A control valve having pressure fluid supply and return passage means and a pair of service passages for connection with the opposite sides of a double acting cylinder or other reversible fluid motor, characterized by:
- A. a feeder passage common to the service passages and through which they are communicable with the supply passage means;
 - B. a valve spool for each service passage, to communicate the same with either the feeder passage or with the return passage means;
 - C. a fluid pressure actuatable valve plunger to regulate flow of pressure fluid to the feeder passage in accordance with variations in the pressure differential between the feeder passage and whichever service passage is in communication therewith;
 - D. pressure chambers into which the opposite end portions of said plunger project to be subjected to the force of pressure fluid therein;
 - E. passage defining means including a passage leading through the interior of each valve spool, for subjecting one of said chambers to the pressure obtaining in whichever service passage is in communication with the feeder passage;
 - F. means defining a passageway communicating the other of said chambers with the feeder passage;
 - G. fluid pressure actuating means for each valve spool, having an actuating cylinder into which pressure fluid can flow to effect actuation of the spool to its vent position;

- H. and means controlled by each valve spool and rendered operative thereby in the feed position thereof to effect flow of pressure fluid from the feeder passage into the actuating cylinder associated with the other valve spool.
9. The control valve of claim 8, wherein said passage defining means comprises:
- A. a shuttle valve having a pair of inlet ports, a common outlet port, and a valve member to close off the outlet port from either inlet port in consequence of flow of pressure fluid into the other inlet port;
 - B. and said shuttle valve having its outlet port communicated with said one chamber of the compensating valve mechanism, and one of its inlet ports being connectable with the internal passage in one of said valve spools, and the other of its inlet ports being connectable with the internal passage in the other valve spool.
10. A valve section for a stacked control valve, having a body with a pair of service passages for connection with the opposite sides of a reversible fluid motor, and having supply and return carryover passage means opening to opposite faces of the body, characterized by:
- A. a feeder passage through which the service passages are fed from said supply passage means;
 - B. a pair of bores, one for each service passage and intersected thereby and by said feeder passage;
 - C. a valve spool in each bore movable to feed and vent positions to communicate its service passage with the feeder passage in said feed position or with the return passage means in said vent position;
 - D. a pressure compensating valve reciprocable in a third bore in the body, to regulate flow of supply fluid to said feeder passage in accordance with variations in the pressure differential between fluid in the feeder passage and that in either service passage communicated with the feeder passage by its valve spool;
 - E. fluid pressure actuating means for each valve spool, comprising a cylinder into which pressure fluid can be delivered to effect movement of the spool to its vent position;
 - F. and passage defining means under the control of each valve spool and rendered operative thereby in the feed position of said spool for effecting delivery of pressure fluid from its associated service passage to the cylinder of the other valve spool, portions of said passage defining means comprising grooves in said faces of the body.
11. A valve section for stacked control valves, characterized by:
- A. a flat body which can be sandwiched between other sections of a stack;
 - B. passage means in the body providing supply and return passages, and a pair of service passages which are connectable with the opposite sides of a reversible fluid motor;
 - C. a pair of valve spools, one for each service passage,
 - 1. one of said spools being movable to a feed position to communicate its service passage with the supply passage,

2. and the other spool being movable to a vent position to communicate its service passage with the return passage;
- D. means providing an actuating cylinder for said other spool by which it is actuatable to its vent position in consequence of flow of pressure fluid into the cylinder;
- E. means providing a control passage which is governed by said one valve spool and rendered operative thereby in the feed position thereof to communicate the associated service passage with said cylinder;
- F. and a groove in one face of the body providing a portion of said control passage.
12. The valve section of claim 11, further characterized by a flat plate overlying and in intimate engagement with said grooved face of the body.
13. The valve section of claim 11, further characterized by:
- A. each valve spool being movable to such feed and vent positions and having its own actuating cylinder;
- B. a control passage associated with each valve spool to be rendered operative thereby in the feed position thereof to communicate the associated service passage with the actuating cylinder for the other valve spool;
- C. and grooves in the opposite faces of the body, one for each control passage and providing a portion thereof.
14. The control valve of claim 13, further characterized by a flat plate covering the groove in each of said faces of the body.
15. The valve section of claim 13, further characterized by:
- A. said valve spools being reciprocally received in spaced apart parallel bores in the body;
- B. one end of each of said bores being closed and cooperable with the adjacent end of the valve spool in the provision of said actuating cylinder for the spool;
- C. and said supply passage having a feeder branch which is common to said valve spools and intersects the bores in which they operate.
16. A control valve having pressure fluid supply and return passage means and a pair of service passages for connection with the opposite sides of a reversible fluid motor, characterized by:
- A. a first valve spool movable to a feed position communicating one of said service passages with the supply passage means;
- B. a second valve spool movable to a vent position communicating the other service passage with the return passage means;
- C. a pressure compensating valve mechanism for regulating fluid flow to said one service passage in accordance with variations in the pressure differential between fluid in the supply passage means and that in said one service passage;
- D. actuating means for said second valve spool operable to shift the same to its vent position;
- E. and means controlled by said first valve spool and rendered operative thereby in the feed position thereof the effect energization of the actuating means for said second valve spool.

17. The control valve of claim 16, further characterized by:
- A. each valve spool being movable to such feed and vent positions;
- B. said supply passage means comprising a feeder passage common to said spools and through which pressure fluid flows to said service passages in the feed positions of their respective spools;
- C. and means rendering said pressure compensating valve mechanism operative to regulate flow of pressure fluid to the feeder passage in accordance with variations in the pressure differential between fluid in the feeder passage and that in either service passage receiving fluid from the feeder passage.
18. The control valve of claim 17, further characterized by:
- A. actuating means for each valve spool operable when activated to effect shifting of the spool to its vent position;
- B. and means controlled by each valve spool and rendered operative thereby upon movement thereof to its feed position to effect activation of the actuating means for the other valve spool.
19. A control valve having a body with spaced apart first and second parallel bores each containing a valve spool which is movable to feed and vent positions at opposite sides of a neutral position to communicate an associated service passage with either pressure fluid supply or return means, characterized by:
- A. each service passage opening to its associated bore at a first zone which is spaced from and intermediate second and third zones of said bore;
- B. said return passage means communicating with each of said third zones;
- C. a third bore between and parallel to said first and second bores;
- D. said pressure fluid supply means comprising a supply passage which opens to said third bore at a location between said first zones, and a feeder passage which extends crosswise of said bores to terminate at said second zones and which joins with the third bore at a location spaced to one side of its junction with the supply passage to be communicable therewith through said third bore;
- E. a compensating valve mechanism in said third bore operable in the feed position of either valve spool to regulate flow of pressure fluid from the supply passage to the feeder passage in accordance with variations in the pressure differential between the feeder passage and whichever service passage is in communication therewith;
- F. and means for effecting actuation of either valve spool to its vent position in consequence of actuation of the other spool to its feed position.
20. The control valve of claim 19, further characterized by:
- A. said first, second and third zones of said valve spool receiving bores being directly opposite one another;
- B. and said means for effecting actuation of the valve spools comprising a hydraulic actuator for each spool, and means for energizing the same by pressure fluid flowing to the service passage associated with the other spool.

21. The control valve of claim 19, further characterized by:

- A. wherein said supply passage comprises the inlet branch of said fluid supply means;
- B. said fluid supply means having an outlet branch from which a second control valve can be supplied with pressure fluid;
- C. and passage means communicating said outlet branch with said third zone of one of the spool receiving bores whereby return fluid in the service passage governed by the spool in said last named bore can flow to said outlet branch of the supply means in the vent position of the valve spool in said bore to make pressure fluid available to the inlet branch of another control valve.

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22. The control valve of claim 19, further characterized by:

- A. said supply passage comprising the inlet branch of said fluid supply means;
- B. said fluid supply means having an outlet branch from which a second control valve can be supplied with pressure fluid;
- C. and passage means communicating said outlet branch with the said third zone of each of the spool receiving bores whereby return fluid in either service passage can flow to said outlet branch of the supply means in the vent position of its spool to make pressure fluid available to the inlet branch of another such control valve.

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