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(54) Spool valve

(57) A hydraulic directional control valve has an axially movable spool S provided with annular flow-controlling grooves 18, 24, 25 communicated with longitudinal metering slots (5, 9, 12-17, 19, Figs 2A and 2B) which lie in two mutually perpendicular planes. These planes also contain cross-holes 6, 11 and 10, 23 respectively.

Because the metering slots register with these cross-holes at selected angular positions, instead of with circumferential recesses in the body as in coventional valves, the metering slots can be made long relative to the length of the valve, providing precise metering in a relatively short valve housing.

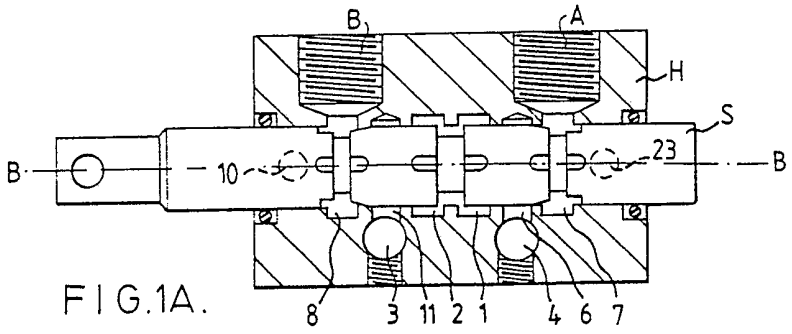

FIG.1A.

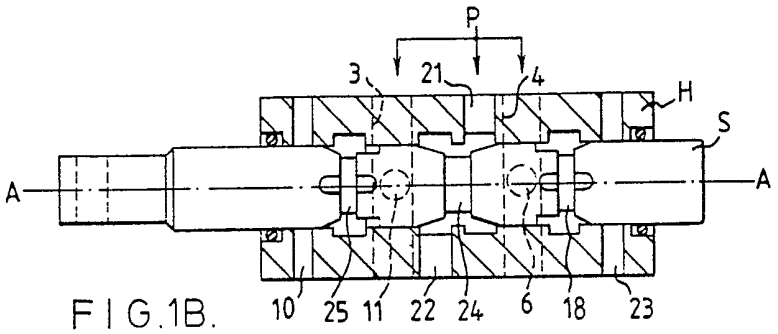

FIG.1B.

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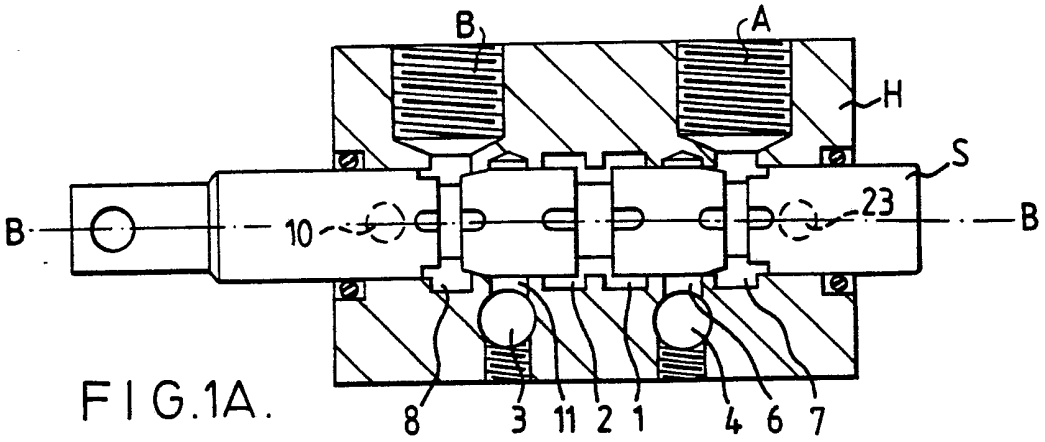

FIG.1A.

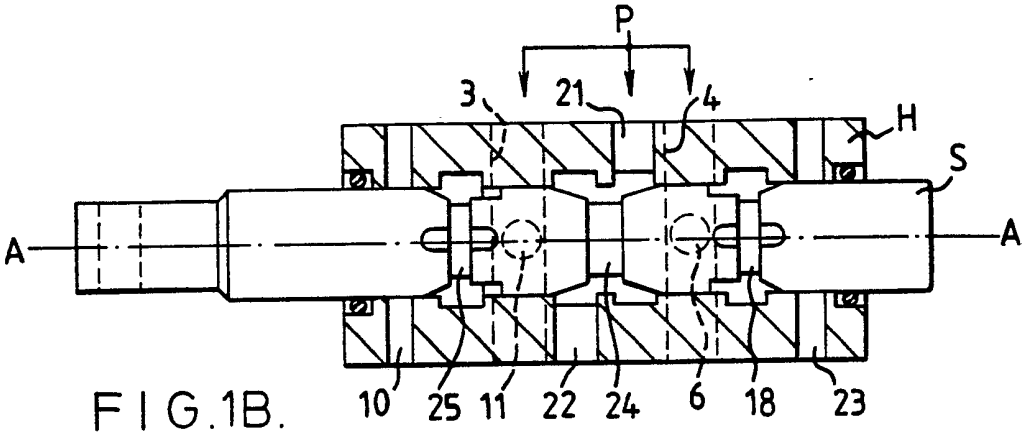

FIG.1B.

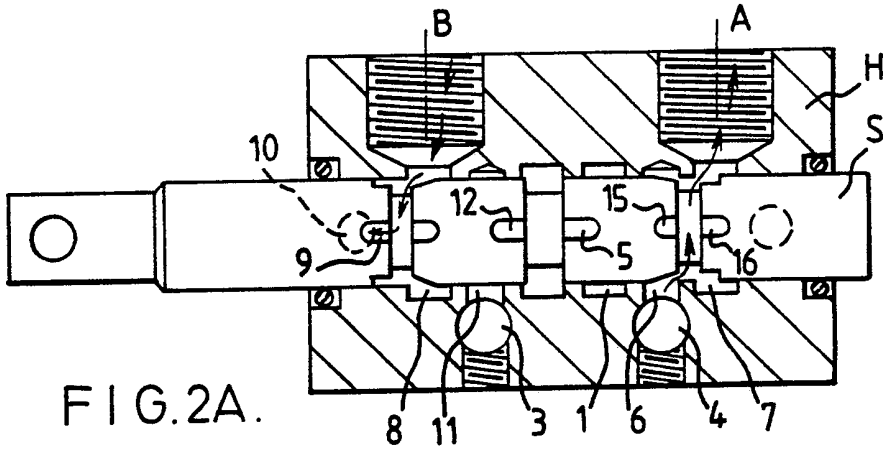

FIG.2A.

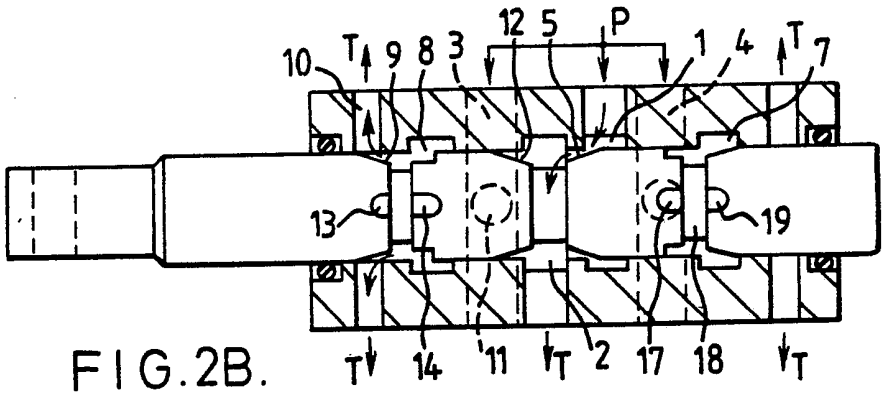

FIG.2B.

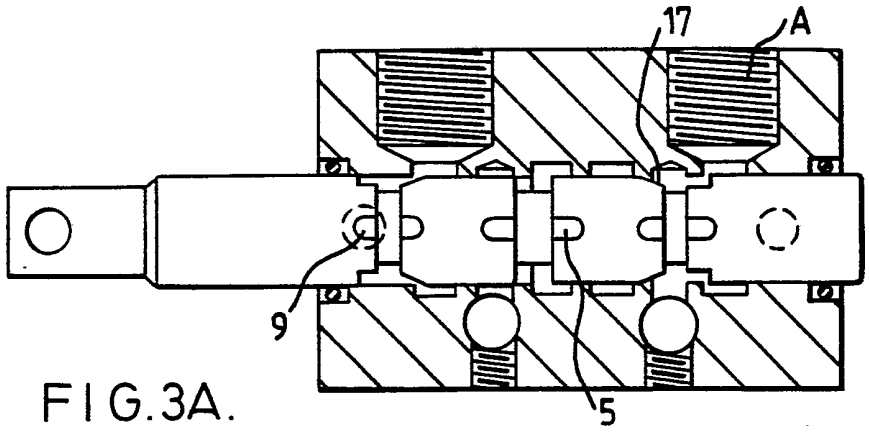

FIG.3A.

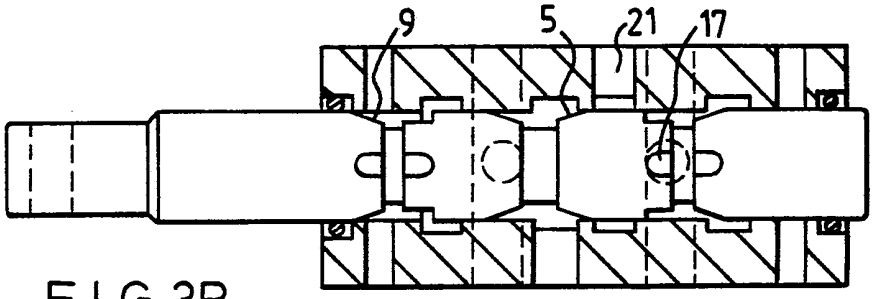

FIG.3B.

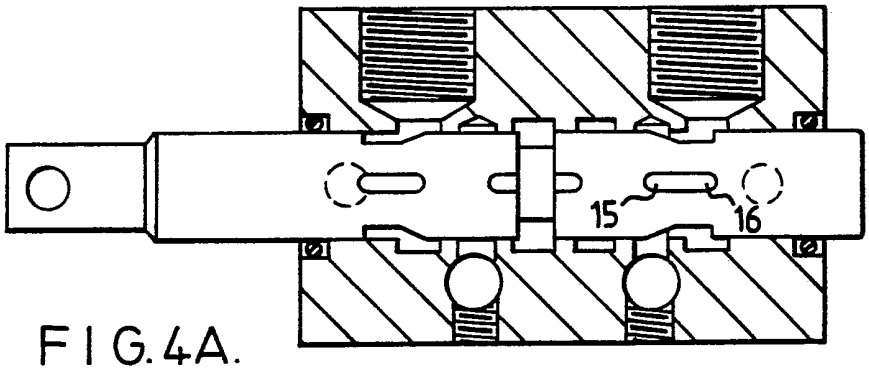

FIG.4A.

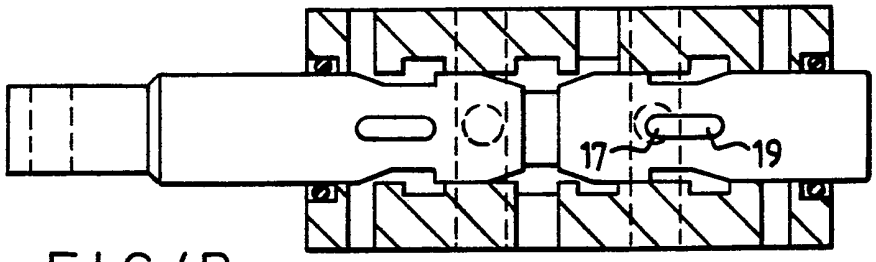

FIG.4B.

M&C FOLIO: 230P56132 WANGDOC: 1234d

SPOOL VALVES

This invention relates to spool valves, and in particular, but not exclusively, to hydraulic directional control valves.

In a conventional spool valve for hydraulic directional control, the valve spool has metering slots, and moves along a bore provided with a plurality of annular grooves, so that the grooves of the bore are selectively opened, closed, and interconnected by the metering slots according to the spool position. The precise relation between a groove and metering slot determines the rate of flow through them and the fluid pressure distribution in the hydraulic system. The annular grooves in the bore are located close to one another, and therefore a metering slot will register with an annular groove as soon as the spool has moved through a short distance. Consequently, to provide precise control of the fluid flow, the movement and position of the spool have to be controlled very accurately, and manufacturing tolerances have to be tight. Alternatively, to provide a long travel for the spool and hence easier control of the flow, the valve must be made longer, with increased cost, size and weight.

An object of the present invention is to provide a spool valve which can have a relatively long spool movement in a relatively short valve housing or bore.

According to the present invention, the bore is provided with at least one transverse hole for the fluid to be controlled, in place of the annular groove provided in a corresponding conventional spool valve.

Because the hole provided in the bore extends over only part of the circumference of the spool, and similarly the metering slot extends over only part of the circumference of the spool, a metering slot will register with a cross-hole only if they have the same angular circumferential position. As a result, the metering slots can be made relatively long, and the spool can be made to have a relatively long movement before the metering slots engage with an annular groove in the bore.

In the valve of the invention, extra distance is available for extending the length of the metering slots and extending the movement (stroke) of the spool in each direction, equivalent to the pitch of each conventional annular groove which has been replaced by a cross hole. This allows the valves comprising the above features to

have a metering improvement of up to three times the metering obtainable in conventional valves with an equivalent length of valve housing. Consequently this invention has important applications in those areas of fluid power control which require precise regulation of fluid flow in the movement of motors, where to provide equal precision valves of much larger physical size would otherwise have to be used, with consequential penalties of increased weight, space and cost.

The invention will be further described with reference to the accompanying drawings, in which:

Figure 1A is a longitudinal section of a hydraulic directional control spool valve embodying the invention, on the line A-A in Figure 1B, with the spool in its central neutral position,

Figure 1B shows the valve of Figure 1A, in longitudinal section on the line B-B,

Figures 2A and 2B are views corresponding to Figures 1A and 1B, showing the valve in a partly open position providing metered flow,

Figures 3A and 3B show the same valve in corresponding sectional views, fully open,

Figures 4A and 4B show views corresponding to Figure 2, of a modified valve.

The valve shown in Figures 1A to 3B has a housing H in which is machined a bore, and spool S which is constrained to slide axially within the bore.

The bore has in its wall four annular grooves 1, 2, 7, 8, disposed symmetrically. The grooves 7, 8 communicate respectively with load ports A, B. The grooves 1, 2 communicate with respective ports 21, 22 connected to the pressure supply P and to the tank T.

The bore wall is also provided with four cross-holes 6, 10, 11, 23, disposed symmetrically.

The above mentioned cross-holes and ports are perpendicular to the axis of the bore. The cross-holes 6, 11 lie in the same radial plane as the ports A, B, between the annular grooves 7, 8 and the annular grooves 1, 2, and communicate with ports 4, 3 respectively. In a plane at right angles, lie the cross-holes 10, 23 and ports 21, 22.

The spool has three circumferential grooves 18, 24, 25 disposed symmetrically, so that in the centred neutral

position of the valve shown in Figures 1A and 1B, the central groove 24 of the spool bridges the grooves 1, 2, and the outer spool grooves 18, 25 register with the outer grooves 7, 8 of the bore.

Each of the annular grooves in the spool communicates with a plurality of longitudinal metering slots, to be described below, which lie in the two mutually perpendicular planes respectively containing the ports A, B and cross-holes 6, 11 on the one hand and the ports 21, 22 and cross-holes 10, 23 on the other hand.

The flow of oil towards and away from the spool, through the annular grooves and cross-holes of the bore in the housing, is controlled as to direction and volume by the positions of the metering slots in relation to these grooves and cross-holes, according to the axial position of the spool in the bore.

The pressure fluid source P is connected to the port 21, and to ports 3, 4 connected to the cross-holes 11, 6. The tank is connected to the port 22 and the cross-holes 10, 23.

Figures 1A and 1B show the valve with its spool in the centre or neutral position, in which pressure fluid

flows from the source P into port 21 and by way of groove 1, groove 24, groove 2 and port 22, out to the tank. Flow to and from the load through the ports A, B is blocked, so that any load connected to these ports cannot move.

Figures 2A, 2B show the spool moved through part of its travel, to a position such that pressure fluid flows from the source P through the port 4 into the cross-hole 6, which is now in register with a metering slot 17 which in turn communicates with the spool groove 18. The latter communicates by way of a pair of further slots 19 with the groove 7 and the load port A. The metering slot 17 has a tapered profile (Figure 2A) creating a metering constriction between it and the edge of the cross-hole 6.

Simultaneously, the load port B is connected to the tank by way of the annular groove 8, a pair of metering slots 14 co-planar with the holes 6, 11, the spool groove 25, a further pair of metering slots 9 co-planar with the holes 10, 23, and the holes 10. The load connected to the load ports is thereby caused to move.

In this position, the source port 21 remains connected to the tank port 22, but a resistance to flow and hence

a pressure difference sufficient to operate the load, is created because the flow path from port 21 to port 22 is by way of a metering slot 5 co-planar with these ports, providing a reduced flow cross section and a resulting pressure rise in the source ports 21 and 4.

The position of the spool relative to the annular groove 1 and cross-hole 6, and hence the flow cross sections provided at the metering slots 5 and 17, control the pressure and the volume of fluid flowing to the load port A.

The position of the metering slot 9 relative to the cross-hole 10 determines the flow cross section available at the metering slot 9 and thereby the volume of fluid flowing from the load through the port B.

Therefore, in a spool position such as that shown in Figures 2A and 2B, in which the metering slots control the rates of flow of fluid through the load ports, the rate of movement of the load can be precisely controlled by adjustment of the spool position.

Further movement of the spool increases the opening cross sections of the metering slots 17, 9 and allows more flow through the load ports, the flow cross section

available at the metering slot 5 becoming progressively smaller until this slot is completely closed off from source port 21 by the spool and all of the pressure fluid flow from the source passes to the load port A and the spool has reached the end of its metered travel. Any further movement of the spool will not affect the fluid flow rate or the rate of movement of the load. In this position the metering slots 9, 17 are fully open, as shown in Figures 3A, 3B.

To create balanced hydraulic forces on the spool the metering slots are in equally sized pairs diametrically opposite each other on the spool and the centre lines of the cross holes in the housing intersect the axis of the spool. Each pair of metering slots on the spool local to ports A and B is aligned with a cross-hole in the housing with which it overlaps in varying degrees as the spool moves as described above to progressively open or shut to the flow of fluid along its length. Hence metering slots 17 align solely with cross-hole 6 to regulate flow into port A and metering slots 9 align solely with cross-hole 10 to regulate flow out of port B. Holes 6 and 10 are at right angles relative to one another to facilitate singularity of alignment between cross-holes and metering slots. This pattern is symmetrically repeated on the rest of valve. This is

the preferred but not exclusive relationship of these factors.

It is not essential to have grooves in the spool. For example groove 18 can be eliminated, in which condition slots 15 and 16, and slots 17 and 19, will be joined. Fig. 4A and 4B show a spool as an example of this modification.

CLAIMS:

1. A spool valve comprising a body in which is a bore, and a valve spool adjustable along the bore, the body having fluid flow ports communicating with the bore and the valve and body having cooperating lands and recesses for controlling flow between said ports in dependence of the position of the spool along the bore, and in which the spool has at least one metering slot extending from a said recess in the spool along the spool, and at least one said port communicates with the bore by a lateral opening in the bore extending only part-way around the circumference of the bore and spool and in register with a said metering slot.

2. A spool valve comprising a body in which is a bore, and a valve spool adjustable along the bore, the body having fluid flow ports communicating with the bore and the valve and body having cooperating lands and recesses for controlling flow between said ports in dependence of the position of the spool along the bore, and in which the spool has at least one metering slot extending from a said recess in the spool along the spool, and at least one said port communicates with the bore by a transverse hole in register with a said metering slot.

3. A spool valve as claimed in claim 1 having a plurality of said openings at different angular positions about the spool and a plurality of said metering slots at different angular positions about the spool, said slots being in register with said openings selectively.

4. A spool valve substantially as herein described with reference to Figs. 1A to 3B, or Figs. 4A and 4B, of the drawings.

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