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HYDRAULIC SERVO FLYING CONTROLS FOR AIRCRAFT

Filed April 9, 1959

2 Sheets-Sheet 1

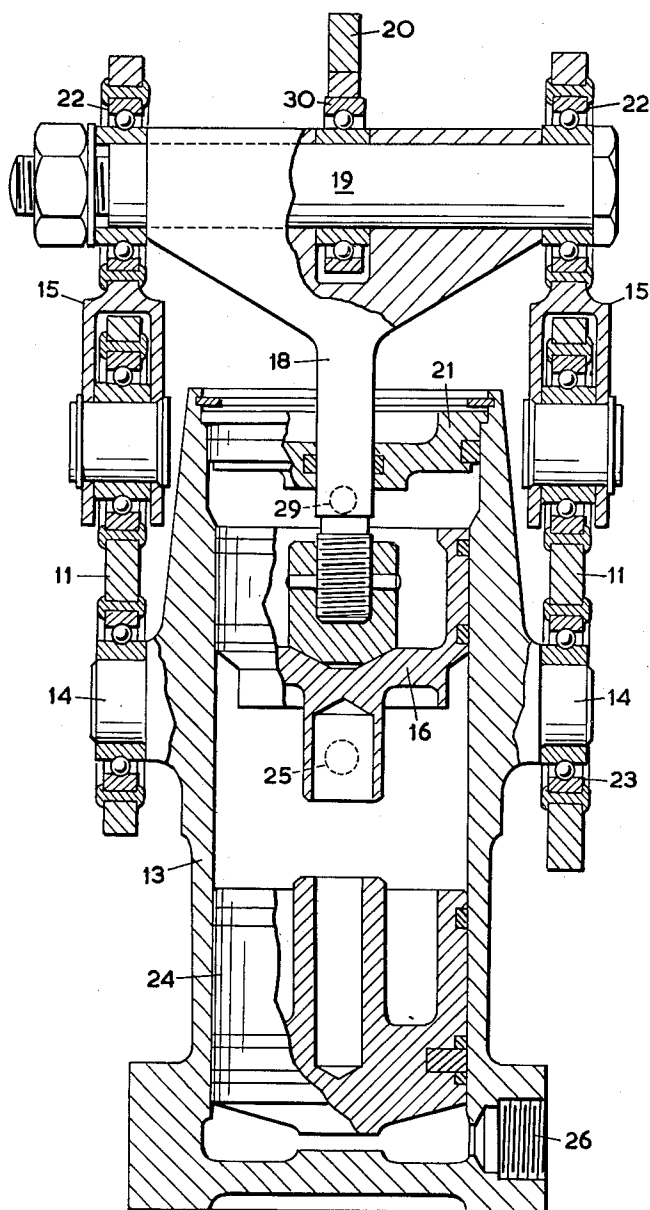


FIG. 1

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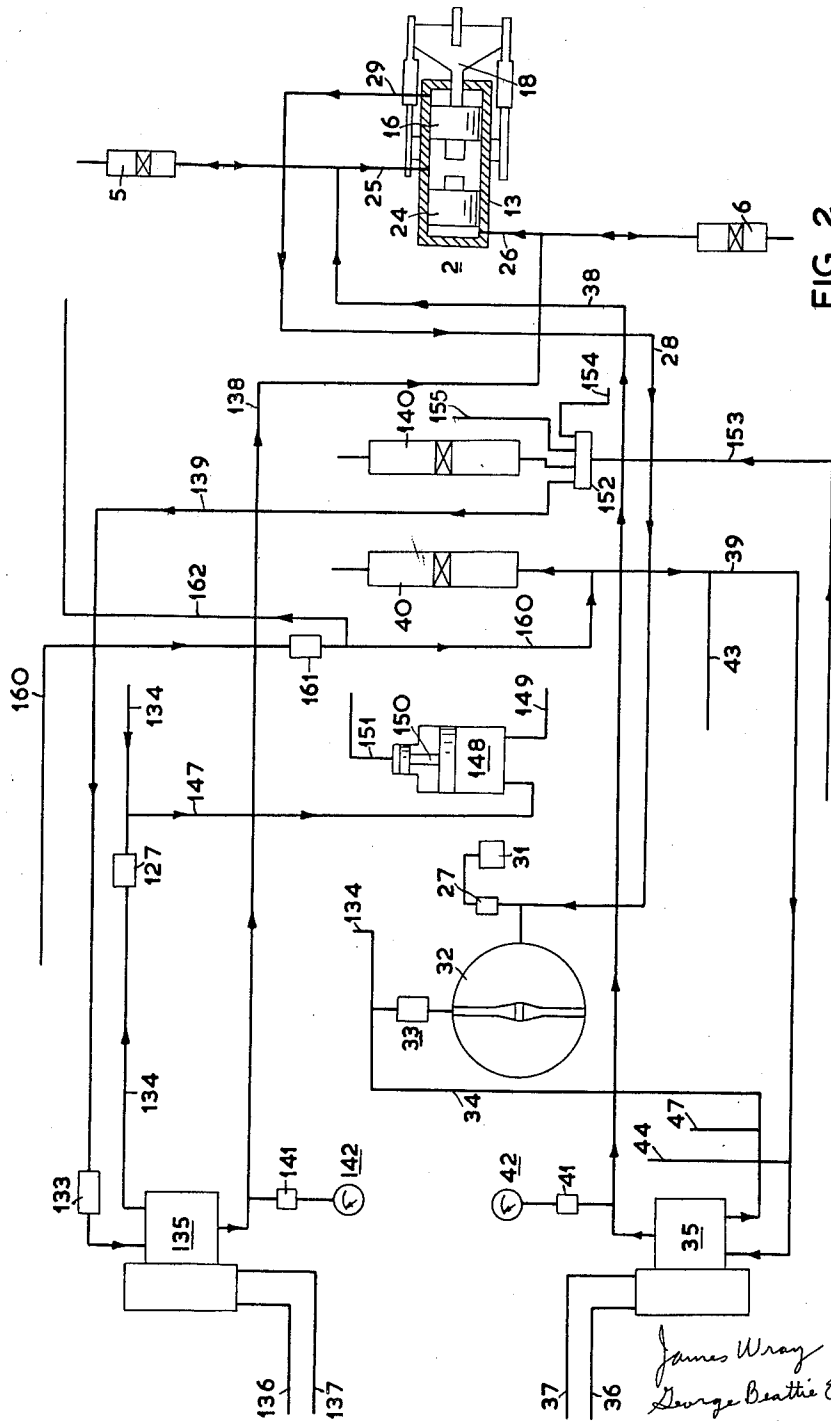


FIG. 2

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3,058,701 HYDRAULIC SERVO FLYING CONTROLS FOR AIRCRAFT

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1 Claim. (Cl. 244—83)

The present invention relates to hydraulic servo flying controls for aircraft where low friction and high response rate combined with a need for duplication and operation from duplicate power sources to ensure the continuity of the operation are primary considerations.

The invention is particularly applicable to hydraulically powered feel simulator systems for power-operated flying controls in that it enables the use of an alternative source of power without the complication of duplicated hydraulic jacks and mechanical connections thereto.

Such feel simulator systems comprise a hydraulic jack containing a primary piston one side of which is subject to a hydraulic pressure controlled by the Mach number of flight, and the other side is connected to the sump. The said primary piston is connected to the pilot's control in such a manner that it is moved out of its rest position always in the same direction, namely against the said hydraulic pressure, regardless in which sense the control is operated. The resistance met is then a measure of the deflection of the pilot's control and of the hydraulic pressure, which is in turn dependent on the Mach number of flight. Thus the "feel" given to the pilot by directly operated controls is well simulated.

According to the present invention on the side connected to hydraulic pressure of the said jack a free piston is fitted which divides the pressure side of the jack cylinder into two compartments each of which is connected to a separate source of hydraulic pressure. If both these sources provide equal pressures, or if the source connected to the cylinder of the jack between the primary piston and the free piston provides a higher pressure, the free piston remains inoperative. When, however, the source of pressure connected between the bottom of the jack cylinder and the free piston provides the higher pressure, the free piston is pushed against the primary piston. Thus the feel system remains equally operative with both or either of the two sources of hydraulic pressure effective, i.e. it does the service of a fully duplicated system without requiring its space.

In order that the invention may be clearly understood and readily carried into effect, an embodiment thereof will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 shows a longitudinal section of the hydraulic jack of a control system according to the present invention,

FIG. 2 is a hydraulic circuit diagram of a feel simulator system.

In FIG. 1 in the cylinder 13 of a hydraulic jack a primary piston 16 is slidable, tightly sealed. This piston 16 has a piston rod 18 which is linked by an axle 19, ball bearings 22 and links 15 to a double lever 11 connected to the pilot's controls and movable in a plane perpendicular to that of the drawing. The axle 14 of the cylinder 13 is journaled by means of ball bearings 23 in the said double lever 11.

The cylinder 13 is tightly closed at one end by the cover 21 through which passes the piston rod 18 tightly sealed. The space of the cylinder 13 enclosed between said cover 21 and the said primary piston 16 is connected to the sump of the hydraulic system by an outlet 29.

A secondary piston 24 is freely movable—but tightly

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sealed in the part of the cylinder 13 between its bottom and the said primary piston 16. A primary inlet 25 for hydraulic pressure fluid is arranged in the cylinder 13 between the said primary and secondary pistons 16, 24, and a secondary inlet 26 for hydraulic pressure fluid is arranged between the bottom of the cylinder 13 and the secondary piston 24.

The two inlets 25, 26 are connected to two separate sources of hydraulic pressure of a magnitude responsive to the Mach number of flight.

When the pilot's control lever 11 is swung in the plane perpendicular to the plane of the drawing in either direction, the primary piston 16 is forced into the cylinder 13, i.e. downward in the drawing. This movement is reacted to by the hydraulic pressure under the piston 16, this reaction depending on the magnitude of the control movement and on the Mach number, i.e. giving artificially that "feel" the pilot gets when operating direct controls.

If both sources of hydraulic pressure work properly, the pressure on both sides of the secondary, free piston 24 should be equal. If the pressure supplied through the secondary inlet 26 fails, the pressure from the primary inlet 25 will force the free piston 24 down towards the bottom of the cylinder 13. If the pressure supplied through the primary inlet 25 fails, the said free piston 24 is forced up by the pressure from the inlet 26 against the primary piston 16. It follows, that as long as at least one of the sources of hydraulic pressure is operative, the hydraulic reaction will act on the primary piston 16 and hence on the pilot's control lever 11. Thus the same result is achieved by the single hydraulic jack arrangement according to the present invention as with two fully duplicated jacks of the known kind, whereby considerable savings in weight, space and costs are achieved.

The present invention is primarily intended for hydraulic servo controls for aircraft, but is also applicable to other uses where duplication of power is sought without full duplication of hydraulic jacks.

In FIG. 2 a hydraulic circuit of the flying controls according to the present invention is diagrammatically illustrated, in which the hydraulic jack described hereinabove in more detail with reference to FIG. 1 is denoted as a whole as the feel jack 2. Its primary inlet 25 is connected to a primary feel circuit accumulator 5 and through the primary signal line 38 to the hydraulic side of the primary feel system simulator denoted 35 as a whole.

A gauge relay 41 with pressure gauge 42 is branched off the line 38. The aerodynamic (input) side of the primary feel system simulator 35 is connected by a line 36 to a pick-up point of static pressure and by a line 37 to Pitot pressure. The hydraulic (output) side of the primary feel system simulator 35 receives hydraulic pressure from the "services" main accumulator 40 through a pressure line 39 from which a line 43 to the brakes accumulator (not shown) and a gauge line 44 are branched off.

A pressure line 160 from the "services" system pumps (not shown) containing a "services" pressure line filter 161 is connected to the "services" main accumulator 40, from which line a line 162 branches off to the primary side of the rudder jack (not shown).

The hydraulic side of the primary feel system simulator 35 is connected by the primary simulator return line 34 and a "services" line return filter 33 to the "services" reservoir 32, to which the outlet 29 of the feel jack 2 is also connected through the primary return line 28, from which a collector box 31 is branched through a non-return valve 27. A brake reducing valve line 47 is branched off from the primary simulator return line 34.

The secondary inlet 26 of the feel jack 2 is connected to a secondary feel circuit accumulator 6 and through the secondary signal line 138 to the hydraulic side of the sec-

ondary feel system simulator denoted 135 as a whole. A gauge relay 141 with pressure gauge 142 is branched off the line 138. The aerodynamic (input) side of the secondary feel system simulator 135 is connected to static pressure by line 136 and to Pitot pressure by line 137.

The said "services" reservoir 32 is connected through the said "services" return line filter 33 and the secondary simulator return line 134, containing a non-return valve 127, to the hydraulic (output) side of the secondary feel system simulator 135. A line 147 branched off the line 134 is connected to the wide side of the port-controls reservoir 148 which is connected to suction through pipe 149. This port-controls reservoir 148 contains a differential piston 150, and the narrow side of it is connected by a line 151 to an external source of fluid pressure.

The hydraulic part of the secondary feel system simulator 135 receives an identical pressure with that of the primary feel system from the port-controls accumulator 140 through a distributor 152 and a pressure line 139 containing a filter 133. This distributor 152 is also connected by a pressure line 153 to the port-controls pumps (not shown), and by the lines 154, 155 to the port in-board aileron jack (not shown) and to the starboard in-board aileron jack (not shown) respectively.

It will be seen from the above, that the feel jack 2 will operate, regardless of whether it receives pressure from the primary feel system through the primary inlet 25, or from the secondary feel system through the secondary inlet 26, or from both, and that duplication of the feel jack 2 as well as of the pipe line system is largely obviated by the feel jack 2 according to the invention as described in more detail with reference to FIG. 1.

What we claim as our invention and desire to secure by Letters Patent, is:

In an aircraft, a servo-operated flying control, comprising in combination: a jack cylinder having a closed bottom, a working piston operatively connected to the said flying controls slidably fitted into the said cylinder, a free piston slidably fitted in said same cylinder between the said working piston and the said bottom, and two separate sources of hydraulic pressure, two independent feel simulators each having an aerodynamic side responsive to the Mach number of flying and a hydraulic side operatively connected each to one of the said sources of hydraulic pressure and adjusting the said pressures to equal values depending on the Mach number applied to the said aerodynamic side of said feel simulators, the hydraulic sides of the said two feel simulators being connected to the said jack cylinder at a point between the said free piston and the said bottom and at a point between said free piston and said working piston respectively, an outlet for hydraulic fluid being provided in the said cylinder on the opposite side of said working piston.

References Cited in the file of this patent

UNITED STATES PATENTS

2,726,738	Fawick	Dec. 13, 1955
2,788,185	Greenland et al.	Apr. 9, 1957
2,873,579	Stafford	Feb. 17, 1959

FOREIGN PATENTS

727,513	Great Britain	Apr. 6, 1955
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