

- [54] **SYNCHRONIZING VALVES**
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[58] **Field of Search** **91/171; 60/97 E**

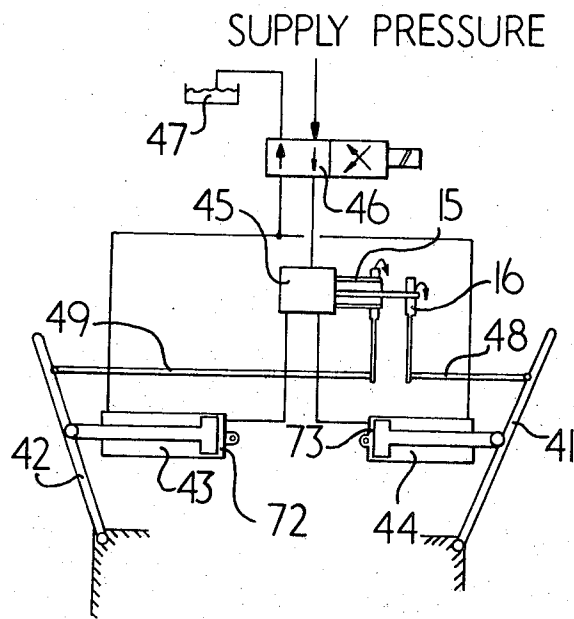
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[57] **ABSTRACT**
A synchronizing valve, for controlling the flow of fluid to and from two fluid pressure actuated components so as to synchronizing their movements, in which a housing incorporates two relatively movable members, one member being provided with a cam profile and being arranged to be operatively connected to one fluid pressure actuated component so that movement of the component causes corresponding movement of the member and the other member being provided with a cam follower and similarly being arranged to be operatively connected to the other fluid pressure actuated component. Relative movement of the two members and hence of the cam profile and follower, resulting from non-synchronous movement of the fluid pressure actuated components, is arranged to actuate a flow proportioning valve means positioned within the housing thereby adjusting the flow of fluid to or from the fluid pressure actuated components to re-establish synchronous movement.

5 Claims, 5 Drawing Figures



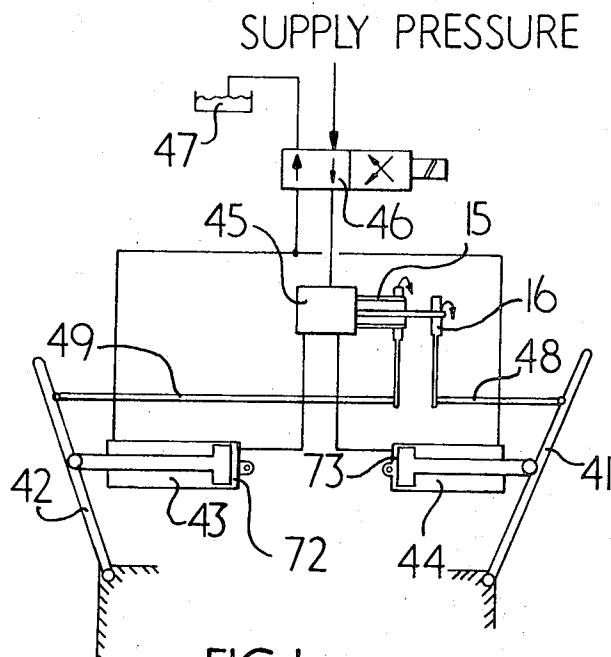


FIG. I.

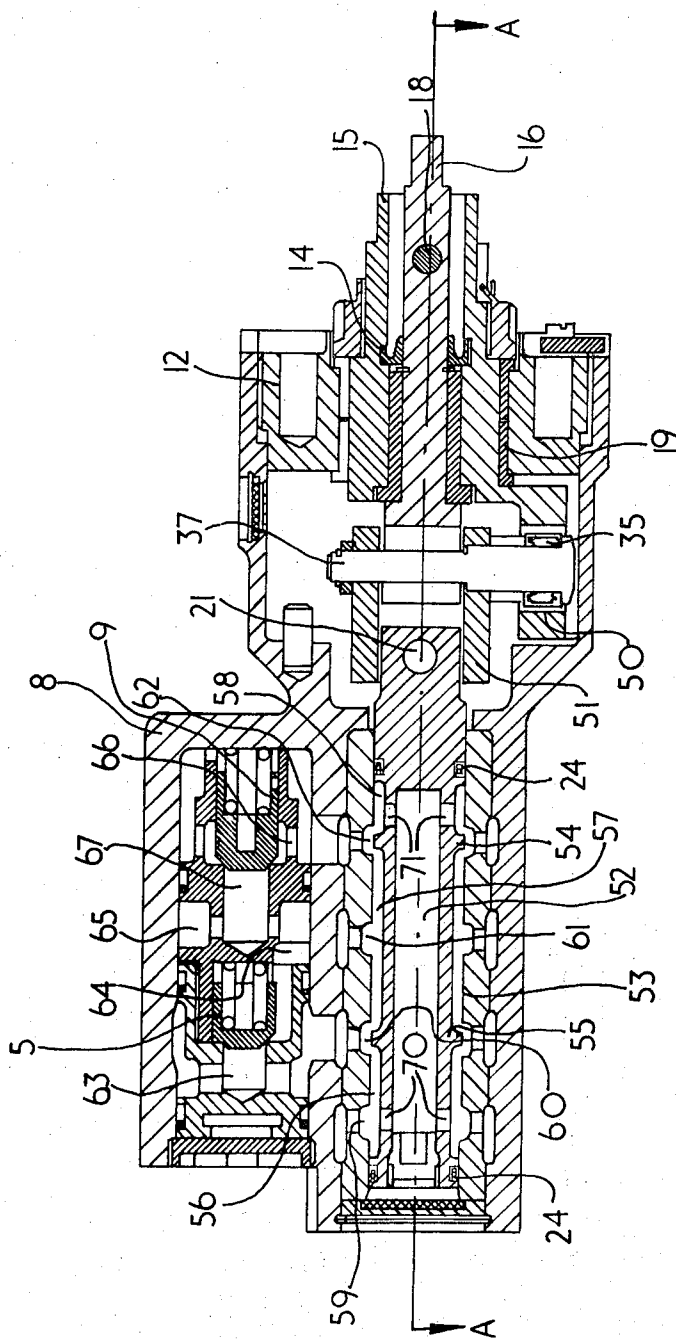


FIG. 2.

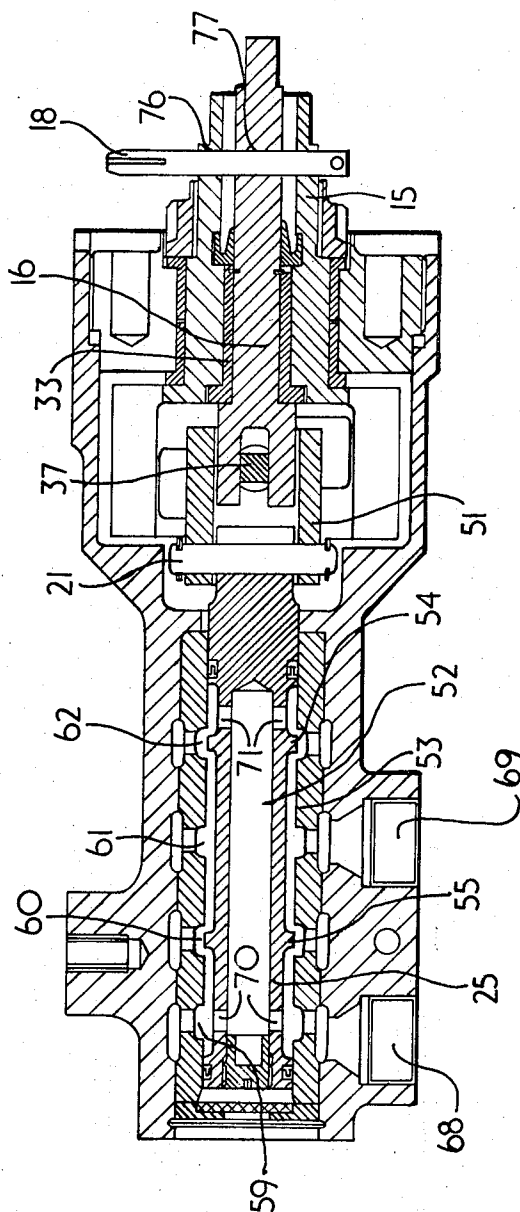


FIG. 3.

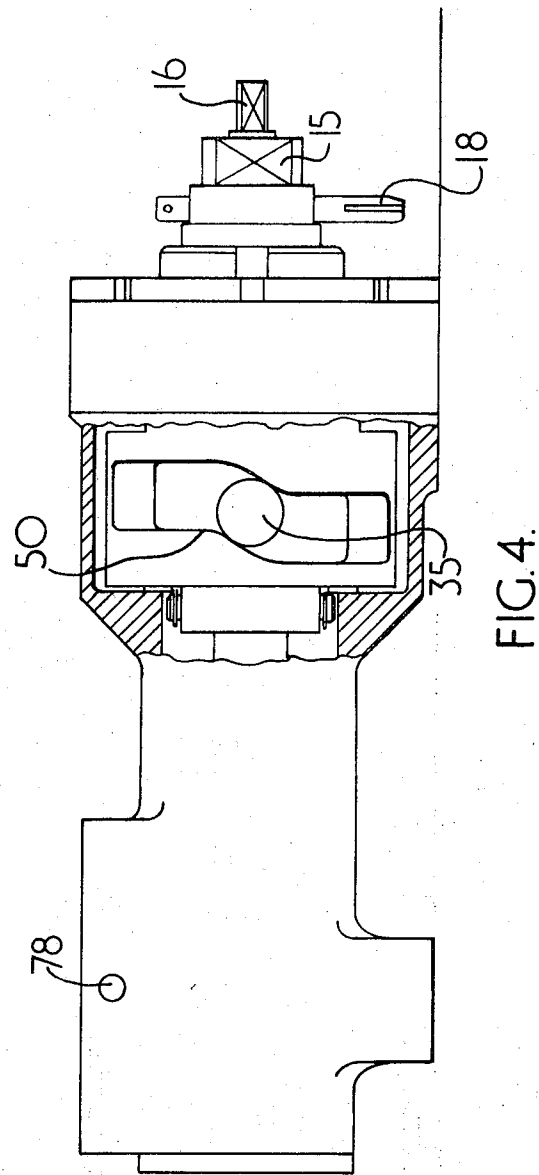


FIG. 4.

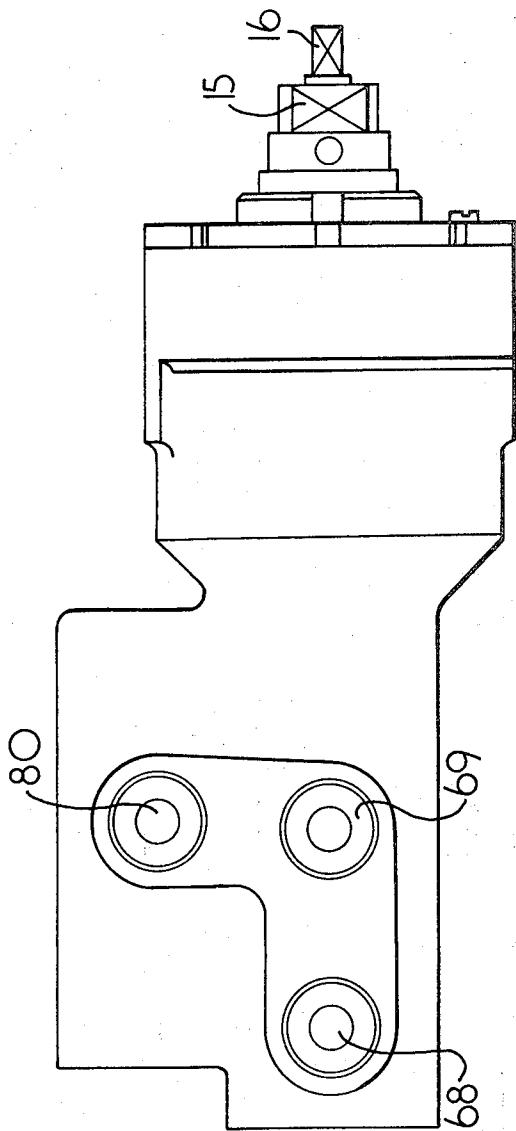


FIG. 5.

SYNCHRONIZING VALVES

This invention relates to synchronizing valves, that is, valves for controlling the flow of fluid to and from two fluid pressure actuated components thereby synchronizing their movements.

One object of the present invention is to provide an improved synchronizing valve.

According to one aspect of the present invention a synchronizing valve for controlling the flow of fluid to and from two fluid pressure actuated components so as to synchronize their movements comprises a housing incorporating two relatively movable members, one member being provided with a cam profile and being arranged to be operatively connected to one fluid pressure actuated component so that movement of the component causes corresponding movement of the member and the other member being provided with a cam follower and similarly being arranged to be operatively connected to the other fluid pressure actuated component, relative movement of the two members and hence of the cam profile and follower, resulting from non-synchronous movement of the fluid pressure actuated components, being arranged to actuate a fluid flow control valve (more particularly a flow proportioning valve means positioned within the housing) thereby adjusting the flow of fluid to or from the fluid pressure actuated components to re-establish synchronous movement.

The present invention also provides a synchronizing system incorporating a synchronizing valve in accordance with the present invention.

One embodiment of the present invention will now be described by way of example with reference to FIGS. 1 to 5 of the accompanying drawings in which:

FIG. 1 is a diagrammatic representation of a synchronizing system in accordance with the present invention;

FIG. 2 is a longitudinal section through a synchronizing valve in accordance with the present invention;

FIG. 3 is a longitudinal section on the line A—A of FIG. 2;

FIG. 4 is an outside part-sectional view of the synchronizing valve shown in FIGS. 2 and 3 showing a typical cam profile and follower arrangement, and

FIG. 5 is a further outside view of the synchronizing valve shown in FIGS. 2 to 4 showing a typical valve inlet and outlet arrangement.

A system for synchronizing the movement of two hydraulically operated aircraft airbrake flaps 41 and 42, as shown in FIG. 1, comprises a pair of rams 43, 44 one arranged to actuate each flap and a synchronizing valve 45 arranged to control the flow of hydraulic fluid to each ram. Flow of fluid to the ends 72 and 73 of rams 43 and 44 respectively is arranged to extend the rams and associated airbrake flaps while the flow of fluid to the other ends 74 and 75 of the rams is arranged to retract the rams and flaps. A selector valve 46 controls the flow of fluid from a source of supply pressure (not shown) to the synchronizing valve 45 and also controls the exhaust of fluid from the synchronizing valve 45 to a fluid reservoir 47.

Each airbrake flap is linked to a separate rotatable shaft member supported by and partially enclosed within the housing of synchronizing valve 45.

In the example shown in FIG. 1 each airbrake is linked to the synchronizing valve by a system of levers 48, 49. It will be understood that any other suitable form of mechanical linkage, such as wires, pulleys, gears or rods, or indeed any suitable form of hydraulic or pneumatic feedback may be employed. Airbrake flap 41 is linked by rod 48 to an inner rotatable shaft member 16 (see FIG. 2) supported within the housing 8 of synchronizing valve 45 by bearing 33 and airbrake flap 42 is linked by rod 49 to an outer rotatable shaft member 15 supported coaxially with shaft member 16 on bearing 19 by bearing housing 12.

Inner shaft member 16 carries a roller shaft member 37 extending at right angles thereto. The end of roller shaft member 37 remote from shaft 16 carries a roller bearing 35 which acts as a cam follower co-operating with a cam profile cut-out 50 (see FIG. 4) in the end of outer rotatable shaft member 15 within housing 8.

The end of inner shaft member 16 within housing 8 is connected to a valve spool 25 by means of a cylindrical connector 51 arranged to fit over the ends of the spool and inner shaft, cylindrical connector 51 being pinned to the inner shaft by roller shaft 37 and to the spool by a separate transversely extending pin 21. Thus relative rotation of inner and outer shaft members 16 and 15 causes relative movement of roller bearing 35 and cam profile 50 thereby causing corresponding axial deflection of spool 25.

Spool 25, which is provided with an axially extending internal bore 52 is arranged to extend within a bore 53 of the housing, each end of the spool being provided with an annular seal 24 to prevent the escape of fluid between the spool and bore 53 into the remainder of the housing. The portion of spool 25 which extends between the seals 24 is of a reduced diameter and is provided with two axially spaced circumferentially extending flanges 54 and 55 which thus form three annular passageways 56, 57 and 58 between spool 25 and bore 53. The external diameter of flanges 54 and 55 is arranged to be such that they can make sealed contact with bore 53 in a manner to be described.

Bore 53 is provided with four axially spaced circumferentially extending grooves 59, 60, 61 and 62. Groove 60 communicates via passageway 63, spring-loaded non-return valve 5 and passageway 64 with combined inlet and outlet passage 65 which in turn communicates with combined inlet and exhaust port 80 (see FIG. 5). Groove 62 also communicates via passageway 66, spring-loaded non-return valve 9 and passageway 67 with combined inlet and outlet passage 65.

Grooves 59 and 61 are connected to rams 43 and 44 respectively via outlets 68 and 69 respectively (see FIG. 3). The axial positions of grooves 60 and 62 within bore 53 are such that when roller bearing 35 is in the center of cam profile cut-out 50 the flanges 55 and 54 are positioned axially centrally within grooves 60 and 62 respectively thereby placing non-return valves 5 and 9 in communication with bore 53.

Spool 25 is provided with two transversely extending drillings 70 and 71 which place annular passageways 56 and 58 in communication with otherwise closed internal bore 52.

Non-return valves 5 and 9 which are directly connected by passageway 64 are arranged so that when the synchronizing valve is supplying fluid to the ends 72, 73 of the rams 43 and 44, in order to extend the airbrake

flaps, the direct flow of fluid through passageway 64 is prevented by non-return valve 5.

A centralizing pin 18 (see FIGS. 3 and 4) extending through aligned transversely extending holes 76,77 in the exposed ends of shafts 15 and 16 is provided to enable the bearing 35 to be centralized within cam profile cut-out 50 during installation of the synchronizing valve and final adjustment of the feedback levers 48,49. Centralizing pin 18 is removed during operation of the valve and stored in hole 78 in housing 8.

The system functions as follows:

The pilot selects the "airbrakes extend" condition using selector valve 46. This connects the supply pressure to synchronizing valve 45 and hence to the ends 72 and 73 of rams 43 and 44 respectively while connecting the other ends 74 and 75 of the rams to fluid reservoir 47.

As flaps 41 and 42 extend, their movement is fed back to synchronizing valve 45 via links 48 and 49 and results in a clockwise rotation of inner and outer shafts 16 and 15. As long as flaps 41 and 42 extend symmetrically, that is in synchronism, shafts 16 and 15 will rotate in a clockwise manner without relative movement therebetween and bearing 35 thus remains in the center of cam profile cut-out 50 thus maintaining spool 25 in its axially central position in which equal quantities of fluid flow to rams 43 and 44 via ports 68 and 69 respectively. The fluid flows to outlets 68 and 69 via passages 65 and 67, non-return valve 9, groove 62, passageways 56,57 and 58, drillings 70 and 71, bore 52 and grooves 59 and 61.

If flap 41 extends ahead of flap 42 then inner shaft 16 will rotate relative to outer shaft 15 causing bearing 35 to move along the cam profile thereby drawing spool 25 to the right, as viewed in the accompanying drawings. This movement of the spool to the right causes flanges 55 and 54 to move to the right in grooves 60 and 62 respectively thereby reducing or completely cutting-off the communication to internal bore 52 via drillings 70 and 71 thus reducing or cutting-off the flow of fluid to outlet 68 while increasing the flow of fluid to outlet 69 via annular passageway 57.

The amount of movement of the spool 25 in response to a given amount of movement of the airbrake flaps 41 and 42 is determined by the shape of the cam profile cut-out 50 and by the arrangement of the feedback linkages 48 and 49. Typically the system is arranged so that one degree movement of either airbrake flap results in a one degree rotation of the associated inner or outer shaft member and the cam profile cut-out is so designed that three degrees relative rotation between the inner and outer shaft members is sufficient to completely cut off the flow of fluid to one outlet while allowing the full flow to the other outlet. The cam profile cut-out shown in the accompanying drawings is arranged to allow up to 65 degrees relative rotation between the inner and outer shaft members in either direction, though after 3 degrees relative rotation the flow of fluid to one outlet is completely cut off as described above.

The reducing or cutting-off of the flow of fluid to outlet 68 and increasing of the flow to outlet 69 reduces or eliminates the rate of extension of flap 41 and allows ram 44 to catch up ram 43 thus re-establishing synchronization between the movements of flaps 41 and 42 thereby eliminating the relative rotation between inner

and outer shafts 16 and 15 and returning bearing 35 to the centre of cam profile cut-out 50.

Should flap 42 extend ahead of flap 41 outer shaft member 15 rotates relative to inner shaft member 16 and bearing 35 moves along cam profile 50 thereby pushing spool 25 to the left, as viewed in the accompanying drawings. This movement of the spool to the left causes flanges 54 and 55 to reduce or completely cut off the flow of fluid to outlet 69, via annular passage 57 while increasing the flow of fluid, via annular passage 58, to outlet 68. This reducing or cutting-off of the flow of fluid to outlet 69 allows ram 43 to catch up ram 44 thus re-establishing synchronization between the movements of flaps 41 and 42 and returning bearing 35 to the center of cam profile cut-out 50.

Thus the extension of airbrake flaps 41 and 42 is controlled by the system and the occurrence of dangerous excessive asymmetry is avoided.

When the pilot selects the "airbrakes retract" condition selector valve 46 connects the ends 74 and 75 of rams 43 and 44 directly to the fluid pressure supply and connects the ends 72 and 73 of the rams to fluid reservoir 47 via synchronizing valve 45. Thus by controlling the rate of exhaust of rams 43 and 44 using synchronizing valve 45 the retraction of flaps 41 and 42 can be synchronized in a similar manner to their extension.

As long as flaps 41 and 42 retract symmetrically inner and outer shafts 16 and 15 rotate in an anti-clockwise manner without relative movement therebetween and bearing 35 again remains in the center of cam profile cut-out 50 thus maintaining spool 25 in its axially central position in which equal quantities of fluid are exhausted from rams 43 and 44. The fluid flows to combined inlet and outlet passage 65 from outlets 68 and 69 via grooves 59 and 61, annular passageways 56, 57 and 58, drillings 70 and 71, bore 52, passageway 63, non-return valve 5 and passageway 64. Non-return valve 9 prevents the direct flow of fluid, via passages 66 and 67, into passage 65.

In the event of asymmetrical retract of the flaps the shaft members 15 and 16 will rotate anti-clockwise relative to each other and cause the appropriate axial movement of spool 25 to control the relative rates of exhaust of fluid from rams 43 and 44 in a similar manner to the control of the extension of the flaps described above. Thus the retraction of the airbrake flaps is controlled by the system and the occurrence of dangerous excessive asymmetry is again avoided.

Although the synchronizing valve described above incorporates a spool valve member arranged to be axially displaced in response to relative movement between a cam and a follower resulting from relative rotation between two co-axial shaft members, the synchronizing valve could equally well be arranged to operate any convenient form of fluid flow control valve, other than a spool valve, in response to relative movement between a cam and a follower resulting from non-rotational relative movement between two relatively movable members.

Further, although the synchronizing system has been described above with reference to the control of hydraulically actuated aircraft airbrake flaps it will be appreciated that the system has a wide field of application in the synchronization of the control of the movement of hydraulically and pneumatically actuated components in general.

I claim:

1. A synchronizing valve assembly for controlling the flow of fluid to and from two fluid pressure actuated components so as to synchronize their movements comprising:

- a. a housing having two relatively movable members comprising inner and outer rotatable shaft members mounted co-axially with one inside the other, one member having a cam profile integrally arranged to be operatively connected to one fluid pressure actuated component so that movement of the component causes movement of said one member;
 - b. the other member having a cam follower and similarly arranged to be operatively connected to the other fluid pressure actuated component;
 - c. a flow proportioning valve means positioned within the housing and means connecting said members to said valve so that relative rotation of the two shaft members along with the cam profile and follower which results from non-synchronous movement of the fluid pressure actuated components will cause the valve to adjust the flow of fluid to or from the fluid pressure actuated components to re-establish synchronous movement.
2. An assembly according to claim 1 wherein the cam follower comprises a roller mounted on a shaft carried by and extending at right angles to the inner rotatable shaft member.

3. An assembly according to claim 2 wherein the cam profile comprises a slot cut in the outer rotatable shaft member and arranged to receive the roller.

4. An assembly according to claim 1 wherein the flow proportioning valve means comprises a spool valve member axially slidable within a bore in the housing, relative movement between the two relatively movable members being arranged to axially displace the spool valve within the bore thereby adjusting the flow of fluid to or from the fluid pressure actuated components.

5. An assembly according to claim 4 wherein the spool valve member is supported at its ends in sealed sliding contact within the bore, the portion of the spool valve member between the sealed ends being of reduced diameter and provided with two axially spaced circumferentially extending flanges which co-operate with the bore to provide three axially spaced passageways between the bore and the reduced diameter portions of the spool valve member, one fluid pressure actuated component being arranged to be in permanent fluid communication with one annular end passageway and the other fluid pressure actuated component being arranged to be in permanent fluid communication with the center annular passageway, the two annular end passages being interconnected by an internal bore extending within the spool valve member, two axially spaced circumferentially extending grooves provided in the wall of the bore, the two grooves communicating with a combined inlet and outlet passage, a non-return valve means disposed between the combined inlet and outlet passage and the circumferentially extending grooves, the non-return valve means being arranged to supply fluid to the fluid pressure actuated components via one groove and to exhaust fluid from the components via the other groove, the flanges provided on the spool valve member being arranged to co-operate with the grooves to allow a substantially equal flow of fluid to or from the fluid pressure actuated components when these components are moving in synchronism, axial displacement of the spool valve member resulting from non-synchronous movement of the fluid pressure actuated components being arranged to allow proportionately more fluid to flow to or from one or the other of the fluid pressure actuated components depending on the direction of displacement of the spool valve member.

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