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(54) Actuator system for a control surface on an aircraft wing

(57) A control surface 11 on an aircraft wing 10 is movable by at least two double-acting piston and cylinder units 13, 14 each of which has different effective areas on opposite sides of its piston. Each of the units 13, 14 is controlled by an associated valve device 20 having a reversing valve 21 for applying a supply pressure P to one of two ports 30, 31, and a control valve 22 for applying the pressure at port 30 to one or to both sides of the piston. In the latter mode of operation the output force is reduced and the speed of operation is increased. The valve device also provides an hydraulic lock for the piston-and-cylinder unit in the event of loss of supply pressure P.

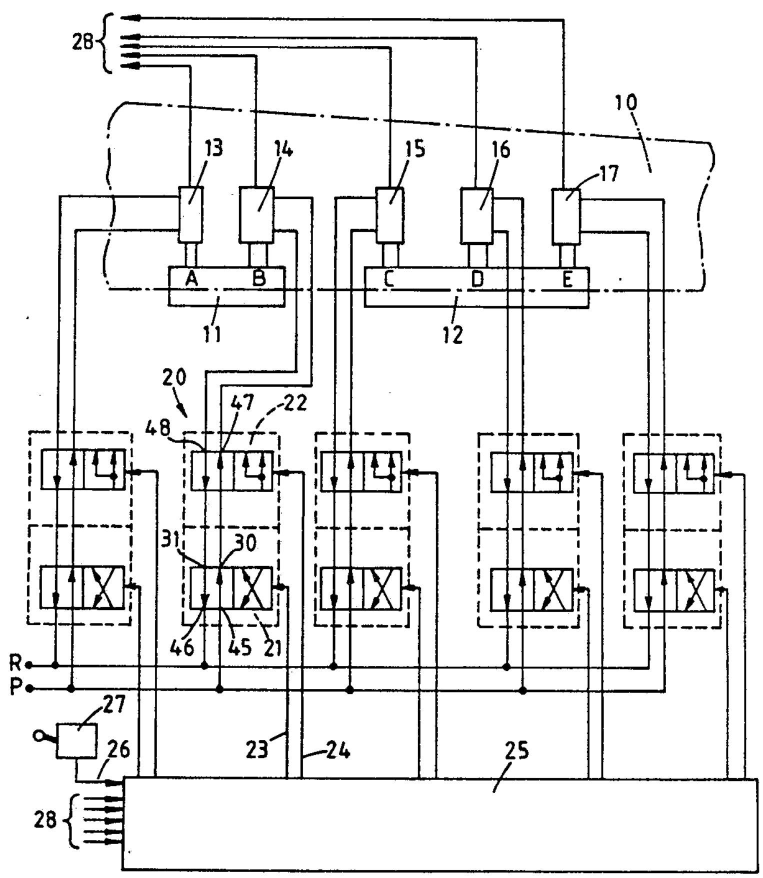

FIG. I.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

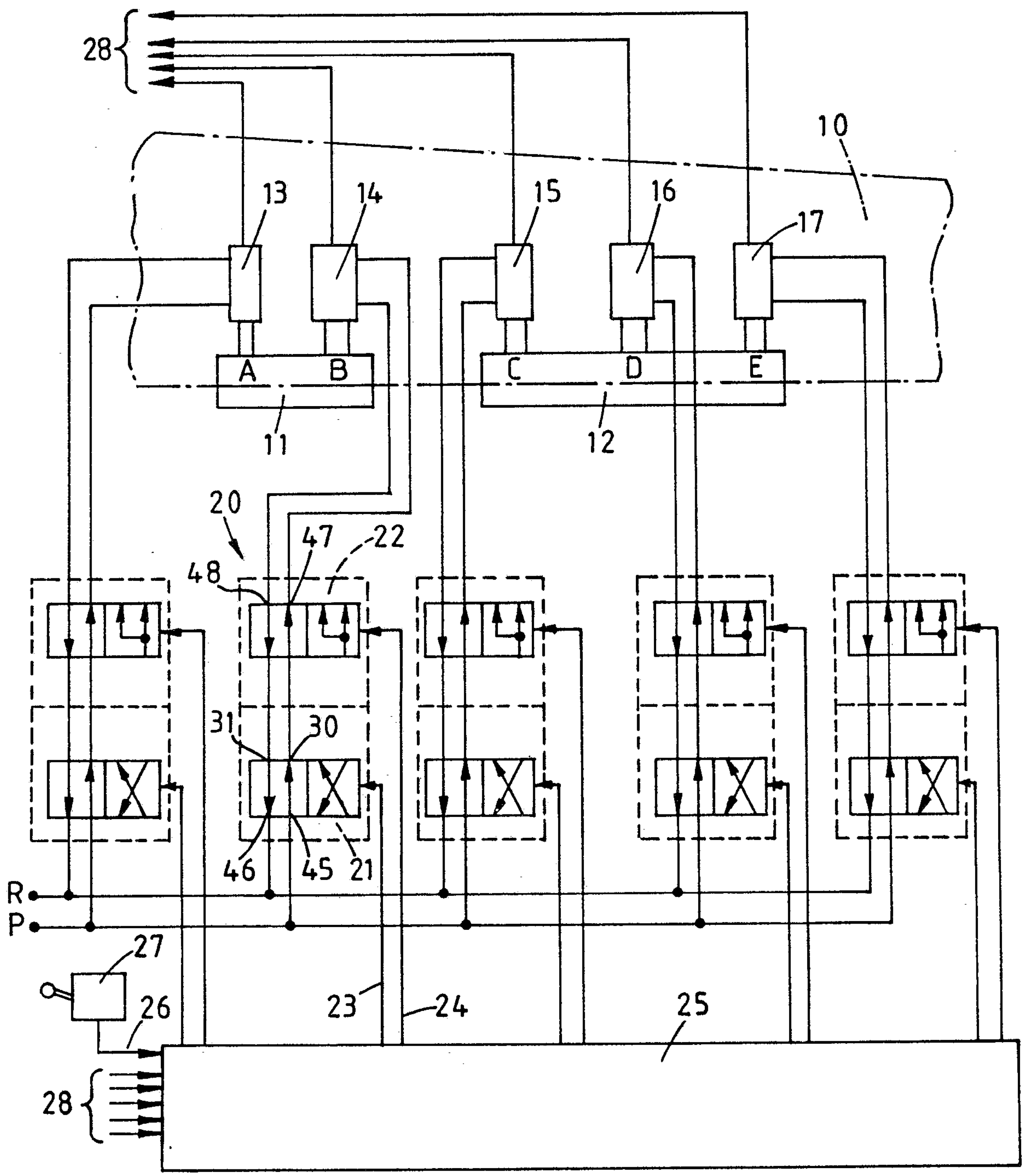
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FIG.1.

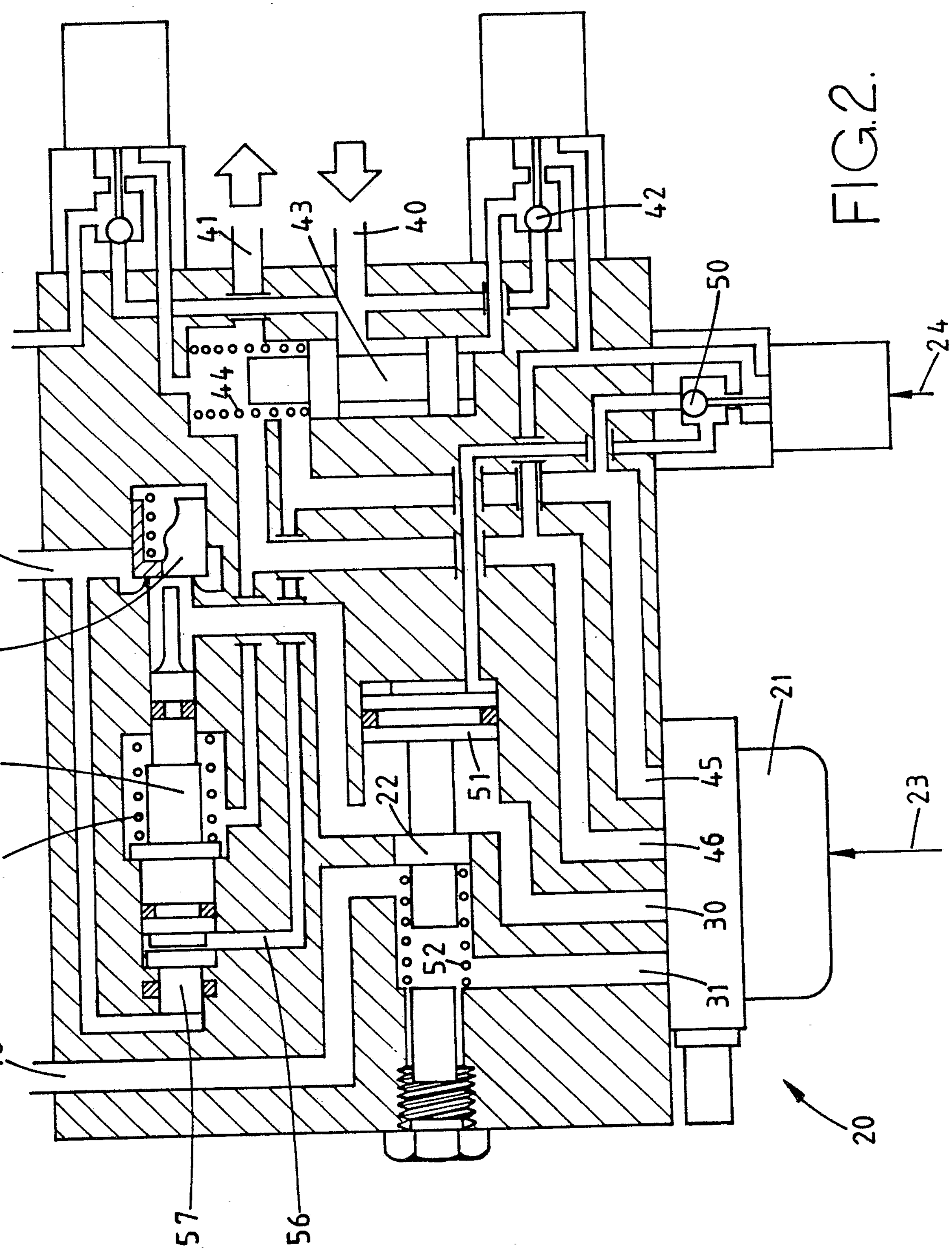

FIG.2.

SPECIFICATION

Actuator system for a control surface on an aircraft wing

Control surfaces on an aircraft wing are commonly actuated by a double acting piston and cylinder unit. Such control surfaces are not fully rigid and have varying loads along their lengths. It is therefore common practice to provide a plurality of piston and cylinder actuators along the length of the control surface, each of these actuators being capable of exerting a force which corresponds to the maximum load force which it is required to overcome. It is desirable that each of the actuators should be capable of exerting a load which is not significantly greater than the normal load force, since otherwise jamming of a control surface could result in severe damage to the wing and to that control surface, unless the wing and control surface structures were considerably strengthened. Such strengthening would impose a weight penalty, and it has therefore been considered necessary to use piston and cylinder units of differing sizes at respective locations on a control surface. If a control surface has a considerable length, or is made up of a number of units of shorter lengths, the wide variation in loads over the whole length may require a substantial number of differently sized actuators, giving rise to problems in manufacture and in the stocking of spares. Additionally, a control surface may require to be fully deployed at a relatively slow speed to increase lift of a wing, or to be moved through a shorter distance at much higher speeds for trimming the attitude of the aircraft, for example to counteract the effect of a wind gust. It is desirable to avoid the provision of two sets of actuators for lift control and manoeuvring respectively.

The present invention provides an actuator system in which the above problems are substantially overcome.

According to the invention there is provided an actuator system for a control surface on an aircraft wing, comprising first and second double-acting piston and cylinder units each of which has different effective areas on opposite sides of its piston and first and second valve devices for controlling application of pressure to said first and second units respectively, each of said valve devices comprising a reversing valve for selectively applied a supply pressure to one of two outlet ports thereof, and a control valve selectively operable to apply the pressure at one of said outlet ports to one side or to both sides of the piston of its associated piston and cylinder unit.

An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings in which:—

Figure 1 is a diagram showing flight control surfaces on an aircraft wing and a multiple actuator system for those surfaces, and

Figure 2 is a diagram of a valve arrangement forming part of Fig. 1.

As shown in Fig. 1 an aircraft wing 10 has mounted thereon, for movement to selected operating positions, control surfaces 11, 12. The control surface 11 is movable by double-acting piston and cylinder units 13, 14 which are applied to locations A, B respectively on the surface 11. The control surface 12 is movable by double-acting piston and cylinder 15, 16, 17 whose outputs are applied to locations C, D, E respectively on the surface 12. The maximum loads on the surfaces 11, 12 at locations A, B, C, D, E increase from low values to 9, 32, 15, 24.5 and 15 kiloNewtons respectively, as the surfaces 11, 12 move from their stowed to their fully deployed positions. In the example described the anticipated maximum loads in the stowing directions of movement are substantially less than the corresponding loads during deployment. In a conventional arrangement this would require four different sizes of actuator in order to prevent the output forces from the actuators greatly exceeding the loads which they are required to overcome. In the present example the anticipated loads at the various locations are met by two actuator sizes only.

The piston and cylinder units 13–17 each have half-area pistons, that is the cross-sectional area of the output stem is half that of the piston head. Thus, if a supply pressure is applied to the whole of the piston head area and a low return pressure applied to the side of the head from which the stem extends (normal operation) the full force output of the unit is obtainable. If, however, the same supply pressure is applied to both sides of the piston (regenerative operation) only half the normal force output is obtained but the output stem moves at up to twice the speed.

In the present example the units 13 and 16 are sized to provide a normal output of 24.5 kiloNewtons, and the units 14, 15 and 17 to provide a normal output of 32 kiloNewtons. During deployment of the control surfaces 11, 12 to modify the lift of the wing 10 the units 14 and 16 are operated in the normal mode and the units 13, 15 and 17 in the regenerative mode. In the regenerative mode the units 13, 15 and 17 thus provide outputs of 12.25, 16 and 16 kiloNewtons respectively. These outputs are sufficiently close to the respective required maxima of 9, 15 and 15 kiloNewtons as not to impose undue penalties in strengthening the wing 10 and control surfaces 11, 12 adjacent the locations A, C, E.

When the control surfaces 11, 12 are to be used for triming purposes they are required to be moved relatively rapidly over shorter distances from their stowed positions. In these circumstances all of the units are employed in regenerative mode, thereby increasing their normal operating speeds.

The units 13–17 are controlled to operate in their normal and regenerative modes, and in forward and reverse directions by respective identical valve arrangements 20, each of which includes a forward and reverse control valve 21 and a valve 22 for switching between normal and regenerative modes of operation. The valves 21, 22 are responsive to electrical signals on respective 23, 24 from a control circuit. The circuit 25 is responsive to input signals on a line 26 from a device 27 by means of which required operations of the surfaces 11, 12 are selected, and also to position feedback signals on lines 28 from the units 13–17. The control valve 21 is operable to connect a pressure supply line P and a low pressure return line R to output ports 30, 31 or to reverse that connection. The valve 22 is operable either to connect the output ports 30, 31 to opposite sides of a piston in an associated one of the units 13–17 or to connect the port 30 to both sides of that piston.

A valve arrangement 20 is shown in more detail in Fig. 2 and has ports 40, 41 to which the supply pressure line P and low pressure return line R are respectively connected. A valve 42 is electromagnetically operable to apply the pressure in the port 40 to one end of a valve spool 43 to move the latter against a spring 44 and thereby to connect the port 40 to an inlet port 45 of the valve 21 which, as indicated above, is operable by electrical signals on the line 23. A return port 46 of the valve 21 is permanently connected to the port 41. In normal operation the ports 30, 31 communicate with an associated piston and cylinder unit through outlet ports 47, 48 respectively.

After the valve 42 has been energised to enable operation of the valve arrangement 20 a further valve 50 is electromagnetically operable by a signal on the line 24 to apply the supply pressure to a piston head 51 of the normal/regeneration selector valve 22, to move the latter against a spring 52 and thereby to allow the port 30 to communicate with both of the ports 47, 48, resulting in regenerative operation as described above.

The port 30 communicates with the port 47 by way of a spring-loaded shut off valve 53 which is movable against its spring by the pressure in port 30 and by a plunger 54. The plunger 54 is biased by a spring 55 to a position in which the valve 53 is shut and, when the valves 42, 43 are operated, is urged against the spring 55 by the supply pressure P applied through a line 56. Thus, when the valve arrangement 20 is disenabled by de-energisation of the valve 42, the valve 53 shuts and a hydraulic lock is present in the associated piston and cylinder unit, preventing movement thereof. A further plunger 57 is responsive to an excessive pressure at the port 47 to urge the plunger 54 against the spring 55 and open the valve 53. Such an excessive pressure may arise as a result of heating the fluid in the associated actuator. The valve 53 reshuts as soon as the excessive pressure is relieved. Since the effective area of the plunger 57 is substantially less than that of the plunger 54, the pressure relieving function of the valve 53 will not occur unless the pressure in the port 47 is substantially higher than the supply pressure P.

It will be apparent that piston and cylinder units having other effective area ratios may be used, thereby to enable selection of required output forces and speeds in regenerative operation.

In an alternative embodiment the valve 21 may have a flow regulating function in addition to that of flow reversal. Additionally or alternatively the valve 22 and the passages within the arrangement 20 may be sized to control fluid flow, and therefore speed of operation of an associated piston and cylinder unit as required.

CLAIMS

1. An actuator system for a control surface on an aircraft wing, comprising first and second double-acting piston and cylinder units each of which has different effective areas on opposite sides of its piston, and first and second valve devices for controlling application of pressure to said first and second units respectively, each of said valve devices comprising a reversing valve for selectively applyiong a supply pressure to one of two outlet ports thereof, and a control valve selectively operable to apply the pressure at one of said outlet ports to one side or to both sides of the piston of its associated piston and cylinder unit.

2. A system as claimed in Claim 1 in which said reversing valves are also operable to regulate flow to said piston and cylinder units.

3. A system as claimed in Claim 1 or Claim 2 in which at least one of said control valves is dimensioned to provide a required flow to its associated piston and cylinder unit.

4. A system as claimed in any preceding claim in which said control valve is operated by a pressure signal derived from said supply pressure.

5. A system as claimed in any preceding claim in which each said valve device includes a first shut-off valve for controlling application of said supply pressure to said reversing value, and a second shut-off valve, responsive to application of said supply pressure to said reversing valve, for connecting one of said outlet ports to said piston and cylinder unit.

6. A system as claimed in any preceding claim in which one side of said piston has twice the effective area of the other side thereof.

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