

[54] **CONTROL VALVE**
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[73] Assignee: **Hydraulic Industries, Inc.**, Hartland, Wis.
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[52] **U.S. Cl.**.....**137/596.12**
[51] **Int. Cl.**.....**F16k 11/10**
[58] **Field of Search**.....**137/596.12, 596.13, 596.1, 137/596.2, 117; 60/52; 91/446**

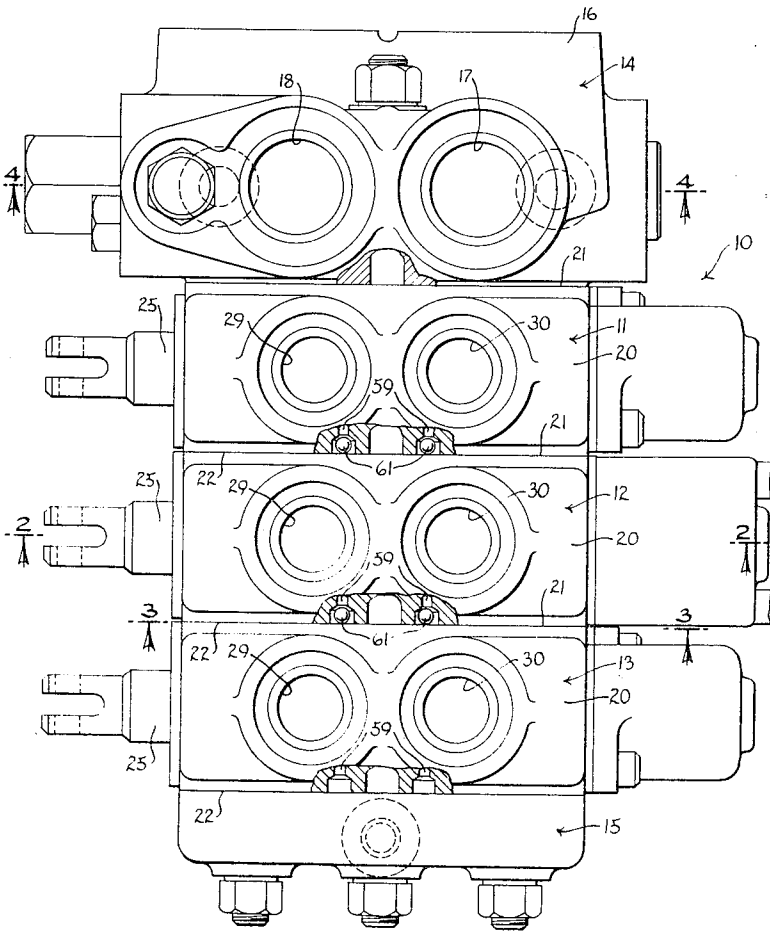
[56] **References Cited**

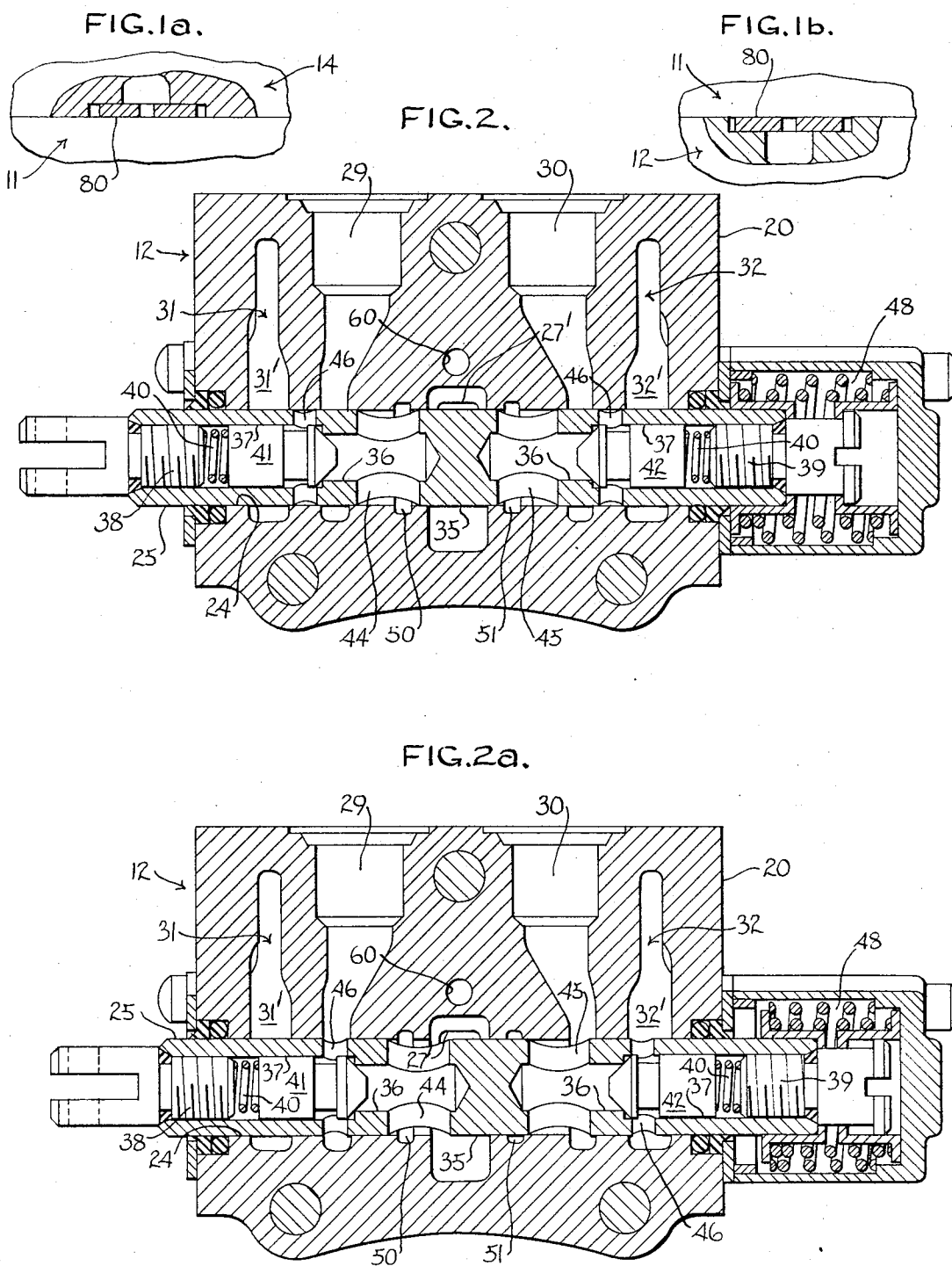
UNITED STATES PATENTS			
3,488,953	1/1970	Haussler	60/52 R
R26,338	1/1968	Allen	137/117
2,755,624	7/1956	Klessig et al.	60/52 R
3,230,841	1/1966	York	91/446
2,994,346	8/1961	Ruhl	137/596.12
2,651,324	9/1953	Hodgson et al.	137/596.12
2,359,802	10/1944	Stephens	137/596.12 X
3,565,110	2/1971	Hodgson	137/596.12
3,145,734	8/1964	Lee et al.	137/596.13

3,164,171 1/1965 Hasbany.....137/596.12
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[57] **ABSTRACT**
A control valve comprising a valve element shiftable to each of a pair of working positions to selectively communicate a service passage with either pressure fluid supply or return passages, and having means providing for control of the rate of fluid flow through the service passage. The rate of flow through a selected service passage of a sectional valve of this invention is controlled by a pressure compensating valve mechanism in the inlet section having a plunger which tends to move to a bypass open position under the influence of fluid pressure at the control valve inlet, and which tends to be moved in the bypass closing direction under the influence of fluid pressure at the service passage. A control passage through which service passage pressure is imposed upon the compensating plunger includes transfer grooves in the face of one housing section at the junction between each control section and an adjoining housing section.

27 Claims, 17 Drawing Figures





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FIG. 2b.

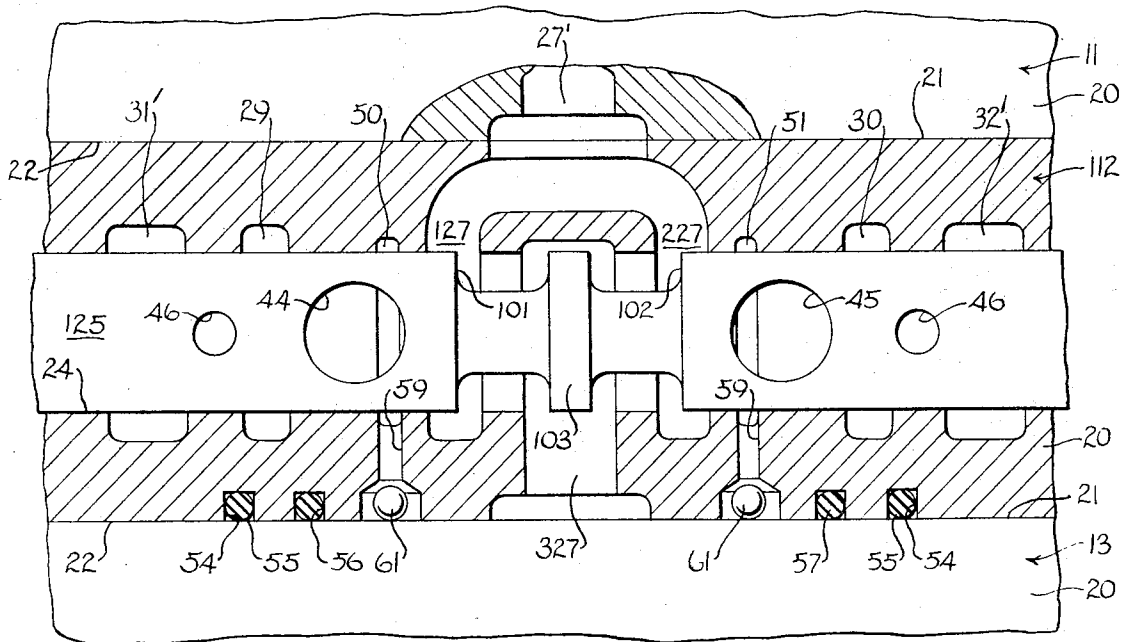


FIG. 2C.

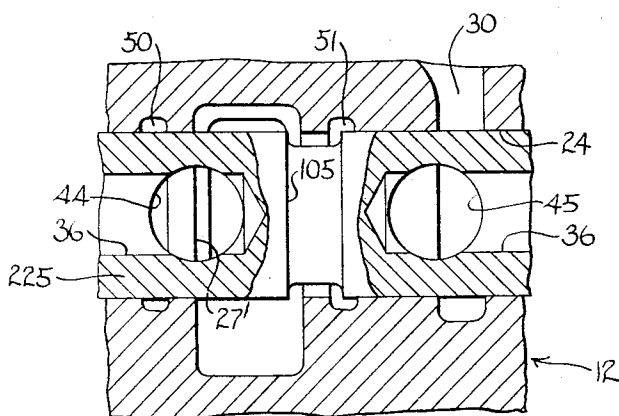


FIG.3.

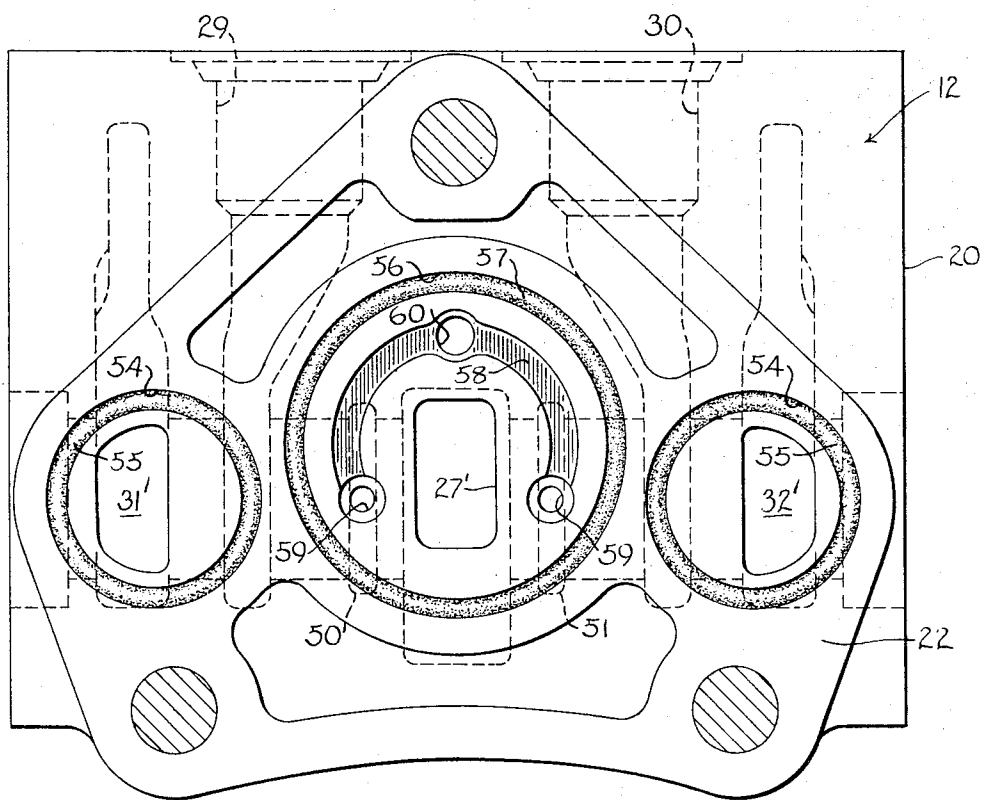


FIG.3a.

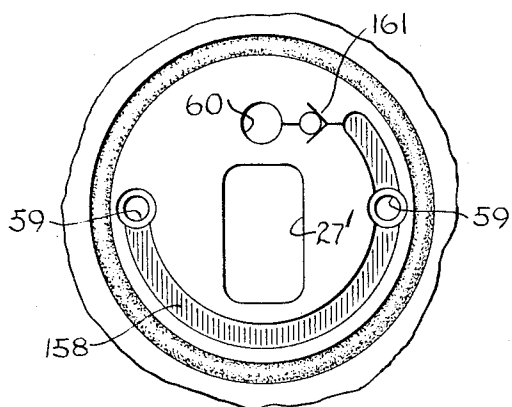
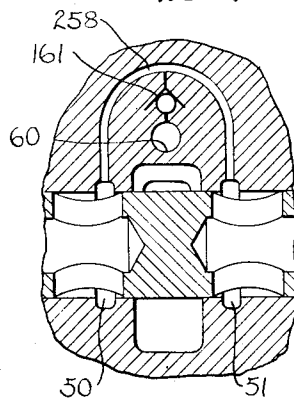


FIG.3b.



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FIG. 4.

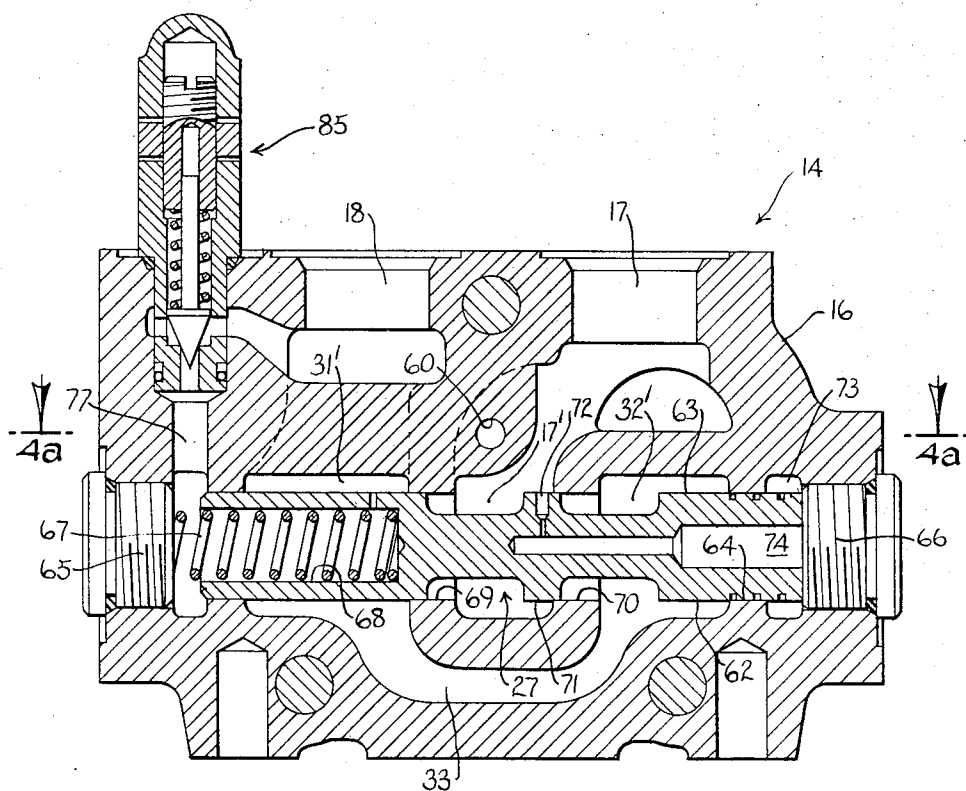
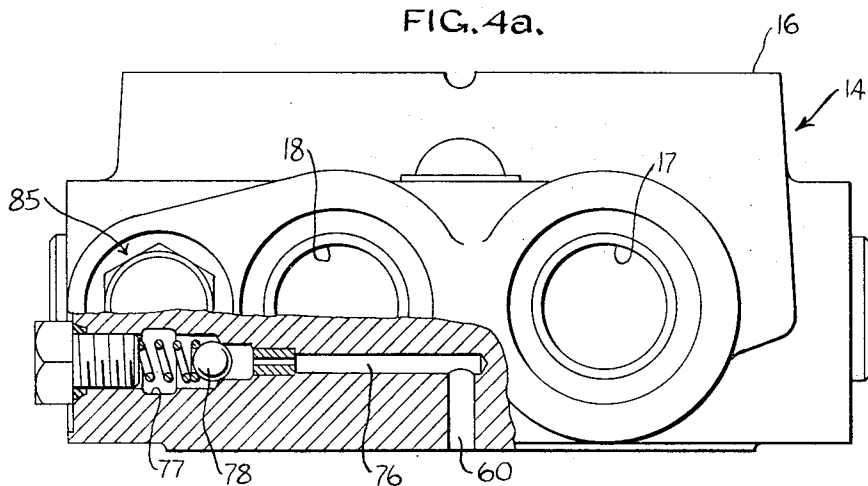


FIG. 4a.



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FIG. 5.

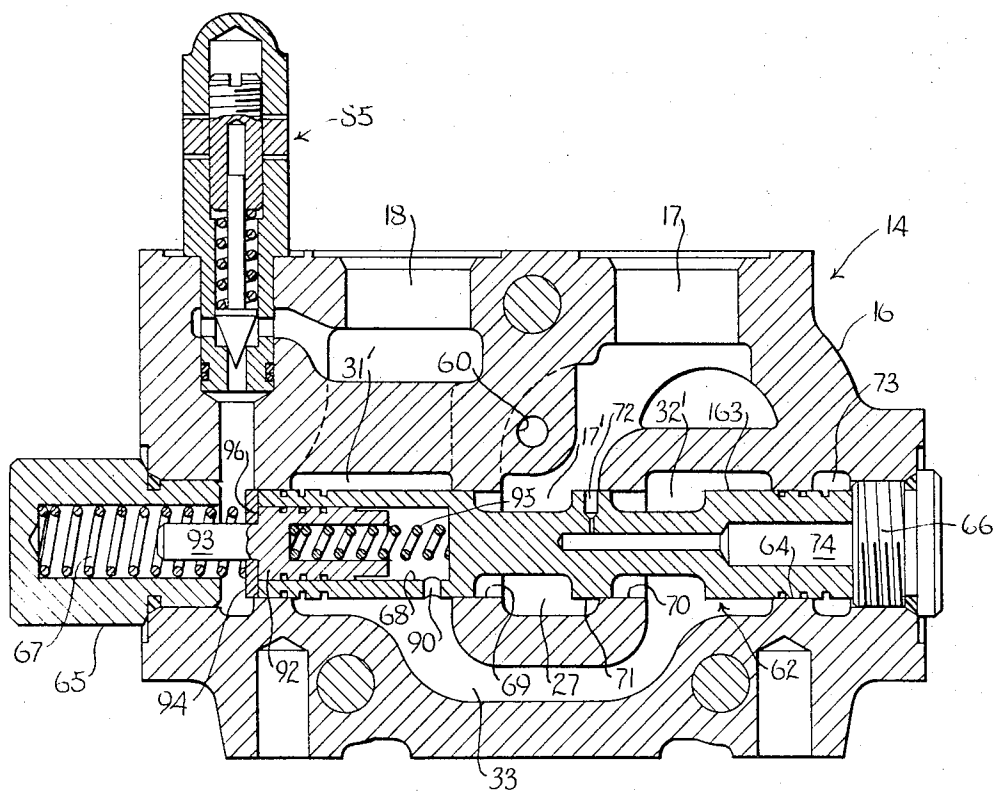
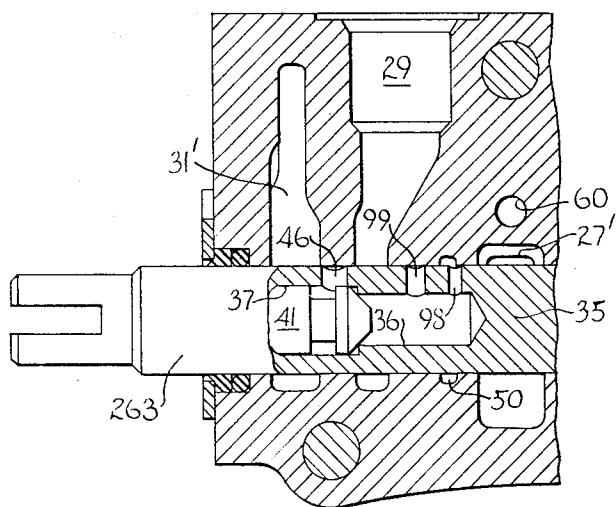


FIG. 6.



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FIG. 7.

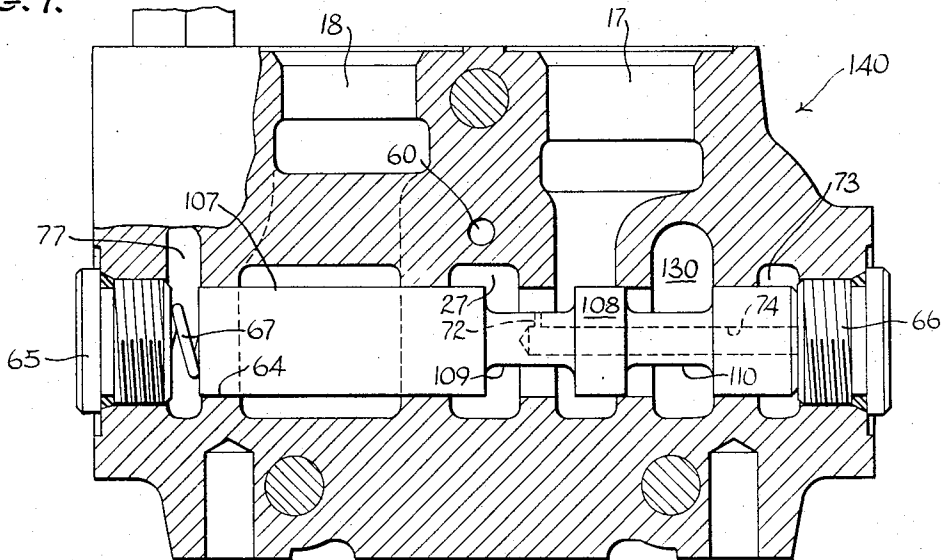


FIG. 7a.

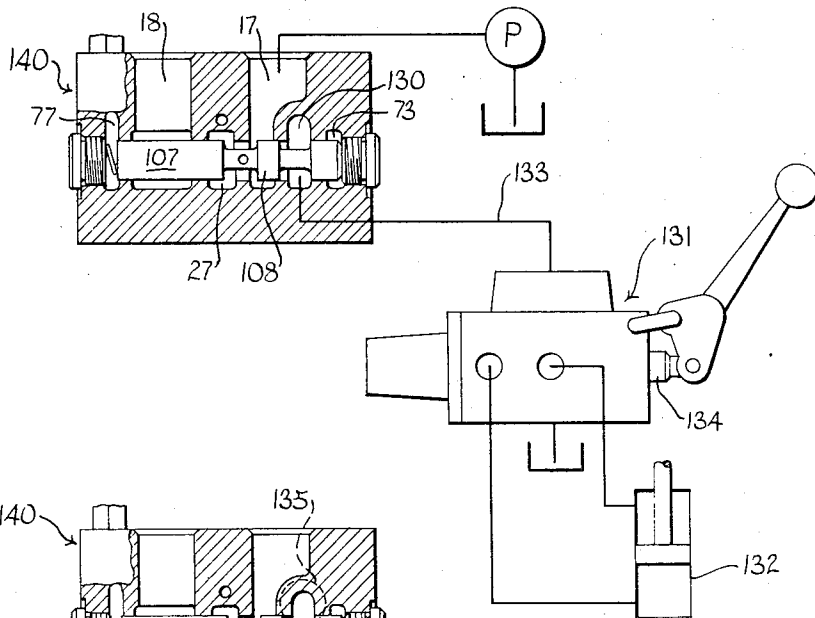
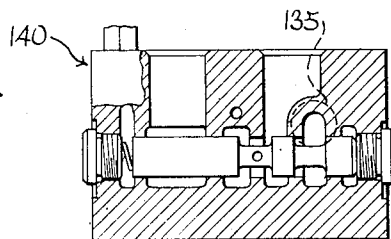


FIG. 7b.



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CONTROL VALVE

This invention relates to hydraulic control valves, and its purpose is to provide a control valve with means to maintain the flow of pressure fluid through a selected service passage of the valve to a motor governed by the valve at a dependably metered rate.

In one form thereof, this invention has as an object the provision of a hydraulic control valve with a valve element for selectively connecting a service passage with either supply or return passage means in the valve, and wherein first restriction means provided by the valve element can constrain fluid to flow from the supply passage means to the service passage at a first predetermined rate in one working position of the valve element; and second restriction means also provided by the valve element can constrain fluid to flow from the service passage to the return passage means at the same or at a different predetermined rate in another working position of the valve element.

In another form of the invention, a pressure compensating valve mechanism assures accurate control over the rate at which supply fluid flows to a service passage in one working position of the valve spool.

The operation of pressure compensating valve mechanisms is well known. Wherever an orifice of some type is provided to throttle fluid flow from the supply passage means to the service passage of a control valve, pressure compensating valve mechanisms can be advantageously employed to maintain a constant pressure drop across the throttling orifice, and consequently thereby assure flow of fluid to the service passage at a uniform rate regardless of variations in the load being moved by the controlled cylinder, or of variations in pump output pressure.

The pressure compensating mechanism embodied in the control valve of this invention operates in a conventional manner in that it automatically maintains such a constant pressure drop across the throttling orifice by diverting more or less of the supply fluid entering the valve inlet to a return passage, via a bypass governed by the plunger of the pressure compensating valve mechanism, in accordance with increase and/or decrease in the pressure differential across the orifice. The plunger tends to be moved in the bypass opening direction under the influence of fluid pressure at the upstream side of the orifice, and it tends to be moved in the bypass closing direction under the influence of fluid pressure at the downstream side of the orifice. Accordingly, in a neutral or hold position of the control valve spool, supply fluid cannot flow through the orifice to the service passage, and there is no pressure drop across the orifice such as occurs when pressure fluid flows therethrough. At that time, the pressure compensating plunger is moved to a bypass open or pump unloading position under the influence of fluid pressure at the control valve inlet.

In general, it is another object of the invention to embody a pressure compensating valve mechanism of the character described in the inlet section of a sectional control valve having one or several control sections assembled in a stack, and wherein an exceptionally large range of throttling action is possible.

More particularly, it is a purpose of the invention to provide a compact and low cost sectional valve mechanism in which one pressure compensating valve

mechanism can serve each of the control sections of which the control valve is comprised.

In a more specific sense, it is the purpose of this invention to provide a pressure compensated control valve of sectional construction, wherein novel passage means featuring transfer grooves in the faces of the control sections at their junctions is relied upon to impose the fluid pressure obtaining at any selected service passage upon the plunger of the pressure compensating valve mechanism.

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 such changes in the specific apparatus disclosed herein may be made as come within the scope of the appended claims.

The accompanying drawings illustrate several complete examples of the physical 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 side elevational view of a sectional control valve of this invention;

FIGS. 1a and 1b are views of a portion of the valve seen in FIG. 1, but showing modifications thereof;

FIG. 2 is a longitudinal sectional view through one of the control sections of the valve seen in FIG. 1, taken on the line 2—2 thereof;

FIG. 2a is a view similar to FIG. 2, but showing the valve spool in a working position;

FIGS. 2b and 2c are fragmentary sectional views illustrating modifications of the invention;

FIG. 3 is a view taken on the line 3—3 of FIG. 1, but at an enlarged scale, showing the seal face of one of the control sections;

FIG. 3a diagrammatically illustrates a slightly modified embodiment of the invention;

FIG. 3b is a fragmentary sectional view corresponding to a portion of FIG. 2, but illustrating another embodiment of the invention;

FIG. 4 is a cross sectional view taken on the line 4—4 of FIG. 1 and showing the compensating valve mechanism in the inlet section of the valve;

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

FIG. 5 is a cross sectional view similar to FIG. 4, but showing a modification of the compensating valve mechanism;

FIG. 6 is a fragmentary view illustrating how the rate at which pressure fluid flows to and from a fluid motor can be controlled by the control spools of the valve; and

FIGS. 7, 7a and 7b are sectional views of another form of inlet section for the control valve of this invention.

Referring now more particularly to the accompanying drawings, the numeral 10 generally designates a control valve for governing the operation of a plurality of fluid motors, such as hydraulic cylinders (not shown). The control valve is of sectional construction, having a number of control sections 11, 12 and 13 stacked one on top of the other to form a bank of control sections confined between end sections 14 and 15 at the top and bottom, respectively, of the stack.

The top section 14 provides an inlet section having a body 16 with an inlet port 17 which is connectable with a source of fluid under pressure, as for example, the delivery port of a pump (not shown). In the present case, the body of the inlet section 14 also has an outlet port 18 therein to provide for return of motor exhaust fluid to a reservoir (not shown). It will be appreciated, however, that the outlet port could just as well be located in the bottom section 15.

Each of the control sections comprises a housing or body 20 having finished flat top and bottom faces 21 and 22, respectively, which are parallel to one another, and which are disposed in flatwise mating engagement with corresponding flat faces on the bodies of adjacent control sections and on the end sections. As will be discussed later, suitable seals confined between adjoining body sections prevent leakage of pressure fluid from their junctions.

The body of each control section is provided with a bore 24 extending lengthwise therethrough midway between its opposite faces 21 and 22, to axially slidably receive an elongated valve element or spool 25. A supply passage 27 extends uninterruptedly from the inlet port 17 in the top section downwardly and centrally through all of the control sections, to intersect the bore 24 in each. Hence, the supply passage 27 can be said to be comprised of an inlet passage portion 17' in the inlet section, communicating directly with the inlet port, and a supply passage portion 27' in the body of each control section.

The supply passage portions 17' and 27' open to the flat faces of the various body sections, and they supply pressure fluid to the bore in each control section from whence it can be diverted by the valve spool 25 therein to one or the other of a pair of service passages 29-30, depending upon which direction the spool is shifted out of its neutral position seen in FIG. 2. The service passages open to one side of the bank of control sections and to the bore in each control section, at opposite sides of the supply passage portion 27' in each.

A pair of return passages 31-32 also extends down through the bank of control sections to intersect their bores, one being adjacent to but axially outwardly of each service passage. Thus, the return passages can be said to comprise return passage portions 31' and 32' in each control section, which open to the opposite faces thereof and register with the corresponding return passage portions in adjoining control sections. The return passage portions in the uppermost control section, of course, register with corresponding downwardly opening return passage portions 31' and 32' in the inlet section 14, which passage portions are internally joined with one another by a linking passage 33.

FIG. 2 illustrates how the valve spool 25 of a control section, in the neutral position of the spool, allows supply fluid to flow through the supply passage portion 27' to a downstream control section, while blocking communication between each service passage and both its adjacent return passage portion and the supply passage portion. When the valve spool 25 is shifted to the right out of its neutral position, part-way toward a first working position seen in FIG. 2a it provides limited communication between service passage 29 and the supply passage portion 27' while communicating ser-

vice passage 30 with the adjacent return passage portion 32'. The valve spool establishes these connections or flow paths by reason of axial passageways formed in the interior of the spool.

For that purpose, each valve spool has tubular opposite end portions closed by a solid center section 35. The bore 36 in each hollow end portion of the spool extends outwardly from the solid center section 35 thereof and opens to a counterbore 37. These counterbores are closed by plugs 38 and 39 at the opposite ends of the spool. The plugs provide seats for coiled compression springs 40 which act upon check valves 41 and 42 in the counterbores to normally hold the same engaged with axially outwardly facing annular seats at the junctions of the counterbores 37 with their respective bores 36.

Pressure fluid flowing from the supply passage portion 27' to either service passage 29 or 30 unseats and flows past its associated check valve 41 or 42. The check valves, of course, block reverse flow of pressure fluid from their respective service passages.

The inner ends of the bores 36 in each valve spool are communicated with the bore 24 in which the spool operates through radial holes 44 and 45, in the wall of each tubular end portion of the spool. In the hold position of the spool these holes are located between the zone where the supply passage portion 27' and their associated service passages 29 or 30 open to the bore 24, and so as to be selectively registrable therewith depending upon whether the valve spool is shifted to the right or to the left of its neutral position seen in FIG. 2.

Other radial holes 46 in the walls of the tubular end portions on the valve spool, located adjacent to but axially outwardly of the check valve seats therein, are selectively communicable with their associated return passage portions or the service passages adjacent thereto upon shifting of the valve spool to working positions at opposite sides of neutral. Actually, the holes 46 can be made to have a degree of communication with the return passages in the neutral position of the valve spool, so as to provide an easy path for flow to the return passages of any leakage fluid from either the service passages 29 or the supply passage 27'. This leakage flow path can extend through either the check valves 41-42, or the clearance along the exterior of the spool, between it and the wall of the bore.

Hence, the bore 36 in the interior of each end portion of the spool can conduct supply fluid to its associated service passage, or it can conduct exhaust fluid from its service passage to the adjacent exhaust passage portion.

If desired, each of the radial holes 44-45-46 can have a diametrically opposite companion hole, as shown. Also, it will be appreciated that while the control section described is intended for the control of a double acting hydraulic cylinder, it can also be used for single acting service. In that case, one of the service passages would be plugged, and the other service passage would be selectively communicable with either the supply passage portion 27' or with the adjacent return passage portion by the valve spool.

A conventional centering spring mechanism 48 can be provided for the valve spool described, to yieldingly resist motion thereof out of its neutral position.

For a purpose which will appear hereinafter, the body of each control section is also provided with a pair of pressure wells 50 and 51 which open to its bore 24 and are formed by enlargements thereof. These pressure wells are located at opposite axial sides of and preferably as close as possible to the zone at which supply passage 27' joins with the bore 24. These wells are communicated with the bores 36 in the interior of the spool through the radial holes 44-45 in the neutral position of the spool as well as in operating positions thereof as will be mentioned later.

When the spool is shifted to the left to a working position establishing communication between service passage 29 and the adjacent return passage portion 31' through the left hand radial holes 44 and 46, communication is disrupted between the pressure well 50 and the adjacent bore 36. At the same time, the other pressure well 51 will be in communication with the hollow interior of the valve spool at the right hand end thereof, at a location directly adjacent to the zone at which pressure fluid then enters the right hand bore 36 from the supply passage portion 27'. This relationship between the pressure wells and the spool is reversed when the spool is shifted to its working position to the right of neutral.

As stated hereinbefore, the supply passage extends downwardly through all the control sections from the inlet section 14. The various branches or passage portions 27' of which the supply passage is comprised open to the finished surfaces 21-22 on the mating faces of all the body sections. The finished surface 22 on the underside of each control section and on the inlet section is provided with a pair of circular grooves 54 which encircle the mouths of the return passage portions and provide for the reception of O-ring seals 55 which are confined between the body sections at their junctions to seal the same against leakage of pressure fluid out of the return passages. A similar but larger diameter circular groove 56 in the finished face on the underside of the inlet section and each control section encircles the mouth of the associated supply passage portion and provides for the reception of an O-ring seal 57 which is also confined between the body sections at their junctions to prevent leakage of high pressure fluid from the supply passage out of the joints between body sections.

Located within the space encompassed by the large O-ring seal on each control section, and concentric therewith, is an arcuate transfer groove 58 which extends about two-thirds of the way around the mouth of the supply passage portion 27'. The ends of this groove terminate at opposite sides of the mouth of the supply passage portion and join with holes 59 that extend upwardly into the body to communicate the groove 58 with the pressure wells 50-51.

Also extending downwardly in the inlet section 14 and continuously through each of the control sections is a control passage 60, which is parallel to but offset from the supply passage 27. The control passage is likewise comprised of registering control passage portions in the inlet section and in each control section, and the control passage portion in each control section opens to the medial portion of the arcuate inner groove 58 in its control section.

Each of the body holes 59 opens to the groove 58 in the underside of its control section through a counter-

bore which can receive a ball check valve 61. The ball checks 61 provide for fluid flow into the groove 58 and control passage 60 from the pressure wells 50 or 51, but they engage valve seats at the junction between the holes and counterbores to block reverse flow of fluid from the control passage into the body holes 59.

The purpose of the control passage, the groove 58, holes 59 and pressure wells 50 and 51 is to provide for subjection of a pressure compensating valve mechanism 62 in the inlet section 14 to the pressure of fluid obtaining at any service passage which is receiving pressure fluid from the supply passage.

The pressure compensating valve mechanism 62 comprises an elongated pressure sensitive plunger 63 which is slidable endwise in a bore 64 in the inlet section 14 with its axis parallel to those of the valve spools. Plugs 65 and 66 close the opposite ends of the bore and also define the limits of sliding motion of the plunger. The plunger is normally held engaged with the plug 66, at its right hand limit of motion, by a coiled compression spring 67 having one end bearing against the other plug 65 and its opposite end portion received in a well 68 in the adjacent end of the plunger. In that position, the plunger closes a bypass between the inlet passage portion 17' and the outlet passage portion 31'.

The bypass is provided by two short portions 69 and 70 of the bore 64, which lie at opposite sides of the junction of the bore and the inlet passage portion 17'. Hence, the inlet of the bypass is jointly provided by the adjacent ends of the bore portions 69-70. The outlet of the bypass is jointly defined by the remote ends of the bore portions 69-70, which open to the junctions between the bore 64 and the return passage portions 31'-32πo.

The land provided by the left end portion of the plunger 63 is normally engaged in the bore portion 69, and it cooperates with a short medial land 71 on the plunger which is normally engaged in the bore portion 70 to close the bypass. A radial hole 72 in the land 71 at all times communicates the inlet passage 17' with a pressure chamber 73 through an axial passage 74 in the right hand end portion of the plunger. The pressure chamber 73 comprises an enlargement of the bore 64 just inwardly of the plug 66, and fluid therein will always be at a pressure value corresponding to that of fluid at the inlet port 17 and the supply passage.

The right hand end of the plunger projects into the chamber 73 and pressure fluid therein acts upon the plunger tending to move it to the left, to a bypass open or pump unloading position whenever there is no countering pressure on the plunger to oppose such movement thereof out of its bypass closing position.

For example, the plunger will be moved to its bypass open position whenever all the valve spools are in their neutral positions, to then allow all the pump fluid entering the inlet 17 to flow through the bypass comprising bore portions 69 and 70, for return to the tank.

Only part of the fluid entering the supply passage is bypassed to the outlet, however, if a valve spool 25 in one of the control sections is then moved to the right to a working position causing a metered amount of pressure fluid to flow from the supply passage portion 27' therein to service passage 29 via the left-hand bore 36. Such flow can be metered through the orifice or throttle provided by limiting communication between the

supply passage portion 27' and the hollow interior of the valve spool through the radial holes 44. Accordingly, supply fluid will enter the interior of the spool from the holes 44 at reduced pressure, which pressure will reflect the load on a fluid motor supplied from service passage 29. Such reduced pressure is also manifested in the pressure well 50, and is accordingly impressed upon the left-hand end of the compensating plunger where it will counteract the bypass opening force exerted thereon by fluid at inlet pressure. As a result, the plunger will seek a balanced position at which the bypass is only partially open, and at which position it will be maintained by the fluid pressure forces acting upon its opposite end portions as long as the position of the valve spool remains unchanged.

The pressure of fluid entering either hollow end portion of the valve spool for flow to the selected service passage will also be manifested in one or the other of the pressure chambers 50 or 51 and in their respective body holes 59, and hence in the groove 58 with which said holes communicate. This results from the fact that in either working position of the spool, that radial port 44 or 45 which communicates with the supply passage will also be disposed to communicate with its associated pressure well and body hole 59, and through the latter, with the groove 58 in the underside of the body.

The pressure obtaining in the groove 58 will also be manifested in the control passage 60, which leads back to the inlet section 14 to communicate with a control passage branch 76. The branch 76 connects with a pressure chamber 77 through a damping check valve 78. The pressure chamber 77 comprises an enlargement of the bore 64 at the left hand end thereof, and the corresponding end of the pressure compensating plunger 63 extends into it so that pressure fluid in the chamber can exert force on the plunger tending to move it in the same direction as its spring 67, namely, in the bypass closing direction.

From this, it will be seen that one end of the compensating plunger is always subjected to the force of pressure fluid obtaining at the valve inlet, while the other end of the plunger will be subjected to the opposing force of pressure fluid obtaining in the service passage to which pressure fluid is directed by a selected one of the valve spools in the bank of control sections. Since the pressure in the selected service passage will vary with the load on the hydraulic cylinder supplied therefrom, any change in the load will result in a corresponding change in pressure in the service passage and also in the chamber 77 of the pressure compensating valve mechanism. As a result, the pressure compensating plunger will be moved to the right, to effect a corresponding increase in the pressure of fluid flowing to the service passage if the load on the cylinder increases; and it will be moved to the left, to effect a corresponding reduction in the pressure of fluid flowing to the service passage if the load on the cylinder decreases.

In either case, plunger movement will be arrested when a predetermined pressure drop corresponding to the desired rate of fluid flow to the cylinder exists across the orifice through which pressure fluid enters the hollow interior of the spool on its way to the selected service passage. As stated, this orifice can be

one arbitrarily determined by an operator in actuating a selected one of the valve spools to a metering position displaced from neutral somewhat less than the spool travel needed to reach a full speed operating position. Hence, the orifice is determined by the degree of communication between the supply passage and one of the radial holes 44 or 45 in the selected valve spool.

When pressure fluid is flowing through such an orifice to one of the service passages, the pressure at the downstream side of the orifice will always be less than that at its upstream side. If the load increases, the pressure differential across the orifice decreases correspondingly and the pressure compensating plunger responds by moving in the bypass closing direction by whatever amount is necessary to restore the desired pressure differential across the orifice. Similarly, the plunger will respond to an increase in the pressure difference at opposite sides of the orifice, resulting from a decrease in the load on the cylinder, by moving in the bypass opening direction to increase the amount of supply fluid bypassing the supply passage by whatever amount is necessary to restore the desired pressure drop across the orifice.

The pressure compensating valve mechanism thus operates to maintain movement of the work performing element of a hydraulic cylinder governed by the control valve at a uniform speed. It is important to note, however, that the load pressure is sensed in the wells 50-51, at locations close to the downstream side of the orifice through which pressure fluid enters the interior of the valve spool for flow to the selected service passage, and hence at a location upstream from the load holding check valve past which the fluid must flow before entering the service passage. Accordingly, the check valve and its spring, and any line pressure losses downstream from the pressure wells 50-51, are then treated as part of the load by the compensating valve mechanism, for more accurate control over the speed of motor operation.

In instances where limited flow of supply fluid to all the hydraulic motors governed by the control sections is essential, one common orifice can be provided for the entire bank of control sections. In that case, the orifice can comprise a hole in a metering washer 80 confined in the junction between the inlet section 14 and the adjacent control section 11, as seen in FIG. 1a. The washer can be seated in a shallow counterbore in the underside of the inlet section, inside the central larger diameter O-ring, and the hole in the washer registers with the mouth of the supply passage portion 27' in the adjacent control section 11.

It will also be apparent that such an orifice washer can be confined in the supply passage 27' between any two control sections, to meter flow of supply fluid to the control sections downstream therefrom. In that case, the washer would be accommodated in a well in the top face of one of the control sections, as in FIG. 1b.

The inlet section 14 can also be provided with a relief valve mechanism 85, which opens to relieve to the outlet 18 excessive pressure in chamber 77 of the pressure compensating mechanism.

In the construction described, the ball checks 61 can close against their respective seats to assure that high pressure fluid will flow to a selected service passage for

high pressure requirement in the event a plurality of valve spools are in working positions at the same time. On the other hand, if the balls are left out of one of the valve sections, as for example, the control section 13, assurance will then be had of fluid flow to a selected service passage in said section for a low pressure requirement, which then has priority over motors governed by the other valve spools operating at higher pressures.

FIG. 3a diagrammatically indicates how the transfer groove 158 in the underside of each control section can communicate the pressure wells 50-51 with the control passage 60 through a single check valve 161 for each groove. However, instead of having external transfer grooves 58, 158 formed in the faces of the valve sections, the pressure wells 50-51 can be communicated with the control passage 60 by an internal bridge 258, and a single check valve 161 through which the bridge connects with the control passage, as seen in FIG. 3b.

FIG. 5 depicts a slightly different form of pressure compensating valve that can be incorporated in the inlet section 14 when quick response of the compensating plunger to its pump unloading position is desired. For example, if the inlet 17 is connected to the high pressure carryover port of an upstream control valve, the plunger 163 will remain in its closed position as long as the spool of the upstream valve is in a full operating position. When that control spool is returned to neutral, however, full pump pressure is suddenly imposed at the inlet 17, and an undesirably high shock pressure would result except for the fact that means is provided to effect quick opening of the plunger 163.

For that purpose, the hollow left hand end of the plunger 163 has a small vent 90 in the side wall thereof, opening into the adjacent portion 31' of the outlet passage, to vent the bottom portion of the well. A small plunger 92 is also slidably received in the well 68 of the main plunger 163, ahead of the vent 90; and a reduced stem 93 on the smaller plunger projects out of the mouth of the well into the interior of the spring 67. In this case, the spring 67 bears against a washer 94 which encircles the stem 93 and is urged by the spring toward engagement with the adjacent end of the pressure compensating plunger 163. The smaller plunger 92 is yieldingly urged axially outwardly toward the spring 67 by a coiled compression spring 95 confined between the plunger and the bottom of the wall 68. The spring 95 yieldingly holds the smaller plunger in an outer position defined by the engagement of the shoulder 96 at the base of its stem with the washer 94.

With this arrangement, the pressure of fluid flowing out of a selected service passage to a fluid motor is imposed upon the left hand end of pressure compensating plunger 163 through washer 94, thereby tending to move the plunger to the right, in opposition to the force which fluid at inlet pressure exerts upon its right hand end. Hence, with the compensating plunger in either a partial bypass position or in a full feed position preventing bypass of inlet fluid to the outlet, actuation of the upstream control valve to bring pump fluid at full pressure into the inlet 17 will result in rapid movement of the compensating plunger to the left, to its bypass open position, in response to the force which pressure fluid in the inlet exerts upon its right hand end.

Such rapid movement of the compensating plunger is assured by reason of the fact that the fluid displaced thereby as it begins to move to the left, acts upon the outer end portion of the smaller plunger 92 and forces the same inwardly into the well 68 to make room for the displaced fluid in the resulting space ahead of the smaller plunger. The vent 90, of course allows for substantially free movement of the smaller plunger 92 into the well.

FIG. 6 illustrates how a valve spool 263, like those previously described, can be modified to allow the spool to be shifted to full first and second working positions and still provide for flow of fluid to and from a service passage governed thereby at the same or at different metered rates. This is in contrast to that form of the invention described hereinbefore, where metered flow of fluid to a service passage was possible only by actuation of the valve spool a distance somewhat short of its full working position.

Only the left hand half of one of the control sections has been shown in FIG. 6, along with its supply passage portion 27', and the corresponding service and exhaust passages 29 and 31', respectively, therein. In this case, the spool 263 has three axially spaced radial holes in the wall of its hollow end portion, numbered 98, 99 and 46, reading to the left from the solid center section 35 of the spool. As before, the hole 46 is located axially outwardly of the seat for check valve 41; and the two holes 93 and 99 are located between the check valve seat and the solid center section of the spool, with the hole 99 closer to the check valve.

The hole 98 is located to be brought into register with the supply passage portion 27' when the valve spool is shifted to a full working position to the right of its neutral position shown, at which time its companion hole 99 will register with the pressure chamber 50, and the third hole 46 will align with the service passage 29. Hence supply fluid can flow from passage 27', through the metering orifice provided by hole 98, to the interior of the spool and past the check valve to service passage 29. The pressure of fluid at the downstream side of the orifice provided by hole 98, of course, is manifested in chamber 50, and also through the arcuate groove 58 in the underside of the control section body, in the control passage 60 for the compensating valve mechanism.

The rate at which fluid flows to the motor is thus dependent upon the size of the hole 98, and its diameter can be predetermined in accordance with the speed of operation desired for the fluid motor governed by the valve spool. Accordingly, with a hole 98 of given size, a load may be raised at the desired rate by the fluid motor with the spool shifted to a full working position to the right of neutral. The same load can be lowered at the same rate, or at either a faster or slower rate, if desired. The descent of the load is governed by the size of the radial hole 99 in the valve spool, which is brought into register with the service passage 29 when the spool is shifted to a full working position to the left of its neutral position shown. At that time fluid returning to the service passage flows to the exhaust passage 31' through hole 99, the check valve 41 and hole 46.

FIG. 2b illustrates how this invention can be embodied in a control valve similar to that seen in FIG. 1, but having one or more control sections of the series-parallel or so-called priority type. As therein seen, the

center section 112 is provided with a series-parallel type valve member 125 which is again slidable axially in its bore 24 to a pair of working positions at opposite sides of a neutral position shown. The control section 112 is also provided with a typical series-parallel type of carryover supply passage comprising a pair of inlet or upstream branches 127-227 which communicate with the bore 24 at axially spaced zones and have a common inlet portion in register with the supply passage 27' in the control section 11. The supply passage in the control section 112 also includes a single downstream branch 327 which communicates with the bore 24 at a location medially between the branches 127-227, and registers with the supply passage portion in the downstream control section 13 in the usual way.

The valve member 125 has two grooves 101-102 therein located at opposite axial sides of a narrow central land 103. These grooves communicate the downstream branch 327 of the supply passage with the supply passage portion 27' in control section 11 through both of the upstream branches 127-227 in the neutral position of the valve member 125.

With the construction described, the grooves 101 and 102 have an axial length such that the downstream branch 327 of control section 112 will be closed off from both upstream branches 127-227 in each working position of the valve member 125, so that flow of supply fluid to the downstream control section 13 will be prevented. It will be understood, of course, that one or the other of the pressure chambers 50-51 will be communicated with its respective service passage, depending upon which of its two operating positions the valve member is shifted to, so as to again cooperate with the body holes 59, arcuate groove 58 and control passage 60 (not shown) in imposing the pressure of fluid in the selected service passage on the plunger of the compensating valve mechanism in the inlet section of the valve bank.

As before, the pilot fluid pressure for augmenting the force of spring 67 upon the compensating plunger is sensed at a location upstream from the check valve 41 through which supply fluid is flowing to the selected service passage. This is highly desirable inasmuch as pressure losses through the check valves or at any location downstream from the throttle ports 44-45 will not affect flow to the work ports; and it helps to eliminate pulsing feed back signals from the work ports to the control passage 60, which could otherwise have an unstabilizing effect upon the plunger 63 of the compensating valve mechanism.

In certain cases, it may be desirable to assure flow to a selected service passage of all of the pump fluid entering the inlet 17 of the control valve. For that purpose, a valve member 225 such as shown in FIG. 2c can be embodied in a selected one (or more) of the control sections, for example in the section 12.

The valve member 225 has a central circumferential groove 105 in its exterior which can be brought into registry with one or the other of the pressure wells 50-51 when the valve member is shifted to a full working position at either side of neutral. As seen in FIG. 2c, the valve member has been shifted to the right, to a working position at which the radial hole 44 no longer throttles flow to its associated service passage, and the external groove 105 establishes communication between the

supply passage 27' and pressure chamber 51. Chamber 51, of course, is communicated with the pressure chamber 77 of the pilot valve mechanism in the inlet section seen in FIG. 4, through the body hole connecting with chamber 51, the face groove 58 and control passage 60, as described hereinbefore.

Thus, the left hand end of the compensating plunger 63 will be subjected to the pressure of fluid obtaining in the supply passage 27' whereas with the embodiment of the invention initially described, it was subjected to reduced pressure obtaining in one or the other of the bores 36 in the hollow end portions of the valve member. In other words, both ends of the compensating plunger will then be subjected to the pressure of fluid obtaining in the supply passage 27, and the spring 67 acting thereon will move the plunger to its right hand limit of motion to completely close the bypass in the inlet section 11. All pressure fluid then entering the inlet 17 will be constrained to flow to the service passage served by the radial hole 44 in the valve member 225.

This contrasts with the embodiment of the invention described initially, wherein the compensating plunger 63 was subjected to a bypass closing force limited in accordance with the reduced fluid pressure obtaining in one or the other of the hollow end portions of the actuated valve member, after flow of pressure fluid from the supply passage through the throttle port provided by the associated radial hole 44 or 45. In the FIG. 2c embodiment, of course, the groove 105 in the exterior of the valve member has the effect of bypassing that throttle port 44 which is in communication with the supply passage 27' and the pressure chamber 50, and of directly communicating the other pressure chamber 51 with the supply passage.

If at such a time the fluid pressure in that end portion of the valve member to which fluid is flowing from the throttle port 44 should be less than that obtaining in the supply passage, the small ball check in the body hole 59 connecting with the pressure chamber 50 will close under the influence of the greater pressure in the other pressure chamber 51, to assure that full supply pressure will be available to act on the compensating plunger and move it to its bypass closing position.

FIGS. 7, 7a and 7b illustrate another form of pressure compensating inlet section 140 which can be used to considerable advantage in place of the inlet section 14 shown in FIG. 1; and in which case the outlet section 15 is provided with a passageway (not shown) to communicate the return passages 31 and 32 with one another.

The inlet section 140 has a compensating valve spool 107 which is axially slidable in a bore 64, and the spool has a land 108 formed between two circumferential grooves 109 and 110. The spool is normally urged toward its right hand limit of motion engaging plug 66, by means of a spring 67.

As before, the position of the compensating spool in bore 64 during use, is determined by the force of spring 67 and by the fluid pressures obtaining in chambers 77 and 73, at the left and right hand ends, respectively, of the bore. The pressure in chamber 77, of course, mirrors the load pressure as hereinbefore explained; while the chamber 73 is pressurized by pump fluid from the inlet 17.

In this case, however, the inlet 17 does not have direct communication with the supply passage 27. It and the supply passage open to the bore 64 at axially spaced zones and are communicable with one another through the spool groove 109. However, the land 108 on the spool closes off such communication of the inlet with the supply passage when the spool is in its left hand limit of motion defined by plug 65. Also, the axial passage 74 in the compensating spool is normally in communication with the inlet 17 through a radial hole 72 which opens to the spool groove 109.

One of the features of the inlet section 140 is that it is provided with a bypass port 130 that can be used either as a pump unloading bypass which opens directly to the exterior of the inlet section for connection with a reservoir line (not shown) or as a power beyond port. The bypass port 130 opens to the bore 64 at a location between the pressure chamber 73 and the junction between the bore and the inlet 17, and it is communicable with the inlet upon shifting of the spool to the left (by pump fluid in chamber 73) a distance sufficient to allow inlet fluid to pass into the spool groove 110. Consequently, it can be said that the land 108 provides for selectively communicating the inlet port 17 with either the supply passage 27 or the bypass port 130, depending upon the axial position of the compensating spool 107.

FIG. 7a more or less diagrammatically illustrates how another control valve 131 for a hydraulic cylinder 132 can be supplied with pump fluid from the bypass port 130 of inlet section 140 via a power beyond supply line 133 at times when the valve elements in the control sections 11, 12 and 13 are in their neutral positions. Since there is then no demand for pressure fluid on the part of any of the control sections 11, 12 and 13, pump output fluid in the inlet port 17 pressurizes chamber 73 sufficiently to shift the compensating spool 107 to the left, to close off the supply passage 27 from the inlet port and to communicate the latter with the bypass port 130. Accordingly, port 130 then becomes a power beyond port, and pump fluid is made available for flow to either end of the hydraulic cylinder 132, depending upon the direction in which the valve element 134 of its control valve 131 is shifted out of neutral.

It is important to note, however, that the fluid motors governed by the control sections 11, 12 and 13 will have priority over the cylinder 132. This is to say that if the valve element of either control section 11, 12 or 13 is shifted to an operating position, the resulting load pressure manifested in chamber 77 of the inlet section 140 will cause the compensating spool 107 to be moved to a position at which its land 108 closes off the power beyond port 130 from the inlet 17 and affords communication between the latter and the supply passage 27. No pressure fluid can then flow to the cylinder 132 from the power beyond port 130, even through the valve element 134 of its control valve were to be shifted to one or the other of its operating positions.

If the bypass port 130 is connected to the reservoir of the system, instead of to the inlet of a control valve as in FIG. 7a, the port 130 becomes the full equivalent of the return passage portion 32' of the FIG. 4 embodiment.

While the convertibility of the port 130 from bypass to power beyond enhances the versatility of the inlet

section 140, it can have still greater utility if the mouth of that port, at the exterior of the section, is closed by a plug 135, as seen in FIG. 7b. In that case, the control valve bank on which the inlet section is installed is effectively converted for closed center operation.

From the foregoing description, together with the accompanying drawings, it will be apparent to those skilled in the art that this invention provides an exceptionally simple hydraulic control valve which is particularly well suited for use on hydraulically operated equipment where the rates of fluid flow to the governed hydraulic motors must be closely regulated.

Those skilled in the art will appreciate that the invention can be embodied in forms other than as herein disclosed for purposes of illustration.

The invention is defined by the following claims:

1. A sectional control valve comprising one or more control sections sandwiched flatwise in a bank between end sections, one of which provides an inlet section having inlet and exhaust passages and a bypass through which supply fluid entering the inlet passage can flow in bypass relation to supply passage means in the control sections depending upon the position of an axially movable pressure compensating plunger which regulates flow of supply fluid through the bypass in accordance with variations in the pressure differential across an orifice through which non-bypassed pressure fluid is caused to flow through the supply passage means to a service passage in one of the control sections whenever a valve element in said control section is moved to a working position in the bore in which the valve element operates, characterized by the following:

- A. said compensating plunger having a pair of surfaces facing in opposite directions and upon which fluid pressure forces can be imposed to effect movement of the plunger in one direction or the other for regulation of flow through the bypass;
- B. means for subjecting one of said surfaces to the fluid pressure obtaining in the inlet passage;
- C. and means for subjecting the other of said surfaces to the fluid pressure obtaining in the service passage, comprising

- 2. a control passage extending from the inlet section to said one control section and opening to one face of the latter at its junction with an adjoining section,
- 2. a groove in the face of one of said adjoining sections at said junction therebetween, to which said control passage opens,
- 3. and a hole in said one control section opening to said groove and adapted to be communicated with said service passage by the valve element in said working position thereof.

2. A sectional control valve comprising one or more control sections sandwiched flatwise in a bank between end sections, one of which provides an inlet section having inlet and exhaust passages and a bypass through which supply fluid entering the inlet passage can flow to the exhaust passage depending upon the position of an axially movable pressure compensating plunger which regulates flow of supply fluid through the bypass in accordance with variations in the pressure differential across an orifice through which non-bypassed pressure fluid is caused to flow through supply passage means to a service passage in one of the control sec-

tions whenever a valve element said control section is moved to a working position in the bore in which the valve element operates, characterized by the following:

- A. said pressure compensating plunger regulating flow through the bypass in accordance with change in the pressure of fluid in the service passage when said valve element is in its said working position, and having a pair of surfaces which face in opposite directions and upon which fluid pressure forces can be imposed to effect movement of the plunger in one direction or the other for regulation of flow through the bypass;
- B. means for subjecting one of said plunger surfaces to the fluid pressure obtaining in the inlet passage;
- C. and passage means by which said other plunger surface can be subjected to the fluid pressure obtaining in said service passage, comprising
 2. communicating control passages in said control and inlet sections opening to one face of said one control section at its junction with an adjoining section,
 2. a hole in said one control section communicable with said service passage by the valve element in said working position thereof,
 3. and a groove in the face of one of said adjoining sections at the junction therebetween to communicate said hole with said registering control passages.
3. The sectional valve of claim 1, further characterized by the following:
 - A. there being return passage means in the bank communicating with the exhaust passage;
 - B. said control section having a pair of service passages each of which is in turn communicated with the supply passage means while the other is communicated with the return passage means by the valve element in consequence of movement thereof from said one working position to a second working position;
 - C. and said control section having one hole for each service passage opening to such groove and communicating therewith by the valve element when the element is in a working position communicating the associated service passage with the supply passage means.
4. The sectional valve of claim 3, further characterized by check valve means in said holes, arranged to permit flow of fluid to said groove.
5. The sectional valve of claim 3, further characterized by each of said check valves being accommodated in a counterbore which opens to said groove.
6. A sectional control valve having end sections and at least one control section confined therebetween to provide a bank in which opposite faces of the sections are in flatwise mating engagement with similar flat faces on adjoining sections, characterized by the following:
 - A. one of said end sections providing an inlet section having therein passage means comprising fluid supply and return passages that extend continuously through each control section;
 - B. each control section having
 1. a service passage through which fluid may be supplied to and/or exhausted from a fluid motor,
 2. a bore with which all of said passages communicate,

3. and a valve element shiftable axially in the bore between first and second working positions to selectively communicate the service passage with either the supply passage or the return passage;
- C. said passage means including a bypass through which pressure fluid entering the inlet section can bypass the fluid supply passage portions downstream thereof;
- D. a pressure compensating valve mechanism in the inlet section, to govern said bypass and operable in response to difference in fluid pressure obtaining in the supply passage and in a service passage which is in communication with the supply passage;
- E. means for subjecting said pressure compensating valve mechanism to the fluid pressure obtaining at the supply passage;
- F. and passage means including a groove in the face of one of said sections at each junction between a control section and an adjoining section, for subjecting said pressure compensating valve mechanism to the fluid pressure obtaining in a service passage which is in communication with the supply passage.
7. A control section for a pressure compensated stacked control valve, which control section has a housing with opposite flat faces, a service passage through which fluid can be supplied to and exhausted from a fluid motor, carryover passages which open to both of said faces and which are adapted to register with corresponding passages in adjoining sections of a stack thereof, said carry-over passages providing pressure fluid supply and return passages, a bore which is intersected by said passages, and an elongated valve element slidable axially in the bore from a neutral position to a first working position to communicate the service and supply passages and to a second working position to communicate the service and return passages, said control section being characterized by the following:
 - A. said carryover passages including a control passage;
 - B. and cooperating means on the housing and on the valve element rendered operative in said first working position of the element to effect communication between the control and service passages, said cooperating means comprising
 1. a hole in the housing opening to the bore and to one face of the housing,
 2. and a groove in said one face of the housing, to which both the control passage and said hole open.
8. The control section of claim 7, further characterized by the following:
 - A. said fluid supply passage having a mouth which opens to said one face of the housing at a location alongside of said groove;
 - B. and a circular groove in said face of the housing, encircling the first designated groove as well as the mouth of the fluid supply passage, to receive and hold a sealing ring in sealing engagement with the face of an adjoining section of a stack thereof.
9. The control section of claim 7, further characterized by the following:

- A. there being a pair of said service passages for connection with the opposite sides of a reversible fluid motor, and communicating with the bore at spaced zones lying at axially opposite sides of an intermediate zone at which the fluid supply passage joins with the bore;
- B. there being a pair of said holes one for each service passage and opening to said first designated groove and to the bore at a location between its associated first designated zone and said intermediate zone;
- C. and the valve element being movable to said first and second working positions to in turn communicate each service passage with its associated hole and with the fluid supply passage, and to communicate the non-selected service passage with the fluid return passage.

10. In a control valve having an inlet and a valve member movable in one direction in a bore in the body of the valve from a neutral position to a partial operating position providing restricted communication between a service passage and an inlet connected supply passage through a throttle port that meters flow of supply fluid to the service passage, the combination of:

- A. a pressure compensating valve mechanism having a bypass through which excess supply fluid entering the inlet can flow to a return port, and having a plunger to regulate flow through the bypass in accordance with differences in inlet and service passage pressure to thereby maintain said metered flow to the service passage despite change in fluid pressure therein;
- B. means for effecting actuation of the plunger to a position allowing partial flow through the bypass in response to the reduced pressure of fluid sensed at a point downstream from the throttle port, at which service passage pressure obtains;
- C. and means rendered operative in consequence of movement of the valve member in said direction to a full operating position, for effecting actuation of the plunger to a bypass closing position in response to the higher pressure of fluid sensed at a point upstream from the throttle port, at which inlet pressure obtains.

11. The control valve of claim 10, further characterized by:

- A. said valve member being movable to partial operating positions at opposite sides of neutral to communicate either of a pair of service passages with the return port and to restrictedly communicate the other service passage with the supply passage through a throttle port for said other service passage;
- B. and said means for effecting actuation of the compensating plunger to bypass closing position being rendered operative in consequence of movement of the valve member to a full operating position at either side of neutral.

12. A control valve having pressure fluid inlet and outlet means and a valve element to control communication of a service passage with fluid supply and return means, characterized by the following:

- A. means defining a feeder passage which is rendered effective by the valve element in one operating

position thereof to communicate the service passage with the fluid supply means;

- B. a load check valve in one of said passages;
- C. means providing a port through which pressure fluid from the inlet means can flow in bypass relation to the fluid supply means;
- D. a pressure compensating valve mechanism having a fluid pressure actuatable plunger to control communication of the inlet means with the fluid supply means and with said bypass port;
- E. means for translating the pressure of fluid obtaining in the inlet means into force on said plunger tending to move it in one direction toward a position at which it closes off communication between the fluid supply means and the inlet means opens up communication between the latter and the bypass port;
- F. and means for translating the pressure of fluid obtaining in one of said passages into force on said plunger tending to move it in the opposite direction toward a position closing off communication between the bypass port and the inlet means and opening up communication between the latter and the fluid supply means.

13. In combination with the control valve of claim

12:

- A. another control valve having a pressure fluid inlet;
- B. and means communicating the pressure fluid inlet of said other control valve with said bypass port.

14. In combination with the control valve of claim

12:

- A. said bypass port having a mouth which opens to the exterior of the control valve;
- B. and a plug closing the mouth of said bypass port.

15. A control section for a stacked control valve comprising a body with opposite flat faces, a bore and an elongated valve element slidable endwise therein to a working position communicating service and supply passages which open to the bore at axially spaced apart first and second zones, respectively, characterized by means in the body providing for detection of the pressure of fluid flowing to the service passage from the supply passage and providing for imposition of said pressure upon mechanism in another section of a sectional control valve, comprising:

- A. a control passage normal to said body faces, all portions of which are spaced from the bore and from the supply passage;
- B. a passageway which is parallel to said control passage and one end of which opens to the bore at a third zone closely adjacent to said second zone, between it and said first zone;
- C. means providing a recess in the exterior of the valve element into which fluid leaving the supply passage initially flows on its way to the service passage in said working position of the valve element, said recess providing communication between the supply passage and said one end of said passageway;
- D. and passage defining means at one face of the body communicating the other end of said passageway with the control passage.

16. A control valve having a body with pressure fluid inlet and outlet means and a valve element to control communication of a service passage with fluid supply and return means, characterized by the following:

- A. a pressure compensating valve mechanism having a fluid pressure actuatable plunger which is movable back and forth in opposite directions to control fluid flow from the inlet means to the fluid supply means;
- B. means providing a feeder passage which is rendered effective by the valve element in one operating position thereof to communicate the service passage with the fluid supply means;
- C. the valve body having a pair of mating surfaces which are normally maintained in intimate engagement with one another;
- D. and means for translating the pressure of fluid in one of said passages into force on the plunger tending to move it in the direction to increase fluid flow to the fluid supply means, comprising a passageway which is in part provided by a groove in one of said mating surfaces.
17. In a control section for a stacked control valve having a carryover type supply passage extending therethrough from one face thereof to the other and intersecting a bore in which a valve element is slidable axially from a neutral position, blocking flow of fluid from the supply passage to a service passage, to first and second working positions respectively communicating the service passage with the supply passage or with a return passage via an axial bore in the valve element, means effective in said first working position of the valve element to provide for imposing the pressure of supply fluid flowing to the service passage upon mechanism in another part of the control valve, comprising:
- A. a control passage in the section extending lengthwise of the supply passage and crosswise of the bore, and having all portions thereof spaced from the supply passage and from the bore;
- B. passage means connecting with the control passage and having one end opening to the bore at a first zone spaced from a second zone at which the supply passage opens to the bore, the other end of said passageway opening to one face of the section through a counterbore which defines an annular check valve seat;
- C. and means providing a recess in the exterior of the valve element of a size to span the space between said zones and conduct pressure fluid directly to said one end of said passage means from the supply passage in said first working position of the valve element.
18. The control section of claim 17, wherein said passage means connects with the control passage through a groove in one face of the section, opening to said counterbore.
19. In a control section for a stacked control valve having a supply passage which opens to opposite faces of the section and intersects a bore in which a valve element is slidable axially to first and second working positions respectively communicating a service passage with the supply passage or with a return passage, means for imposing a fluid pressure force upon mechanism in another section of a stacked control valve containing said control section, of a valve substantially corresponding to that of supply fluid in the service passage in said first working position of the valve element, comprising:

- A. a control passage in the section extending lengthwise of the supply passage and crosswise of the bore, and having all portions thereof spaced from the supply passage and from the bore;
- B. passage means comprising a signal passage opening to the bore at a zone closely adjacent to the supply passage, and a groove in one of said faces of the section connecting the signal passage with the control passage;
- C. and means on the valve element providing a recess in its exterior through which pressure fluid leaving the supply passage flows on its way to the service passage and through which recess such supply fluid also enters the signal passage in said first working position of the valve element.
20. A control valve comprising a body with a pair of bores and an elongated valve element slidable endwise in each bore to a first working position communicating service and supply passages which open to its bore at axially spaced apart first and second zones, respectively, characterized by means in the body providing for detection of the pressure of fluid flowing to either service passage from the supply passage and providing for imposition of said pressure upon pressure compensating mechanism in another portion of the control valve, comprising:
- A. a control passage all portions of which are spaced from said bores and from the supply passage;
- B. a passageway for each bore, one end of which opens thereto at a third zone closely adjacent to said second zone and between it and said first zone;
- C. means providing a recess in the exterior of each valve element into which fluid leaving the supply passage initially flows on its way to the service passage governed by said valve element in said working position thereof, said recess then providing communication between the supply passage and said one end of the associated passageway;
- D. passage defining means spaced a distance from each bore and communicating the other end of the associated passageway with the control passage;
- E. and a pair of check valves, one associated with each of said passageways, to prevent flow of fluid thereto from the control passage.
21. The control valve of claim 20, wherein each valve element communicates its associated service passage with an exhaust passage in a second working position and is further characterized by:
- A. a hollow portion providing an internal passage through which pressure fluid flows from the supply passage to its associated service passage in said first working position of the valve element;
- B. two axially spaced holes in the wall of said hollow portion of the valve element, one being closer to the supply passage and serving to communicate the latter with said internal passage in said first working position of the valve element and the other hole communicating said internal passage with said one end of said passageway in said first working position of the valve element;
- C. and said other hole being communicable with the service passage in the second working position of the valve element, to pass return fluid from the service passage to the exhaust passage.

22. A control valve comprising a pair of valve elements each movable in a bore to a working position communicating an associated service passage with an inlet passage via a supply passage serially connecting with said bores, and a single pressure compensating valve mechanism having a fluid pressure responsive valve plunger to control communication of a pressure fluid inlet with said supply passage and with a bypass through which inlet fluid can flow in bypass relation to the supply passage in an amount depending upon variations in the pressure differential between inlet fluid and in either service passage communicated therewith, characterized by:

A. means by which the pressure of inlet fluid is translated into a force on the plunger tending to move the same in the bypass opening direction;

B. means by which the pressure of fluid at either service passage is translated into an opposing force on the plunger tending to move the same in the bypass closing direction;

C. and means on the upstream valve element for blocking the supply passage at the bore containing said upstream valve element whenever the latter is moved to a full working position substantially unrestrictedly diverting pressure fluid from the supply passage to its associated service passage.

23. A control section for a stacked control valve comprising a body with a bore and an elongated valve element slidable endwise therein to a working position communicating service and supply passages which open to the bore at axially spaced apart first and second zones, respectively, characterized by means in the body providing for detection of the pressure of fluid flowing to the service passage from the supply passage and providing for imposition of said pressure upon mechanism in another section of a sectional control valve, comprising:

A. a control passage all portions of which are spaced from the bore and from the supply passage;

B. a passageway one end of which opens to the bore at a third zone closely adjacent to said second zone and between it and said first zone;

C. means providing a recess in the exterior of the valve element into which fluid leaving the supply passage initially flows on its way to the service passage in said working position of the valve element, said recess providing communication between the supply passage and said one end of said passageway;

D. passage defining means spaced a distance from the bore and communicating the other end of said passageway with the control passage;

E. substantially flat opposite faces on the control section to which the supply passage and said control passage open;

F. and said passage defining means comprising a groove in one of said faces, communicating the control passage with the other end of said passageway.

24. A control valve having a body with pressure fluid inlet and outlet means and a valve element to control communication of a service passage with fluid supply and return means, characterized by the following:

A. a pressure compensating valve mechanism having a fluid pressure actuatable plunger which is movable

back and forth in opposite directions to control fluid flow from the inlet means to the fluid supply means;

B. means providing a feeder passage which is rendered effective by the valve element in one operating position thereof to communicate the service passage with the fluid supply means;

C. the valve body having a pair of mating surfaces which are normally maintained in intimate engagement with one another;

D. means for translating the pressure of fluid in one of said passages into force on the plunger tending to move it in the direction to increase fluid flow to the fluid supply means, comprising a passageway which is in part provided by a groove in one of said mating surfaces.

E. and a load check valve in said feeder passage.

25. In a control section for a stacked control valve having a carryover type supply passage extending therethrough from one face thereof to the other and intersecting a bore in which a valve element is slidable axially from a neutral position blocking flow of fluid from the supply passage to a service passage, to first and second working positions respectively communicating the service passage with the supply passage or with a return passage via an axial bore in the valve element, means effective in said first working position of the valve element to provide for imposing the pressure of supply fluid flowing to the service passage upon mechanism in another part of the control valve, comprising:

A. a control passage in the section extending lengthwise of the supply passage and crosswise of the bore, and having all portions thereof spaced from the supply passage and from the bore;

B. passage means connecting with the control passage and having one end opening to the bore at a first zone spaced from a second zone at which the supply passage opens to the bore;

C. means providing a recess in the exterior of the valve element of a size to span the space between said zones and conduct pressure fluid directly to said one end of said passage means from the supply passage in said first working position of the valve element;

D. and means on the valve element for interrupting fluid flow through the supply passage at the bore in said first working position of the valve element.

26. In a control section for a stacked control valve having a supply passage which opens to opposite faces of the section and intersects a bore in which a valve element is slidable axially to first and second working positions respectively communicating a service passage with the supply passage or with a return passage, means for imposing a fluid pressure force upon mechanism in another section of a stacked control valve containing said control section, of a value substantially corresponding to that of supply fluid in the service passage in said first working position of the valve element, comprising:

A. a control passage in the section extending lengthwise of the supply passage and crosswise of the bore, and having all portions thereof spaced from the supply passage and from the bore;

- B. passage means comprising a signal passage opening to the bore at a zone closely adjacent to the supply passage, and a groove in one of said faces of the section connecting the signal passage with the control passage;
- C. means on the valve element providing a recess in its exterior through which pressure fluid leaving the supply passage flows on its way to the service passage and through which recess such supply fluid also enters the signal passage in said first working position of the valve element;
- D. and means on the valve element for interrupting fluid flow through the supply passage at the bore in said first working position of the valve element.
27. A control valve comprising a body with a bore and an elongated valve element slidable endwise therein to a first working position communicating service and supply passages which open to the bore at axially spaced first and second zones, respectively characterized by means in the body providing for detection of the pressure of fluid flowing to the service passage from the supply passage and providing for imposition of said pressure upon pressure compensating mechanism in another portion of the control valve, comprising:
- A. a control passage all portions of which are spaced from the bore and from the supply passage;
- B. a passageway, one end of which opens to the bore at a third zone closely adjacent to said second zone and between it and said first zone;
- C. means providing a recess in the exterior of the valve element into which fluid leaving the supply passage initially flows on its way to the service

- passage in said working position of the valve element, said recess then providing communication between the supply passage and said one end of said passageway;
- D. passage defining means spaced a distance from the bore and communicating the other end of said passageway with the control passage;
- E. said valve element communicating the service passage with an exhaust passage in a second working position and having a hollow portion providing an internal passage through which pressure fluid flows from the supply passage to the service passage in said first working position of the valve element;
- F. two axially spaced holes in the wall of said hollow portion of the valve element, one being closer to the supply passage and serving to communicate the latter with said internal passage in said first working position of the valve element and the other hole communicating said internal passage with said one end of said passageway in said first working position of the valve element, the other of said holes being communicable with the service passage in the second working position of the valve element, to pass return fluid from the service passage to the exhaust passage;
- G. and said holes having different diameters to effect metering of fluid flow from the supply passage to said internal passage at one rate and to effect metering of return fluid flow from the service passage to the exhaust passage at a different rate.

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