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PILOT-TYPE SELECTOR VALVE FOR HYDRAULIC MOTORS

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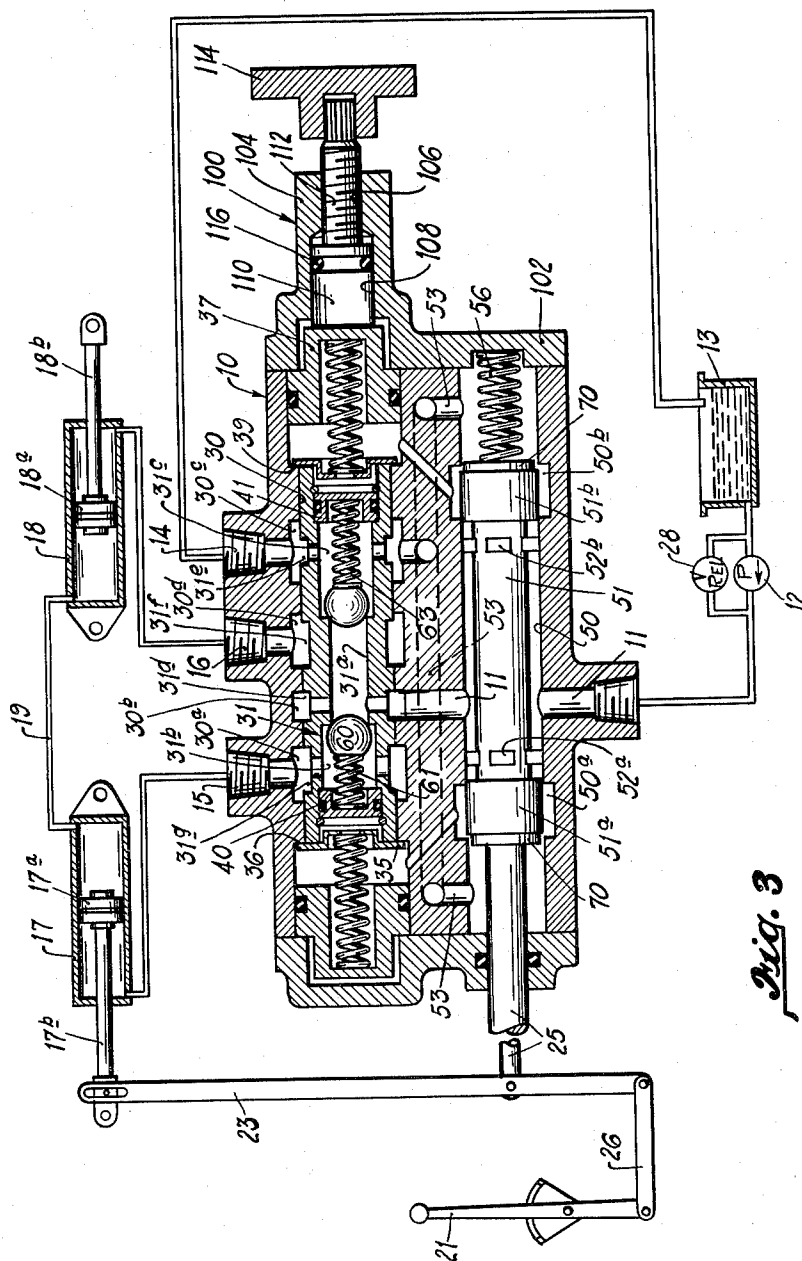


Fig. 3

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PILOT-TYPE SELECTOR VALVE FOR HYDRAULIC MOTORS

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This invention is a continuation-in-part of my co-pending application 318,479, filed November 3, 1952, and now abandoned, and relates to selector valves for controlling hydraulic motor cylinders and is adapted for, although not limited to, hydraulic lift systems for tractors.

An object of the invention is to reduce the cost of manufacture of selector valves of the shuttle piston type without impairing their efficiency.

Another object is to provide a selector valve that automatically supplies a limited back pressure to the motor cylinder to prevent a vacuum being drawn therein by load forces.

A further object of invention is to provide in a selector valve of the shuttle piston type which may be used in a hydraulic lift system for tractors, manually controllable means for controlling the speed of the extension stroke of a tractor mounted cylinder.

Another object of invention is to provide in a selector valve of the shuttle piston type which may be used in a hydraulic lift system for tractors, manually controlled means for controlling the speed of the extension stroke of a tractor mounted cylinder and remote tool cylinder connected in series with the tractor mounted cylinder.

Another object is to provide a relatively simple, inexpensive and reliable pilot-type valve construction.

A conventional pilot valve of the shuttle type comprises a valve cylinder having a central pressure chamber, a pair of return chambers spaced on opposite sides of the pressure chamber and a pair of control ports respectively intermediate the pressure and return ports, in combination with a shuttle piston having a pair of lands which in neutral position block the control ports from both the pressure and return chambers. When the shuttle piston is moved in either direction away from neutral, the lands simultaneously uncover the control ports to connect one to the pressure chamber and the other to the return chamber. For sensitive control in a system employing automatic follow-up, the lands must be only slightly longer than the control ports they cover so that only a relatively slight movement of the piston covers or uncovers the ports. This necessitates very accurate machining of the lands, which is expensive.

The extent of accurate machining required is reduced in accordance with the present invention by slightly reducing the diameters of the outer end portions of the piston lands so that in neutral position of the piston the reduced portions thereof lap the control ports and provide a restricted leakage path between the control ports and the return chambers. With this construction it is not necessary to accurately space the outer edges of the lands from the inner edges, since either control port is already connected to return chamber at the instant the other control port is connected to pressure. The arrangement entails a slight wastage of pressure fluid into the return chamber from the control port connected to the pressure chamber while the valve is opening, but this is inconsequential in practice.

It is common in many hydraulic systems to connect two

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motor cylinders in series with each other to a single control valve. When the valve is in neutral, the motor cylinders are theoretically hydraulically locked against movement. However, under heavy load, and as a result of unavoidable leakage in the valve, one of the motors may creep in such direction as to apply suction to one end of the other cylinder and the frictional resistance to movement in the latter cylinder may cause a vacuum to be drawn between the two motors. Further in accordance with the invention I prevent such action by applying a constant low pressure through a check valve to the other end of the said other cylinder sufficient to overcome its friction and prevent a vacuum being produced in the one end in response to suction applied thereto. The desired low pressure is produced by a relief valve in the return passage of the valve, which low pressure is also used to enable pilot operation of the main valve under all conditions.

A full understanding of the invention may be had from the following detailed description with reference to the drawing, in which:

Figure 1 is a schematic view of a hydraulic system incorporating a valve in accordance with the present invention, the valve being shown in longitudinal section;

Figure 2 is an enlarged detailed section showing the relative dimensions of the lands and ports of the pilot valve; and

Figure 3 is a schematic view of the hydraulic system similar to Figure 1, showing manually adjustable "speed control" means associated with the valve structure.

Referring to Figure 1, the system therein disclosed comprises a pilot-type valve 10 having a pressure passage 11 connected to the output of a pump 12 which draws fluid from a reservoir 13. The valve 10 also has a return port 14 which is connected to the reservoir 13 and a pair of motor ports 15 and 16 which are connected to two motor cylinders 17 and 18 respectively. As shown, the motor port 15 is connected to the left end of the motor cylinder 17 and the motor port 16 is connected to the right end of the motor cylinder 18. The right end of the motor cylinder 17 is connected to the left end of the motor cylinder 18 by a conduit 19 so that the two motor cylinders are connected in series relation between the motor ports 15 and 16.

In the present instance, the motor cylinder 18 is the working cylinder, having a piston 18a which has a piston rod 18b which may be connected to the load to be moved. The other motor cylinder 17 is used as a control cylinder to stop the motors when they have moved into a position corresponding to the setting of a control handle 21. To this end the piston rod 17b of the motor cylinder 17 is connected to the upper end of a lever 23 which is connected intermediate its ends to the piston rod 25 of the valve 10 and is connected at its lower end by a link 26 to the lower end of the control handle or lever 21. Movement of the handle 21 into a new position causes the lever 23 to fulcrum about its point of connection to the piston rod 17b and to move the valve rod 25 in direction to supply fluid to move the motors 17 and 18 in a desired direction. This movement of the motor piston rod 17b causes the lever 23 to fulcrum about its lower end and move the valve rod 25 back into neutral position when the motors have reached a position corresponding to the last setting of the handle 21.

The valve 10 is of the open center type in which fluid from the pump 12 is bypassed through the valve back to return when the valve is in neutral position. However, to prevent the development of excessive pressures during any phase of the operation, it is customary to connect a relief valve 28 across the pump 12.

The valve 10 comprises a body defining a main cylinder 30 containing a reciprocable main piston 31 which is

normally maintained in a central neutral position by a pair of centering springs 32 and 33 at opposite ends thereof. The spring 32 is interposed between an outer closure member 34 for the cylinder 30 and a washer 35 which bears against one end of the piston 31 and also bears against a flange 36 when the piston is in neutral position, thereby limiting the extent to which the piston can be moved by the spring 32. The spring 33 is similarly interposed between the other outer closure member 37 and a washer 38 which bears against the right end of the piston 31 and against a shoulder 39 in the valve body.

The main cylinder 30 has a first annular motor port 30a connected to the motor port 15, a second annular pressure port 30b connected to the pressure passage 11, a third annular return port 30c connected to the return port 14, and a fourth annular motor port 30d connected to the motor port 16.

The main piston 31 is hollow, having a central bore 31a communicating with a counterbore 31b at the left end and with a counterbore 31c at the right end. The outer end of the counterbore 31b is closed by a closure member 40 and the right or outer end of the counterbore 31c is closed by a closure member 41. The outer cylindrical surface of the piston 31 consists of lands separated by recesses including a first annular recess 31g, a second annular recess 31d, a third annular recess 31e and a fourth annular recess 31f. The first piston recess 31g is connected by passages through the piston with the counterbore 31b, the second piston recess 31d is similarly connected to the center bore 31a, and the third recess 31e is connected to the right hand counterbore 31c.

The valve body also defines a pilot cylinder 50 containing a pilot piston 51 which is connected at its left end to the piston rod 25 previously mentioned. The pilot cylinder 50 is provided with two spaced annular control ports 50a and 50b respectively which are connected to the left and the right ends respectively of the main cylinder 30. The center portion of the cylinder 50 is connected to the pressure passage 11 and the outer end portions of the cylinder 50 are connected by passages 53 to the annular return port 30c in the main cylinder, which as previously indicated is connected directly to the return port 14.

The pilot piston 51 is provided with a pair of spaced lands 51a and 51b, which cooperate with the pilot cylinder control ports 50a and 50b respectively, and is provided with guide surfaces 52a and 52b that bear against the pilot cylinder but do not seal therewith. A helical spring 56 is shown compressed between the right end of the pilot piston 51 and the right end of the pilot cylinder 50 to take up lost motion in the linkage including the handle 21 and lever 23 and insure immediate response of the piston to movement of the control handle 21 or of the motor piston rod 17b.

The apparatus functions as follows:

Normally the main piston 31 is maintained in neutral position by the centering springs 32 and 33, and the pilot piston 51 is in center position, as shown, in which the lands 51a and 51b block the control ports 50a and 50b respectively from the high pressure chamber defined within the pilot cylinder 50 between the two lands 51a and 51b. Under the condition described, the motor passage 15 is connected only to the first piston recess 31g and thence to the counterbore 31b. This counterbore 31b is isolated from the center bore 31a by a check valve consisting of a poppet ball 60 which is urged against the left end of the center bore 31a by a light helical compression spring 61. This check poppet 60 prevents any flow of fluid from the motor port 15 into the valve. The other motor port 16 is blocked, since the fourth piston recess 31f is directly juxtaposed thereto. Therefore both of the lines leading to the motors 17 and 18 are blocked and the motors will be held in the position to which

they were last moved, disregarding unavoidable leakage.

At this time pressure fluid delivered by the pump 12 to the pressure passage 11 enters the center bore 31a of the main piston through the second cylinder port 30b and second piston recess 31d and is discharged therefrom past a pressure reducing valve into the right counterbore 31c which is connected to the return port 30c in the main cylinder in all positions of the piston. The pressure reducing valve is shown as consisting of a ball poppet 62 urged against the right end of the center bore 31a by a spring 63 which is relatively stiff as compared to the spring 61, and is so designed as to require an appreciable pressure drop, say 25 to 50 p.s.i., in order to open the poppet 62. The pressure reducing valve therefore functions to maintain a certain minimum pressure in the pressure passage 11 even when the valve is in neutral position, so as to permit control of the main valve by the pilot valve at all times. It is to be understood that in a system in which the valve 62 would maintain a pressure of 25 to 50 p.s.i. in the pressure passage 11, the total pressure output of the pump might be in the neighborhood of 1000 pounds and the minimum pressure maintained by the valve would be only sufficient to positively overcome the frictional resistance to movements of the motor pistons. This minimum pressure is applied past the check poppet 60 to the motor port 15 and thence to the left end of the motor 17, but ordinarily it would produce no movement of either motor because the other motor port 16 connected to the other end of the motor circuit is positively blocked in neutral position of the valve.

Let it be assumed now that there is a heavy load connected to the motor piston rod 18b urging it to the right and that as a result of this force there is some leakage of fluid into the motor port 16 and past the clearances between the main cylinder and the main piston lands, permitting the motor piston 18a to creep to the right. This movement of the piston 18a creates suction in the left end of the motor cylinder 18 and in the right end of the motor cylinder 17 which may be insufficient to overcome the frictional resistance of the motor piston 17a. If special means were not provided to prevent it, this suction might draw a vacuum in the right end of the motor cylinder 17 and the left end of the cylinder 18 which would interfere with the normal operation of the system. However, in accordance with the present invention the minimum pressure of say from 25 to 50 p.s.i. produced in the center bore 31a by the pressure reducing valve 62 is applied past the check ball 60 into the motor port 15 and thence to the left end of the motor cylinder 17. This pressure is sufficient to force the motor piston 17a to follow any creeping movement of the motor piston 18a and thereby prevent the production of a vacuum in the system. The resultant movement of the motor piston 17a with the motor piston 18a will actuate the pilot valve (in a manner which will become apparent from the description to follow) and cause the restoration of the motor pistons to their original position.

Now assume that it is desired to cause the motor pistons 17a and 18a to move a predetermined distance to the right. This is accomplished by shifting the control handle 21 a predetermined distance to the right, causing a corresponding leftward movement of the lower end of the lever 23, which at this time fulcrums about its upper end and carries the pilot piston rod 25 to the left. Corresponding movement of the pilot piston 51a to the left causes the land 51a to connect the pressure chamber in the pilot cylinder intermediate the lands 51a and 51b to the control port 50a thereby admitting low pressure fluid (at 25 to 50 p.s.i.) to the left end of the main cylinder 30 which moves the main piston 31 into its rightmost position, compressing the centering spring 33 in so doing. As the main piston 31 moves into its right-

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most position, fluid to the right of shoulder is exhausted into the control port 50b and then to passage 53 past land 51b and then to the reservoir through return port 14. In the right end position of the main piston 31, the first piston recess 31g bridges and interconnects the ports 30a and 30b respectively, thereby applying pressure fluid directly through the motor port 15 to the left end of the motor cylinder 17. At the same time the second piston recess 31d is carried out of registration with the cylinder pressure port 30b so that the pressure fluid can no longer be bypassed past the pressure reducing valve 62 to the return line. However, the second piston recess 31d is carried into lapping relation with the motor port 30d so that fluid can be returned through the motor port 16, the motor port 30d, the piston recess 31d, and the piston bore 31a past the valve 62 to the return line. The motor pistons are therefore moved to the right, and the movement of the motor piston rod 17b shifts the upper end of the lever 23 about its lower end as a fulcrum thereby moving the pilot piston 51 to the right into neutral position, this position being reached when the motor pistons have traveled a distance corresponding to the last setting of the control handle 21, whereupon the piston land 51a again blocks flow from the pressure passage to the left end of the main cylinder, and permits return of the main piston to neutral by the centering spring 33. Owing to follow up movement by the lever 23, the pilot valve 51 is moved rightwardly for restoration to its neutral position thereby opening communication of control port 50a to passage 53 allowing fluid to be exhausted from the cylinder 30 at the lefthand end of the main piston 31 and allowing the piston to move leftwardly to its neutral position.

When the main piston 31 is in its right hand position, it will be seen that pressure from the pressure passage 11 is communicated to the back or spring side of the check valve 60 while the return flow from motor 18 is communicated through motor port 30d to the central bore 31a communicating with the inlet side of the check valve 60. If the weight, etc., tending to move the piston rod 18b causes piston 18a to be moved faster than pump 12 can supply fluid to the motor 17, check valve 60 will open to permit flow from the motor 18 to proceed directly to the motor 17, thereby preventing cavitation in the system. In this respect, back pressure valve 62 is important inasmuch as it helps to maintain the entire system above atmospheric pressure.

Movement of the control handle 21 to the left causes the motor pistons to move to the left in the following manner: The leftward movement of the handle 21 causes the pilot piston 51 to move to the right to admit pressure fluid past the land 51b to the right end of the main cylinder 30 and thereby move the main piston 31 into its left end position, compressing the centering spring 32 in so doing. In its left end position, the main piston recess 31f connects the motor passage 16 to the pressure port 30b, thereby admitting pressure fluid to the right end of the motor cylinder 18. At the same time, the second motor piston recess 31d is moved into communication with the motor port 30a permitting return of fluid through the motor port 15 and the piston recess 31d to the center bore 31a and thence past the pressure reducing valve 62 to the return line.

As clearly seen in Figure 3, a manually adjustable "speed control" assembly 100 may be incorporated in the control valve to limit the travel of the main piston 31 and the speed of the extension stroke of the piston of cylinder 18 and a contraction stroke of the piston of cylinder 17.

The actuation and functioning of the valve 10 is substantially the same as in the description relating to Figure 1. The valve 10 includes at end 102 an extending portion 104 in axial alignment with the main cylinder 30. The extending portion 104 includes therein a central tapped bore portion 106 terminating in an enlarged

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counterbored portion 108 adjacent the closure member 37. Reciprocally supported in the counterbored portion 108 is an adjustable stop member 110 which can be urged into contact with closure member 37 to move said member 37 toward the main piston 31. Movement of stop member 110 is controlled by the adjustable screw member 112, threadedly supported in the tapped portion 106. The screw member 112 has a knurled handle 114 secured on its external end in any suitable manner. Suitable seal means 116, such as a ring seal, is provided on the outer periphery of stop member 110 to prevent fluid leakage out through the tapped bore 106.

The "speed control" operates as follows: as previously mentioned the valve 10 is actuated and functions in a manner similar to the structure of Figure 1 however, when it is desirable to control the speed of the extension of the piston 17b or 18b, the adjustable stop member 110 is moved inwardly, moving closure member 37 toward the piston 31 and thus reducing the length of travel of piston 31 toward the closure member 37. The reduction of travel of piston 31 will alter the relationship of the external recesses 31g, 31d, 31e, 31f on the outer surface of piston 31 relative to the motor ports 30a and 30d, pressure port 30b, and return port 30c. Assuming the above mentioned adjustment has been made, movement of the handle 21 to the right will result in pistons 17a and 18a moving toward the right on an extension stroke, in the case of piston 18a, and a contraction stroke in the case of piston 17a and the passage of fluid through the valve will be as described relative to Figure 1. Closure member 37 limits the rightward movement of piston 31 and the opening between motor port 30d and annular recess 31d is reduced, i.e. the land between recesses 31d and 31f, does not move as far to the right, as when the piston is permitted maximum travel to the right, as seen for example in Figure 1. With the impeded flow of exhaust fluid between motor port 30d and recess 31d, the speed of rightward travel of pistons 18a and 17a is diminished accordingly, since the speed at which the fluid can be exhausted from the right end of cylinders 18 and 17 controls the speed of the extension stroke of the respective pistons contained therein.

In the event cylinder 18 is eliminated in a given system wherein only a tractor mounted cylinder is used, and line 19 is connected to motor port 16, the valve structure will operate in the same manner as just described.

It has been previously mentioned that a defect of pilot-type selector valves as heretofore manufactured has been that the lands on the pilot piston had to be manufactured with extreme accuracy to cause connection of one end of the main cylinder to the return line simultaneously with connection of the other end of the main cylinder to the pressure line. If such accuracy was not obtained, the main valve responded slowly to movement of the pilot piston. Thus if the pilot piston admitted pressure fluid to one end of the main cylinder before it connected the other end of the main cylinder to return, then the main piston would not move until the return connection was completed.

In accordance with the present invention this defect is eliminated by reducing the diameter of the left end of the land 51a and the right end of the land 51b, which are the ends of the lands that control the flow of fluid from the main cylinder to return. The reduced sections of the lands 51a and 51b are indicated at 70 in Figure 1, and Figure 2 shows approximate dimensions that may be employed.

It will be observed from Figure 2 that the right edge of the land 51a overlaps the right edge of the control port 50a .012 inch and that the left edge of the control port 50a is approximately at the mid point of the reduced section 70 of the land 51a and that the total length of the reduced section 70 may be .050 inch. The radius

of the reduced section 70 is shown as .004 inch less than the radius of the main portion of the land 51a. Some leakage from port 50a directly into the return line is occasioned by this clearance, but as soon as the pilot valve has traveled approximately .020 inch from neutral position the main portion of the land seals the path to return and the leakage occurs only during a small part of the opening movement of the valve. However, at the time the right edge of the land 51a clears the right edge of the control port 50a during leftward movement of the pilot piston 51, the reduced section 70 at the right end of the land 51b is already providing a path for return fluid from the right end of the main cylinder 30, so that the main piston 31 begins to move as soon as the right edge of land 51a clears the edge of the control port 50a. The distance between the right edge of the land 51a and the left edge of the land 51b must still be accurately determined by careful machining, but since the outer edges of the two lands 51a and 51b do not require accurate positioning, the total cost of production of the piston is substantially reduced without undesirable results in use.

The invention is disclosed in connection with a double acting system in which the motors 17 and 18 are positively hydraulically actuated in both directions. However, it is also applicable to single acting systems in which the motor load acts only in one direction. Thus if the load on motor piston rod 18b always urged it to the left, the motor passage 16 of the valve 10 and the motor port 30d and piston recess 31f could be eliminated, and the right end of motor cylinder 18 vented to atmosphere, thereby making the system single acting.

Although for the purpose of explaining the invention, a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. A control valve comprising a housing having a valve chamber therein provided with a motor port, a pressure port, and an exhaust port in the side walls thereof; a valve member slidably engaging the side walls of said chamber and movable between a first, an intermediate, and a third position; check valve means in said valve member constructed and arranged to permit flow therethrough in a first direction, said valve member having flow passages therein located and arranged to connect said pressure port with said motor port through said check valve means when in its intermediate position, to connect said motor port to said exhaust port when in its first position, and to connect said pressure port to said motor port by-passing said check valve means when in its third position, and means associated with said control valve for providing a predetermined back pressure to said check valve means when said valve member is in its intermediate position.

2. A control valve comprising a housing having a valve chamber therein provided with a pair of motor ports, a pressure port, and an exhaust port in the side walls thereof, a valve member slidably engaging the side walls of said valve chamber and movable between a first, an intermediate, and a third position, check valve means in said valve member constructed and arranged to permit flow therethrough in a first direction, back pressure valve means in said valve member having its discharge ported to be in communication with said exhaust port in all three positions of said valve member; and said valve member having flow passages therein located and arranged to connect said pressure port with said back pressure valve means and at the same time permit flow through said check valve means to one of said motor ports when said valve member is in its intermediate position, to connect said one motor port with said back pressure valve means by-passing said check valve means while connecting said pressure port

directly with the other motor port when said valve member is in its first position, and to connect said pressure port to said one of said motor ports by-passing said check valve means while connecting the other of said motor ports to said back pressure valve means when said valve member is in its third position.

3. In a valve of the type having a housing provided with a chamber whose side walls slidably receive a valve member movable between first, intermediate and third positions; a first pair of cooperating ports individual ones of which are positioned in said side walls and valve member respectively and which substantially align with one another when said valve member is in its intermediate position, a second pair of cooperating ports individual ones of which are positioned in said side walls and valve member respectively and which substantially align with one another when said valve member is in its intermediate position, said first and second pairs being spaced apart from each other; a first passageway in said valve member communicating the valve member ports of said first and second pairs; check valve means in said passageway preventing flow from said first pair to said second pair of ports; and a second passageway portions of which are located in said valve member and said housing and which communicates said valve member port of said second pair with a return connection in said housing for all three positions of said valve member; said ports being so located and arranged that with the valve member in its first position said ports of said second pair are moved out of communication and said valve member port of said second pair communicates with the housing port of said first pair, and with the valve member in its third position said ports of said second pair are moved out of communication with each other and the valve member port of said first pair communicates the housing ports of said first and second pairs.

4. In a valve of the type having a housing provided with a chamber whose side walls slidably receive a valve member movable between first, intermediate and third positions; first, second, third and fourth pairs of spaced cooperating valve ports, one port of each pair being positioned in the side walls of said chamber and the other port of each pair being positioned in said valve member, the ports of each pair being positioned to communicate with each other when said valve member is in its intermediate position; said valve member having a passageway communicating with its first, second and fourth ports; check valve means in said passageway constructed and arranged to prevent back-flow from the valve member port of said first pair to the valve member port of said second pair; said ports being located and arranged such that with the valve member in its first position the valve member port of said second pair communicates with the chamber port of said first pair and the valve member port of said third pair establishes communication between the valve chamber ports of said second and third pairs, such that with the valve member in its third position the valve member port of said first pair communicates the valve chamber ports of said first and second pairs and the valve member port of said second pair communicates with the valve chamber port of said third pair, and such that said fourth pair of ports communicate with each other for all positions of said valve member.

5. In a valve of the type having a housing provided with a chamber whose side walls slidably receive a valve member movable between first, intermediate and third positions; first, second, third and fourth pairs of spaced cooperating valve ports, one port of each pair being positioned in the side walls of said chamber and the other port of each pair being positioned in said valve member, the ports of each pair being positioned to communicate with each other when said valve member is in its intermediate position; said valve member having

a passageway communicating with said first, second and fourth ports; check valve means in said passageway constructed and arranged to prevent back-flow from the valve member port of said first pair to the valve member port of said second pair; said ports being located and arranged such that with the valve member in its first position the valve member port of said second pair communicates with the chamber port of said first pair and the valve member port of said third pair establishes communication between the valve chamber ports of said second and third pairs, such that with the valve member in its third position the valve member port of said first pair communicates the valve chamber ports of said first and second pairs and the valve member port of said second pair communicates with the valve chamber port of said third pair, and such that said fourth pair of ports communicate with each other for all positions of said valve member; and back pressure valve means for maintaining a predetermined back pressure against fluid entering the valve member port of said second pair.

6. In a control valve of the type having a housing provided with a chamber whose side walls slidably receive a valve member movable between first, intermediate and third positions; first, second, third and fourth pairs of spaced cooperating valve ports, one port of each pair being positioned in the side walls of said chamber and the other port of each pair being positioned in said valve member, the ports of each pair being positioned to communicate with each other when said valve member is in its intermediate position; said valve member having a passageway communicating with said first, second and fourth ports; check valve means in said passageway constructed and arranged to prevent back-flow from the valve member port of said first pair to the valve member port of said second pair; said ports being located and arranged such that with the valve member in its first position the valve member port of said second pair communicates with the chamber port of said first pair and the valve member port of said third pair establishes communication between the valve chamber ports of said second and third pairs, such that with the valve member in its third position the valve member port of said first pair communicates the valve chamber ports of said first and second pairs and the valve member port of said second pair communicates with the valve chamber port of said third pair, and such that said fourth pair of ports communicate with each other for all positions of said valve member; back pressure valve means in the portion of the passageway of said valve member positioned between the valve member ports of said second and fourth pairs for maintaining a predetermined back pressure against fluid entering the valve member port of said second pair; spring means urging said valve member toward its intermediate position; first and second fluid pressure means adjacent opposite ends of said valve member and adapted to force said valve member into its third and first positions respectively; pilot valve means in communication with the chamber port of said second pair of ports and movable between first, intermediate, and third positions, said pilot valve means being constructed and arranged when in its first position to admit pressure to said first fluid pressure means and when in its third position to admit pressure to said second fluid pressure means, thereby positioning said valve member to control fluid flow between said pairs of ports.

7. In a valve of the type having a valve member provided with a land dividing a valve chamber into high and low pressure opposed chambers and adapted to regulate the pressure in a valve port of predetermined width located in the side walls of said valve chamber, a land portion having a width greater than the width of said valve port and having first and second land portions, said first land portion being located adjacent the high pressure opposed valve chamber and having a width smaller than the width of said valve port and having a uniform cross section adapted to provide sealing engagement with the

sidewalls of said chamber, said second land portion being located adjacent said low pressure opposed chamber and being of reduced uniform cross section to provide a restricted flow passage adapted to communicate said low pressure opposed chamber with said valve port, said reduced uniform cross section extending into said valve port a distance in excess of the clearance provided between said reduced cross section and the side walls of said chamber to permit said land to control the pressure in said valve port with a minimum of movement without having the width of said land accurately predetermined in relation to the width of said valve port.

8. In a spool valve having a chamber provided with a pair of spaced valve ports in the side walls thereof, each of said ports having one edge thereof adjacent a high pressure portion of said valve chamber to which fluid is communicated at a high pressure and each of said ports having the opposite side edge adjacent a low pressure portion of said chamber from which fluid is conducted at a lower pressure, a valve closure member slidable in said chamber having a pair of spaced lands each of which extends over a respective valve port when said valve closure member is in its normal position, said lands having first portions of uniform cross section for sealing engagement with said one side edge of its cooperating valve port to which pressure fluid is communicated, said lands being spaced apart such that said first land portions just sealingly engage said high pressure portions of said valve chamber when said closure member is in its normal position, each of said lands having a total width greater than the width of its cooperating valve port and including a second land portion of reduced cross section overlying said opposite side edge of its cooperating valve port when said closure member is in its normal position, said second land portions providing predetermined clearance with respect to the sidewalls of said chamber and extending into its cooperating valve port a distance greater than said predetermined clearance, whereby said valve closure member will vary the pressure in said valve ports with a minimum of closure movement without having the width of said lands accurately predetermined.

9. In a valve of the type having a housing provided with a chamber whose side walls slidably receive a valve member movable between first, intermediate and third positions; first, second, third and fourth pairs of spaced cooperating valve ports, one port of each pair being positioned in the side walls of said chamber and the other port of each pair being positioned in said valve member, the ports of each pair being positioned to communicate with each other when said valve member is in its intermediate position; said valve member having a passageway communicating with said first, second and fourth ports; check valve means in said passageway constructed and arranged to prevent back-flow from the valve member port of said first pair to the valve member port of said second pair; said ports being located and arranged such that with the valve member in its first position the valve member port of said second pair communicates with the chamber port of said first pair and the valve member port of said third pair establishes communication between the valve chamber ports of said second and third pairs, such that with the valve member in its third position the valve member port of said first pair fully communicates the valve chamber ports of said first and second pairs and the valve member port of said second pair is isolated from said second chamber port and just opens communication with the valve chamber port of said third pair, and such that said fourth pair of ports communicate with each other for all positions of said valve member, and adjustable means for limiting movement of said valve member from said intermediate position toward said third position to cause restricted flow through said third chamber port.

10. A valve according to claim 5 in which said valve member comprises an open ended tubular member hav-

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ing counterbores at its opposite ends joined by a center bore; closure means closing the outer ends of said counterbores; said check valve means comprising a poppet in one of said counterbores and a relatively light spring compressed between the poppet and the adjacent closure member for seating the poppet against the adjacent end of said center bore; and said pressure reducing valve comprising a poppet in the other counterbore and a relatively stiff spring compressed between it and the adjacent closure member for seating it against the adjacent end of said center bore; said one counterbore connecting directly to said first valve member port, said center bore connecting directly to said second valve member port, and said other counterbore connecting directly to said fourth valve member port.

11. A valve as set forth in claim 4 wherein the adjustable stop means is carried in the valve housing in axial alignment with the movable valve member and is adjustable by an externally extending screw member in axial alignment therewith.

12. In a valve of the type having a housing provided with a chamber whose side walls slidably received a valve member movable between first, intermediate and third positions; said housing having first and second motor ports, an exhaust port, and a pressure port communicating with the sidewalls of said chamber, a check valve which permits flow from its first side to its second side, said valve member having passage means therein which communicates said first motor port to said exhaust port while communicating said second motor port to said pressure port when in its first position, which communicates said pressure port with said first motor port when in its intermediate position, and which communicates said pressure port to said first motor port and to said second side of said check valve while also communicating said second motor port to said exhaust port and to said first side of said check valve when in its third position; whereby return flow from said second motor port may flow through said check valve to said first motor port should insufficient flow be received from said pressure port to completely fill the motor chamber supplied by said first motor port.

13. In a valve of the type having a housing provided with a chamber whose side walls slidably receive a valve member movable between first, intermediate and third positions, said housing having first and second motor ports, an exhaust port, a pressure port communicating with the sidewalls of said chamber, a check valve which permits flow from its first side to its second side, said valve member having passage means therein which communicates said first motor port to said exhaust port while communicating said second motor port to said pressure port when in its first position, which communicates said pressure port with said first motor port when in its intermediate position, and which communicates said pressure port to said first motor port and to said second side of said check valve while also communicating said second motor port to said exhaust port and to said first side of said check valve when in its third position, and a back pressure valve for throttling flow out said exhaust port to hold a back pressure on said second motor port and said first side of said check valve when said valve member is in its third position; whereby return flow from said second motor port may flow through said check valve to said first motor port should insufficient flow be received from said pressure port to completely fill the motor chamber supplied by said first motor port.

14. In a hydraulic system: a flow-through discharge system; a back pressure valve having inlet and outlet

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ports, said outlet port being connected to said flow-through discharge system; a control valve having a pressure port, a motor port and a control member movable between a normal position wherein said pressure port is communicated to said inlet of said back pressure valve and an actuating position wherein said pressure port is communicated to said motor port while said pressure port is isolated from said inlet of said back pressure valve; spring centering means for moving said control member from said actuating position to said normal position; pressure differentially operated motor means for moving said control member from said normal position to said actuating position, said motor means being sized to overcome the force of said spring centering means with the differential pressure developed between the inlet and outlet of said back pressure valve; and a pilot valve having a normal position wherein it communicates substantially equal pressure to opposite sides of said pressure differentially operated motor means, and a second position wherein the pressure differential between the discharge of said back pressure valve and said pressure port is communicated to said motor means in a manner to move said control member into its actuating position.

15. In a hydraulic system: a flow-through discharge system; a back pressure valve having inlet and outlet ports, said outlet port being connected to said flow-through discharge system; a control valve having a pressure port, first and second motor ports and a control member movable between a normal position wherein said pressure port is communicated to said inlet of said back pressure valve, and an actuating position wherein said pressure port is communicated to said first motor port while said pressure port is isolated from said inlet of said back pressure valve and said second motor port is communicated to said back pressure valve; spring centering means for moving said control member from said actuating position to said normal position; pressure differentially operated motor means for moving said control member from said normal position to said actuating position, said motor means being sized to overcome the force of said spring centering means with the differential pressure developed between the inlet and outlet of said back pressure valve; and a pilot valve having a normal position wherein it communicates substantially equal pressure to opposite sides of said pressure differentially operated motor means, and a second position wherein the pressure differential between the discharge of said back pressure valve and said pressure port is communicated to said motor means in a manner to move said control member into its actuating position.

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