

UNITED STATES PATENT OFFICE

2,222,886

SERVOMOTOR CONTROL SYSTEM FOR AIRPLANES

Waldemar Voigt, Haunstetten, near Augsburg, Germany, assignor to Siemens Apparate und Maschinen (Gesellschaft mit beschränkter Haftung), Berlin, Germany, a corporation of Germany

Application January 16, 1937, Serial No. 120,888
In Germany January 16, 1936

5 Claims. (Cl. 244—78)

This invention relates to airplanes and more particularly to the operation of the control surfaces wherein an auxiliary source of power is employed to assist the pilot in moving the control surfaces.

One of the objects of the present invention is to provide a servomotor interconnected with the manually controlled lever to assist the pilot in effectively moving the elements of an airplane while in flight.

In the preferred embodiment it is a further object of this invention to interconnect the manually controlled lever with the servomotor in such a manner as to effect a reaction on the former when the latter is operated.

It is a further object to provide an adjustable connection between the manually controlled lever and the servomotor by which the amount of reaction on the former from the latter may be varied.

It frequently happens that dangerous stresses and strains are built up in the airplane structure as for instance when recovering rapidly from a nose dive. Accordingly, it is a further object of this invention to provide a mechanism which will automatically and temporarily take over the operation of the control surfaces of the plane in the event that such stresses and strains are developed to an excessive degree during flight.

These and other objects of the invention will become apparent from inspection of the following specification when read with reference to the accompanying drawings wherein is illustrated the preferred embodiment of the invention. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not designed as a definition of the limits of the invention, reference being had to the appended claims for that purpose.

In the drawings:

Fig. 1 shows diagrammatically one form of auxiliary power control for the application of fluid pressure for operating the elevator of an airplane;

Fig. 2 shows, in section, the preferred form of the control valve diagrammatically illustrated at *e* in Fig. 1;

Fig. 3 shows diagrammatically the preferred form of the auxiliary power control;

Fig. 4 shows, in section, the control valve diagrammatically illustrated at *e''* in Fig. 3, and

Fig. 5 shows, in section, the adjustable connection diagrammatically illustrated at *q* in Fig. 3.

Referring more particularly to the drawings, in Fig. 1 a control lever *a*, pivoted at a fixed point on the airplane fuselage, carries at its lower end, pivotally attached thereto, a rod consisting of two sections *b* and *c*. The outer end of section *c* is pivotally connected to the operating lever *d* of the airplane elevator *p*. Between the control rod sections *b* and *c* is arranged the valve means *e* in such a manner that the casing of the valve is pivotally connected to the inner end of the rod section *c* while the inner end of rod section *b* passes through a guide *f* into the valve casing where it is connected to a movable member 2, shown in detail in Fig. 2. Two conduits *g* and *h* lead from each end of the valve *e* to each end of the fluid operated servomotor cylinder *i* which is also pivoted at a fixed point on the airplane fuselage. Cylinder *i* contains a sliding piston *j* which is pivotally attached, at a suitable point through the piston rod *k*, to the control rod section *c*. Fluid under pressure is supplied to the valve *e* through a conduit *l* from a pump *m* driven by the main power plant of the airplane; a discharge conduit *o* leads from the valve *e* back to the suction side of the pump. If desired, a pressure accumulator *n* may be interconnected with the conduit *l*.

In Fig. 2, the valve *e* of Figs. 1 and 3 is shown in cross-section and consists of a casing 10 having on the inside small recessed ports 4 and 5. Attached to the center of the casing, on opposite sides thereof, are conduits *l* and *o* which represent respectively the fluid inlet and discharge. At each end of the casing, conduits *g* and *h* lead to opposite ends of the servomotor cylinder *i*. The piston valve 2 is recessed as shown at 2*a* for cooperation with the ports 4 or 5 and is operated by means of the control rod section *b*. The casing 10 is pivotally connected to the inner end of control rod section *c*. Adjustable stop screws 6 and 7, carried by the casing, serve to limit the piston travel.

The auxiliary control, diagrammatically illustrated in Fig. 1, operates in the following manner:

When the control lever *a* is moved in the direction indicated by the arrow, a force is transmitted through the rod section *b* to move the valve 2 to the left against the adjustable stop screw 6. This interconnects conduits *l* and *g* through the recessed ports 2*a* and 4, thereby subjecting the right hand side of piston *j* to fluid pressure. The other side of the piston is connected to the discharge through conduits *h* and *o*. As the piston *j* moves to the left under

the action of fluid pressure, it draws the control rod section *c* with it by means of the piston rod *k*, thereby moving the elevator *p* in an upward direction. As the control rod section *c* moves to the left, the valve casing 10, being pivotally connected thereto, is also moved to the left and if the control rod section *b* is held stationary, valve 2 will thereby lap ports *l* and *o*.

In the event of power failure, the manual effort applied to the lever *a* in the direction of the arrow, will move the elevator *p* in an upward direction since a linkage connection is formed by the lever *a*, control rod section *b*, valve 2, stop screw 6, casing 10 and control rod section *c*.

The area of piston *j* and the pressure of the fluid may be varied to exert any desired force, such as for example, a force less than that required to actuate the control surface *p* so that it will function merely as an assister.

In Fig. 3 is shown, diagrammatically, the preferred embodiment of this invention and consists of parts similar to that of Fig. 1. The control rod *a* carries, just below its fixed pivot, an externally threaded, rotatable sleeve *q* which co-operates with an internally threaded non-rotatable ring 12, shown in detail in Fig. 5. This ring is connected to the servomotor cylinder casing through the rod *r* which is pivoted at each end.

A control valve *e''* is interposed in the inlet and discharge conduits *l* and *o* and is interconnected with the conduits *g* and *h* by means of conduits *g''* and *h''* respectively. This valve serves to control the fluid passing through the valve *e* in accordance with certain conditions referred to hereinafter.

In Fig. 4, the control valve *e''* of Fig. 3, is shown in cross-section and consists of a casing 10'' firmly affixed in a vertical position to the fuselage of the airplane. The piston valve 2'' is provided on each side with annular recesses 14 and 16 formed between the smaller pistons 18 and 20 which are connected to the main piston 2'' through stems 22 and 24. Adjustable stops 6'' and 7'' are provided in each end of the casing. Normally the inlet conduit *l* is continuous through recess 14 while the discharge conduit *o* is continuous through recess 16. Conduits *g''* and *h''* interconnect with conduits *g* and *h* of the control valve *e* and are normally covered by the pistons 2'' and 18 respectively. The piston valve is pressed against the upper stop by means of a spring 9.

The connections between the threaded sleeve *q* and the servomotor casing are preferably formed in such a manner that the first movement of the lever *a* actuates the valve *e* to energize the servomotor.

The force exerted by the servomotor *i* through the pivoted rod *r* and ring 12 on the sleeve *q* is less than the total force required to actuate the control surface *p* and therefore only assists the operator in moving the rod *a* clockwise. This assisting force may be increased or decreased as the operator desires by rotating the sleeve *q* and thereby adjusting the ring 12.

Normally the operation of Fig. 19a is similar to that of Fig. 1. Recesses 14 and 16 in valve *e''* permit the flow of fluid to and from the valve *e* and servomotor *i* without interruption. When, however, the airplane is righted after a nose dive, the centrifugal acceleration which occurs, owing to the upward curvature of the flight path, will manifest itself in increased weight of all the

various parts. This weight, if unduly increased, may endanger the airplane structure.

The tension of spring 9 is so adjusted that excess centrifugal acceleration will force the valve piston 2'' downwards. In this new position, the inlet conduit *l* and the discharge conduit *o* will be closed off by the pistons 2'' and 20. By closing off the normal inlet and discharge conduits, the conduits *g''* and *h''* will be uncovered and the flow of fluid will then be through the conduit *l*, recess 14, conduit *h''* into the left-hand side of servomotor *i*. The discharge on the right-hand side of the cylinder will be through conduits *g*, *g''*, recess 16 and conduit *o*. This will cause the piston *j* to move to the right and through the piston rod *k* and control rod section *c* the elevator *p* will be moved in a clockwise direction, thereby reducing the upward path of the airplane. When this upward path has been modified so that centrifugal action no longer affects the piston valve, the spring 9 will push it up to its normal position thereby reestablishing the flow of fluid as in normal flight.

This auxiliary valve *e''* may be designed so that it can be made entirely ineffective in extreme emergency cases where the altitude of the airplane is insufficient to permit a safe path of acceleration.

It is obvious that the invention disclosed includes within its scope the actuation of other elements or objects aside from those mentioned herein, which require the use of auxiliary power for their operation.

While one illustrated embodiment of the invention has been described in detail, it is not my intention to limit its scope to that embodiment or otherwise than by the terms of the appended claims.

What is claimed is:

1. In an airplane having a controlled member, a controlling lever connected thereto for directly actuating the same, means including a servomotor having a connection with said controlled member for moving the latter by power, said servomotor having relatively movable elements, one element thereof connected to the controlled member for moving the latter in either of two directions, means connecting the other element to said controlling lever, an adjustable coupling forming a part of said connecting means, control mechanism for governing the energization of said servomotor, said mechanism including a movable device connected with said controlling lever whereby movement of the latter in opposite directions serves to energize said servomotor in opposite directions, and means responsive to centrifugal force developed in the airplane travelling in a curved path during a sudden recovery from a dive for changing the energization of said servomotor.

2. In an airplane having a controlled element, a controlling member, means including a power actuator having a connection with said controlled element for moving the latter by power, control mechanism for governing the energization of said power actuator, said mechanism comprising a pair of valves separate from each other, the first of which is cooperatively associated with the said controlling member for governing the energization of said power actuator, the second of which is cooperatively associated with said first valve and with said power actuator for energizing the power actuator independently of said first valve when the latter is in one position.

3. In an airplane having a controlled member,

a controlling member, means including a power actuator having a connection with said controlled member for moving the latter by power, control mechanism for governing the energization of said power actuator, said mechanism including a movable device connected with said controlling member whereby movement of the latter in opposite directions serves to energize said actuator in opposite directions, additional means separate from said mechanism cooperatively associated with said movable device and with said power actuator, said means including a member subjected to the action of centrifugal force developed in the airplane travelling in a curved path by a sudden recovery from a dive for changing the energization of said power actuator when said movable device is in one position.

4. In an airplane having a controlled member, a controlling lever connected thereto for directly actuating the same, means including a servomotor having a connection with said controlled member for moving the latter by power, said servomotor having relatively movable elements, one element thereof connected to the controlled member for moving the latter, the other element thereof connected to said controlling lever, control mechanism for governing the energization of said servomotor, said mechanism comprising a pair of valves, the first of which is cooperatively associated with the said controlling lever for gov-

erning the energization of said servomotor, the second of which is cooperatively associated with said first valve and with said servomotor for energizing the servomotor independently of said first valve when the latter is in one position.

5. In an airplane having a controlled element, a controlling lever connected thereto for directly actuating the same, means including a servomotor having a connection with said controlled element for moving the latter by power, control mechanism for governing the energization of said servomotor, said mechanism including a control valve connected with said controlling lever whereby movement of the latter in opposite directions serves to energize said servomotor in opposite directions, a pilot valve cooperatively associated with said control valve and with said servomotor, said pilot valve comprising a resiliently supported piston normally controlling the supply of pressure fluid to the control valve, said piston being responsive to the action of centrifugal force developed by the airplane travelling in a curved path in response to a sudden recovery from a dive for closing the flow of pressure fluid to said control valve and opening the flow of pressure fluid to said servomotor whereby the latter is energized independently of the control valve, when the control valve is in one position.

WALDEMAR VOIGT.