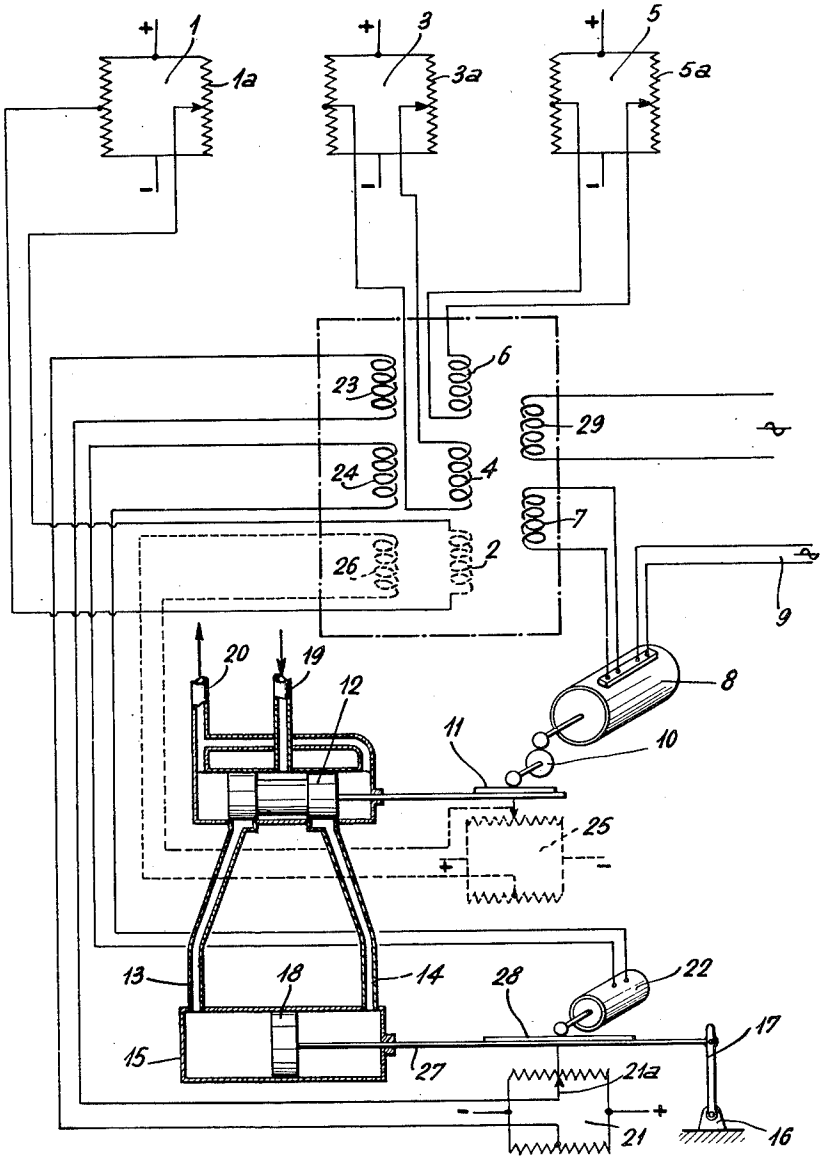
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ELECTRO-HYDRAULIC JACK DEVICE FOR CONTROLLING THE STABILITY OF AIRCRAFT

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ELECTRO-HYDRAULIC JACK DEVICE FOR CONTROLLING THE STABILITY OF AIRCRAFT

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Certain aircraft, and especially, but not exclusively, those which take-off and land vertically, have need of an artificial stability during the periods when their speeds of flight are small or zero and when the aerodynamic stability is insufficient. This artificial stabilisation must be obtained by means which give a great safety of operation. The operating systems which use magnetic amplifiers have this quality, but have also the disadvantage of reaching rapidly a prohibitive weight as soon as the power required becomes large, which is often the case for operating means for the usual types of controls or for controls which work on the jet of the reactor of the aircraft or which deflect the direction of this jet.

In the electro-hydraulic jack device which forms the object of the invention, the signals given by the displacement of the potentiometer sliders actuated by the pilot, the gyroscope and the gyrometer or rate-gyroscope, act, after amplification, on a two-phase motor arranged so as to rotate in one direction or in the other, depending on the sense of the resultant signal which is transmitted to it. It is possible to choose a type of small motor which enables the current passing into the amplifier to be reduced and, in consequence, to reduce the size of the amplifier. The motor drives, through the medium of a reduction gear, the straight-line or rotary slide-valve of a valve suppling the hydraulic jack of the control. The return loop can be effected by causing the shaft of the hydraulic jack to act on a potentiometer, on a tachometric generator, or on any other known device, depending on whether the correspondence-control is required to act by position, by speed or mixed.

As in general the speed of the hydraulic jack is proportional to the opening of the valve, the signal of speed given by a tachometric generator fixed on the shaft of the hydraulic jack can be replaced by the position signal of a potentiometer, the slider of which is coupled to the shaft of the slide-valve of the valve.

The motor and the valve which supplies the hydraulic jack may be formed as a unit with the jack, or alternatively they may be separate and grouped together in a unit comprising the amplifier, the motor and the valve.

The description which follows below with reference to the accompanying drawings (which are given by way of example only and not in any sense by way of limitation) will make it quite clear how the invention may be carried into effect.

The single figure of the drawing shows a diagram of an electro-hydraulic jack in accordance with one form of embodiment of the invention, provided with a mixed correspondence-control (speed and position of the control member).

In this diagram, the sliders **1***a*, **3***a*, **5***a*, of potentiometers, each inserted in a Wheatstone bridge marked **1**, **3** and **5**, are respectively actuated by the pilot's operating lever, a gyroscope, and a gyrometer. The coils **2**, **4** and **6** of a magnetic amplifier are connected to the respective diagonals of these Wheatstone bridges in such manner that any displacement of the sliders **1***a*, **3***a* and **5***a* of the potentiometers will cause to appear, at the terminals of these coils, potentials of which one part of the algebraic sum determines the de-phasing and the current in the control

winding **7** of a two-phase motor **8** and, in consequence, the direction of rotation and the speed of this motor, the latter then beginning to rotate in a direction which depends on the said sum. The power is provided by the induction of the coil **29** of the magnetic amplifier, and the fixed reference phase **9** is directly connected to the two-phase motor without passing through the amplifier.

The rotation of the motor **8** drives the distributor slide-valve **12** through the medium of a reduction gear **10** and a toothed rack **11**, the valve **12** supplying one or the other of the conduits **13** and **14**, of a hydraulic jack **15** which acts on the shaft **16** of the control member to be actuated, through the intermediary of a slider lever **17**. Depending on the direction of rotation of the motor **8**, the fluid coming under pressure from the pump through the conduit **19** is sent into one or the other of the two conduits **13** and **14**, which determines which face of the piston **18** will receive the thrust of the liquid and, in consequence, the direction of action of the control member fixed on the shaft **16**. The return of the liquid to its reservoir is made through the conduit **20**.

The rod **27** coupling the piston **18** to the slider of the lever **17** drives on the one hand the slider **21***a* of a potentiometer inserted in a Wheatstone bridge **21** and, on the other hand, a tachometric dynamo **22** through the intermediary of a toothed rack **28**. The coils **23** and **24** of the magnetic amplifier are respectively connected to the diagonal of the Wheatstone bridge **21** and to the tachometric dynamo **22**, in such manner that when the control member rigidly fixed on the shaft **16** will have reached an angular displacement proportional to the algebraic sum of the signals given by the potentiometers of the bridges **1**, **3** and **5**, the algebraic sum of the potentials at the terminals of the coils **23** and **24** is of the same value but of opposite sign to the algebraic sum of the potentials existing at the terminals of the coils **2**, **4** and **6**. The effects of the coils cancel out, the de-phasing of the winding **7** with respect to the fixed phase **9** becomes zero and the motor **8** stops, leaving the slide-valve **12** in the open position. The piston **18** thus continues to move in the same direction until the action on the potentiometer **21** and the tachometric dynamo **22** causes the production, at the terminals of the coils **23** and **24**, of potentials, the algebraic sum of which has an absolute value greater than but of opposite sign to the algebraic sum of the potentials existing at the terminals of the coils **2**, **4** and **6**, which determines a de-phasing of opposite sign in the winding **7**.

In accordance with the form of correspondence-control chosen, either by position, or by speed, or mixed, the jack will act by taking up either a position, or a speed, or a predetermined position in accordance with the mixed control.

Known means such as corrector-networks may be interposed in the circuits in order to limit the oscillations or the instability of the system.

The speed of the hydraulic jack **15** being proportional to the displacement of the slide-valve **22** of the valve which supplies this jack, the tachometric dynamo **22**, driven by the jack **15** can be replaced, for the correspondence-control by speed, by a potentiometer **25** which detects the position of the slide-valve **12**, employing the circuit indicated in dotted lines.

Depending on the servitudes of the control member to which this operating device is applied, only one of the two forms of correspondence-control by speed and by position can be retained.

The device described combines a high degree of safety in operation, the accessories used being all completely tested by current use, with extremely low weight for considerable power.

The magnetic amplifier could be replaced by an electronic amplifier. The input and return signals, instead of being supplied by potentiometers, could be generated di-

rectly by known means, especially those known by the names of "Selsyn" "Microsyn" or "Resolver."

What is claimed is:

1. An electro-hydraulic jack device for controlling each of the control surfaces of an aircraft, comprising three Wheatstone bridges, each bridge including a potentiometer, a pilot's control connected to the slider of the first of said potentiometers, a gyroscope connected to the slider of the second of said potentiometers, and a gyrometer connected to the slider of the third of said potentiometers, for producing electric input signals of variable magnitude and sign under the action of said pilot's control, said gyroscope and said gyrometer, an amplifier receiving said input signals and supplying a resultant signal, a two-phase motor one of the phases of which is supplied in an invariable manner by an alternating source and the other phase of which is supplied as a function of said resultant signal whereby said motor turns in a direction which depends on the sign of said resultant signal, a distributor valve driven by said motor, a hydraulic jack connected to said distributor valve and acting on the control surfaces of the craft in a direction corresponding to the direction of rotation of said motor, and means responsive to position and means responsive to the speed of said control surfaces, said means producing follow-up signals applied to said amplifier where said follow-up signals and said input signals are mixed together for providing said resultant signal.

2. An electro-hydraulic jack device for controlling the control surfaces of an aircraft, comprising means producing electric input signals of variable amplitude and sign under the action of a pilot's control, a gyroscope and a gyrometer, an amplifier of the magnetic type comprising a plurality of input coils receiving said input signals together with at least one electrical return signal and an

output coil supplied with the flux resulting from said input and return signals, a two-phase motor one of the phases of which is supplied in an invariable manner by an alternating source and the other phase of which is constituted by said output coil of said amplifier whereby said motor turns in direction which depends on the sign of said resultant flux, a distributor valve driven by said motor, a hydraulic jack connected to said distributor valve and acting on the control surfaces of the craft in a direction corresponding to the direction of rotation of said motor, and at least one electrical follow-back device which develops said electrical return signal to the input of said amplifier.

3. Electro-hydraulic jack device as claimed in claim 2, comprising two electrical follow-back devices, one of which detects the speed of displacement of said hydraulic jack, the other of which detects the position of said hydraulic jack.

4. Electro-hydraulic jack device as claimed in claim 2, comprising two electrical follow-back devices, one of which detects the speed of displacement of said hydraulic jack, the other of which detects the position of said distributor valve.

References Cited in the file of this patent

UNITED STATES PATENTS

2,188,834	Fischel	Jan. 30, 1940
2,317,383	Hull	Apr. 27, 1943
2,471,821	Kutzler	May 31, 1949
2,592,173	Noxon	Apr. 8, 1952
2,681,777	Rossire	June 22, 1954
2,733,878	Ciscel	Feb. 7, 1956
2,797,379	Young	June 25, 1957
2,852,212	Mallery	Sept. 16, 1958
2,890,844	Cooper	June 16, 1959