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(54) **Spool valve with adjustable overlap**

(57) An hydraulic control valve having an elongate valve body (11) including longitudinally spaced first and second inlet ports (24, 27), and longitudinally spaced first and second outlet ports (23, 26), a drive spindle (14) extending longitudinally within the valve body, first and second control spools (15, 16) slidably mounted on the drive spindle, resilient means (21) acting between the control spools and the drive spindle to urge the control spools to occupy respective first positions relative to the drive spindle, and means (22) for applying hydraulic pressure to the control spools to move them to occupy a second position, against the action of said resilient means, relative to the drive spindle.

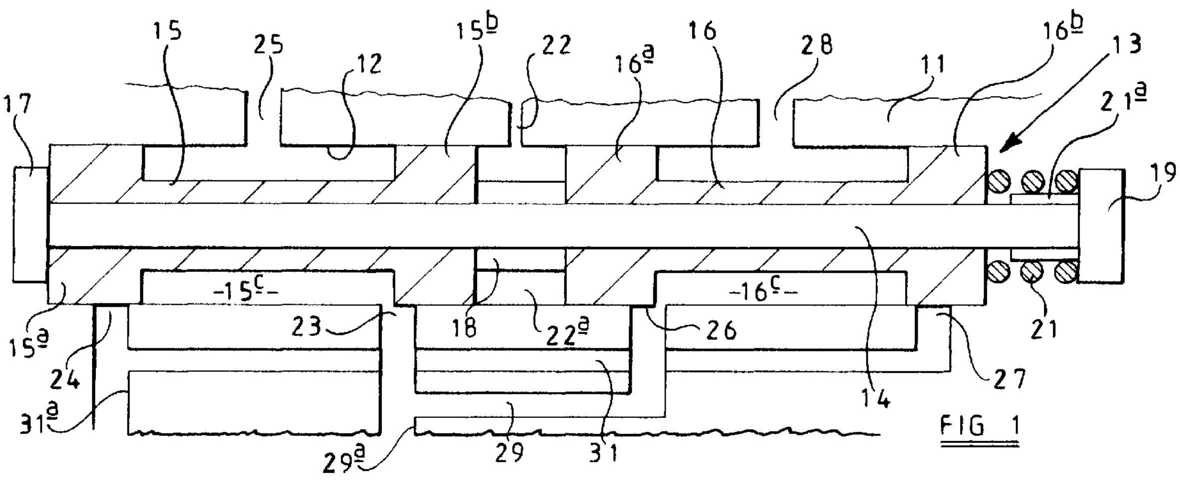

FIG 1

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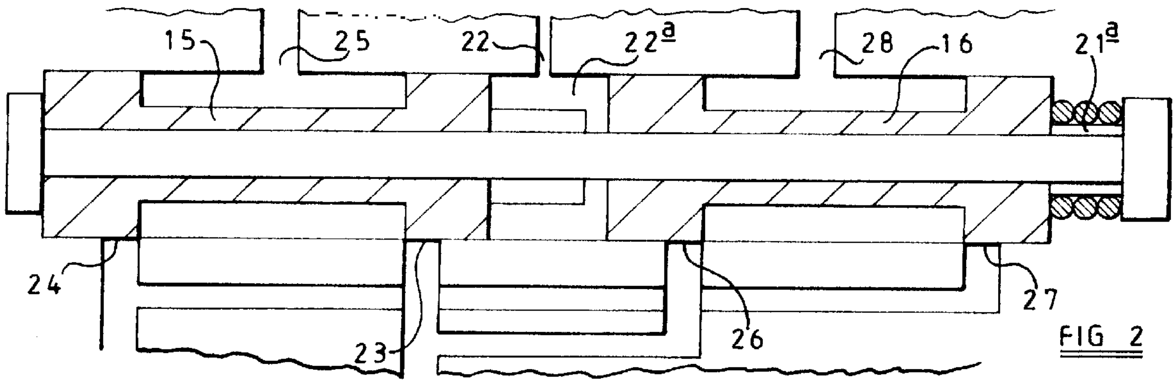

FIG 2

Description

This invention relates to hydraulic control valves particularly, but not exclusively for use in the control of the position of aircraft flight control surfaces.

A conventional hydraulic control valve construction includes a valve body incorporating at least one fluid inlet port and at least one fluid outlet port, a control member moveable within the valve body to make and break fluid flow communication between said inlet port and said outlet port, and a drive element moveable relative to the valve body between rest and operative positions to move the control member to make and break said fluid flow communication. The operating characteristics of the conventional valve and the system controlled thereby are determined directly by the position of the drive element relative to the valve body, and it is an object of the present invention to provide an hydraulic control valve wherein at least one operating characteristic can be adjusted independently of control inputs to the valve control member by way of the drive element.

In accordance with the present invention there is provided an hydraulic control valve comprising a valve body having an inlet port and an outlet port, a valve member moveable within the valve body to make or break communication between the inlet and outlet ports, a drive element coupled to said valve member for moving said valve member relative to the valve body to operate the valve and, means for moving the valve member relative to the valve body and the drive element to effect an adjustment in the position of the valve member relative to said inlet port and/or said outlet port.

Preferably said valve member is a valve spool, and said drive element is a drive spindle upon which said spool is slidably mounted.

Conveniently said spool is urged to a first operative position relative to said spindle by a resilient device, and is moveable from said first position against the action of said resilient device to a second operative position by hydraulic pressure acting on the spool.

In accordance with a second aspect of the invention there is provided an hydraulic control valve having an elongate valve body including longitudinally spaced first and second inlet ports, and longitudinally spaced first and second outlet ports, a drive spindle extending longitudinally within the valve body, first and second control spools slidably mounted on the drive spindle, resilient means acting between the control spools and the drive spindle to urge the control spools to occupy respective first positions relative to the drive spindle, and means for applying hydraulic pressure to the control spools to move them to occupy a second position, against the action of said resilient means, relative to the drive spindle.

Preferably the movement of the control spools relative to the drive spindle alters the positioning of lands of the drive spools relative to respective ports of the valve body, in a predetermined position of the drive spindle.

Desirably the application of hydraulic pressure to the control spools moves them in opposite directions relative to the drive spindle against the action of said resilient means.

One example of the invention is illustrated in the accompanying drawings, wherein:-

Figure 1 is a diagrammatic cross-sectional view of an hydraulic control valve in which the spool assembly is in a notional rest position relative to the body of the valve; and

Figure 2 is a view similar to Figure 1 showing the spool assembly in the same notional rest position, but with the spools moved relative to the valve body to alter the valve operating characteristics.

Referring to the drawings the hydraulic control valve illustrated is a spool valve primarily, but not exclusively, intended for use in a standby rudder power control unit of an aircraft. The standby rudder power control unit (SRPCU) is employed in combination with a main rudder power control unit (MRPCU) to control the position of the aircraft rudder in accordance with control inputs provided by the pilot, and generally the SRPCU has three possible operating modes, Bypass; Normal; and Rudder Assist.

In the Bypass position the SRPCU is inoperative in that it provides no power assistance to the MRPCU in driving the rudder.

In the Normal operative mode the SRPCU and MRPCU are both operative to drive the rudder, the two acting in parallel.

In the Rudder Assist mode the SRPCU takes control of the rudder from the MRPCU which may actually be inoperative at that time.

The SRPCU includes an hydraulic actuator in the form of a double-acting hydraulic ram, which links the aircraft structure and the moveable control surface of the rudder and supplies power to move the rudder either alone, or in combination with a similar actuator of the MRPCU. The supply of hydraulic fluid to the actuator is controlled at least in part by a control valve of the kind illustrated in Figures 1 and 2, the control spool assembly of the valve being moveable in response to the pilot's movements of a rudder control member.

The hydraulic control valve includes a valve body 11 having a cylindrical bore 12 slidably receiving a spool assembly 13. The valve body may be defined by a valve housing or by a guide member formed with the bore 12 and received in a valve housing. The spool assembly 13 includes an elongate spindle 14 through which mechanical control inputs derived from the pilot's rudder control are transmitted to the assembly 13. Slidably mounted on the spindle 14 and in lapped sliding engagement in the bore 12 are first and second substantially identical control spools 15, 16 each of which has a reduced diameter region intermediate its ends such that each spool has a land (indicated by the suffix a) at one end, and an identical land (indicated by the suffix b) at its opposite axial end, the lands being in sliding, sealing engagement with the wall of the bore 12, and defining between them, in the bore 14, respective annular chamber 15c, 16c.

One end of the spindle 14 protrudes from the spool 15 and is formed with an integral head 17 against which an axial end of the land 15a abuts. A cylindrical spacer 18 is slidably disposed on the spindle 14 between the spools 15, 16. The end of the spindle 14 remote from the head 17 is formed with a further integral head 19 and a helical compression spring 21 acts between the head 19 and an axial end of the land 16b of the spool 16. Thus the spring 21 urges the spool 16, the spacer 18 and the spool 15 towards the head 17 so that the spool 15 abuts the head 17 and the spacer 18 is trapped between the spools 15, 16.

At around the midpoint in the length of the bore 12 the valve body 11 contains a port 22 communicating with the bore 12, and through which pressurized hydraulic fluid can be supplied to the chamber 22a within the bore 12 defined between the spools 15, 16 and around the spacer 18. Moreover, adjacent the spool 15 the valve body has a supply port 24, a return port 23, and a control port 25 all communicating with the bore 12, and correspondingly associated with the spool 16 is a supply port 27, a return port 26 and a control port 28. A passage 31 within the valve body interconnects the supply ports 24, 27 so that they can receive hydraulic fluid under pressure from a common supply line 31a, and a further passage 29 in the valve body interconnects the return ports 23, 26 with a common return line 29a. In use the port 25 is connected to one side of the hydraulic actuator ram for the rudder control surface, the port 28 being connected to the opposite side of the ram.

The control spool assembly 14, 15, 16 has a centralised position usually referred to as the null position, and this is the position of the assembly illustrated in both Figure 1 and Figure 2. It can be seen that the dimensioning of the spool lands 15b, 16a and the spacer 18 is such, in relation to the positioning of the return ports 23, 26 that with the spool assembly in its null position and the chamber 22a vented, the land 15b only partially closes the port 23, and the land 16a similarly only partially closes the port 26. Thus there is communication between the return line 29a and one side of the actuator ram by way of the port 23, the annular chamber 15c and the port 25. Simultaneously there is communication between the return line 29a and the opposite side of the ram by way of the passage 29, the port 26 and the port 28. In this configuration the return ports 23, 26 are said to be underlapped. It can be seen that the lands 15a, 16b overlie the supply ports 24, 27 and so the supply ports are closed and thus are said to be overlapped. The positioning of the ports 25, 28 is such that they communicate with the chambers 15c, 16c respectively through the whole of the permitted range of movement of the spool assembly.

Underlapping of the return ports provides particular operating characteristics of the control valve and the system associated with the control valve. Thus it will be recognised that with the ports 23, 26 underlapped in the null position of the control spool assembly fluid flow communication exists between opposite ends of the associated ram and thus fluctuations in pressure at one end of the ram will be reflected at the opposite end. Moveover should the ram be driven physically by an external force, then it is not hydraulically locked and fluid displaced from one end of the ram by such a movement flows to the opposite end of the ram.

The response of the system to small movements of the spool assembly from the null position is sluggish since a predetermined displacement of the spool assembly from the null position is required before one of the two return ports is closed with consequential opening of the corresponding supply port. Thus underlapping the return port control lands 15b, 16a provides a small range of movement on either side of the valve null position where the system has no pressure gain, in addition to providing a limited flow path between the ends of the actuator ram as mentioned above. Where the valve is used in an SRPCU then in the Normal operating mode of the SRPCU the chamber 22a will be vented so that the spools 15, 16 will be in the position shown in Figure 1 and thus the SRPCU will be passive around the null position of the control valve thereby minimising the possibility of a "force fight" between the SRPCU and the MRPCU when both are operative. The MRPCU will not exhibit the same operating characteristics, and thus in effect will be in primary control of the rudder control surface position in those situations where the SRPCU control valve is in its null position.

Figure 2 illustrates the valve of Figure 1 but in the configuration it occupies when sufficient hydraulic pressure is applied to the chamber 22a to displace the spools 15, 16 outwardly relatively to one another against the action of the spring 21. It can be seen that while the spool 15 remains in abutment with the head 17 of the spindle 14 a clearance exists between the spacer 18 and the spool 16 and the spring 21 has been compressed until the spool 16 abuts a spacer collar 21a positioned beneath the spring 21, and in turn abutting the head 19. It will be recognised that the increased spacing of the spools 15, 16 is relatively small, and the corresponding displacement of the spindle 14 generated by the spool movement is half the increased spacing between the spools. Thus although the spindle 14 has been moved, the spool assembly still remains in its null position, and the linkage arrangements associated with the spindle 14 for driving the spindle to operate the valve, accommodates this tiny adjustment in the position of the spindle 14 in use.

It can be seen that applying pressure to the chamber 22a to overcome the action of the spring 21 moves the spools 15, 16 so that the lands 15b, 16a just close the ports 23, 26, while maintaining the ports 24, 27 just closed. In this operating condition, with the lands 15b, 16a closed over both the supply and return ports in the null position, the valve is very sensitive, the response of the valve to input movements of the spindle 14 being instantaneous since the smallest movement of the spool assembly will open either the port 23 or the port 26 with corresponding opening of the port 27 or 24. There is however no communication between the opposite ends of the actuator ram in the null position, and thus the possibilities for fluid leakage from the system are minimised. In the rudder control application a solenoid valve will ensure that the chamber 22a is vented in the Normal operating mode, and pressurized only in the Rudder Assist operating mode. Thus although the valve does not, in the Rudder Assist mode, exhibit a region around the null position with zero pressure gain the "force fight" problem does not arise as the MRPCU is inoperative.

It will be recognised that there may be applications where for convenience the flow through the valve is reversed in which case supply ports became return ports and vice versa.

Notwithstanding that the invention is exemplified above in relation to a standby rudder power control unit, it is to be understood that the invention may find use in other systems where, for example, more than one ram is operative to move a component and a "force fight" situation could develop.

Claims

1. An hydraulic control valve comprising a valve body (11) having an inlet port (24; 27) and an outlet port (23; 26), a valve member (15; 16) moveable within the valve body to make or break communication between the inlet and outlet ports, and a drive element (14) coupled to said valve member (15; 16) for moving said valve member relative to the valve body to operate the valve, the valve being characterised by means for moving the valve member relative to the drive element to effect an adjustment in the position of the valve member relative to said inlet and outlet ports for a given position of the drive member relative to the valve body.

2. An hydraulic control valve as claimed in Claim 1, characterised in that said valve member is a valve spool (15; 16), and said drive element is a drive spindle (14) upon which said spool is slidably mounted.

3. An hydraulic control valve as claimed in Claim 2, characterised in that said spool (15; 16) is urged to a first operative position relative to said spindle (14) by a resilient device (21), and there is provided means (22) for applying hydraulic pressure to said spool to move said spool from said first position against the action of said resilient device to a second operative position.

4. An hydraulic control valve characterised by including an elongate valve body (11) having longitudinally spaced first and second inlet ports (24, 27), and longitudinally spaced first and second outlet ports (23, 26), a drive spindle (14) extending longitudinally within the valve body, first and second control spools (15, 16) slidably mounted on the drive spindle, resilient means (21) acting between the control spools and the drive spindle to urge the control spools to occupy respective first positions relative to the drive spindle, and means (22) for applying hydraulic pressure to the control spools to move them to occupy a second position, against the action of said resilient means, relative to the drive spindle.

5. An hydraulic control valve as claimed in Claim 4, characterised in that the movement of the control spools relative to the drive spindle alters the positioning of lands of the drive spools relative to respective ports of the valve body, in a predetermined position of the drive spindle.

6. An hydraulic control valve as claimed in Claim 4 or Claim 5, characterised in that the application of hydraulic pressure to the control spools moves them in opposite directions relative to the drive spindle against the action of said resilient means.

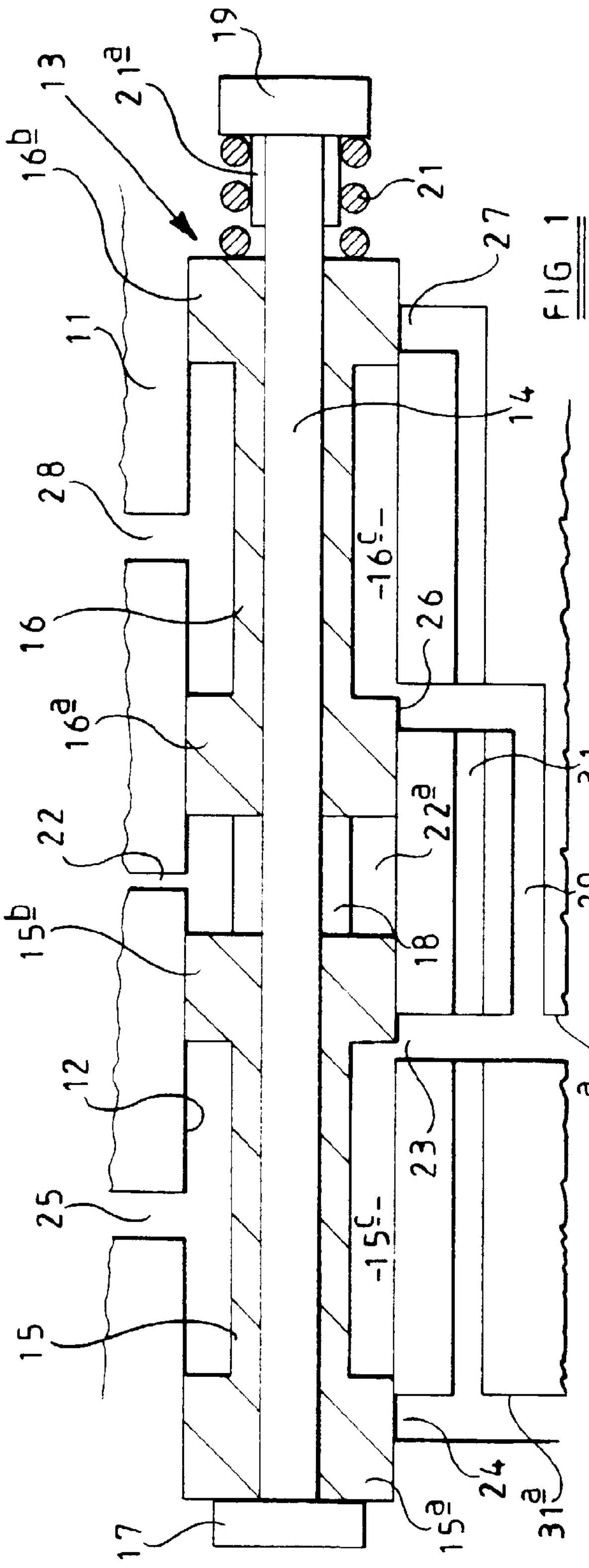
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FIG 1

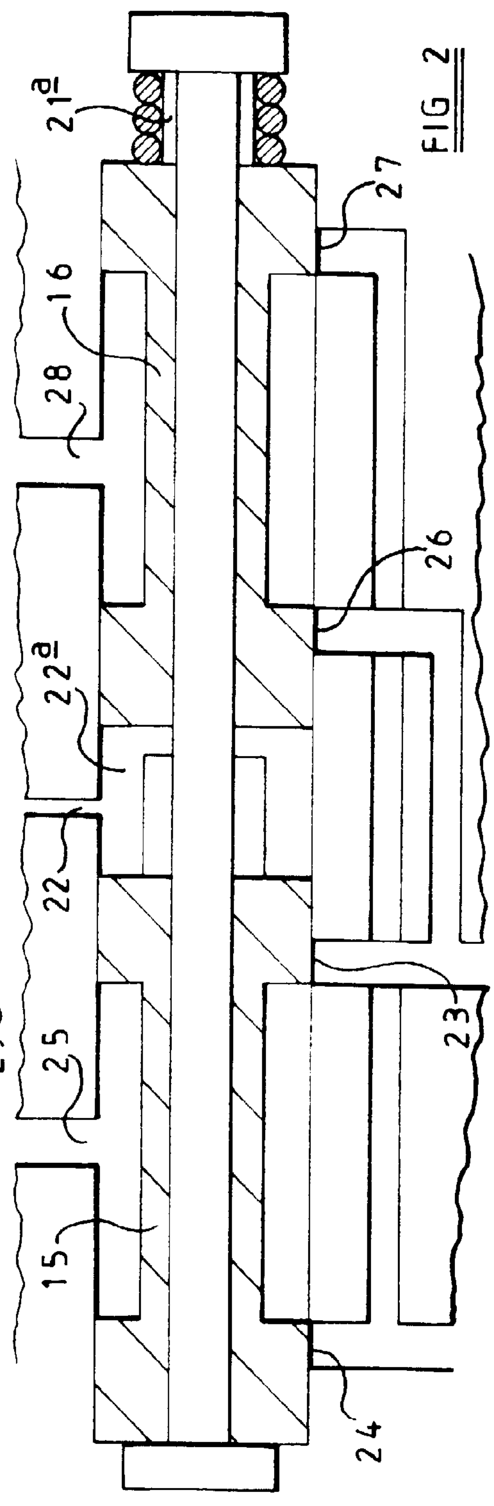
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FIG 2