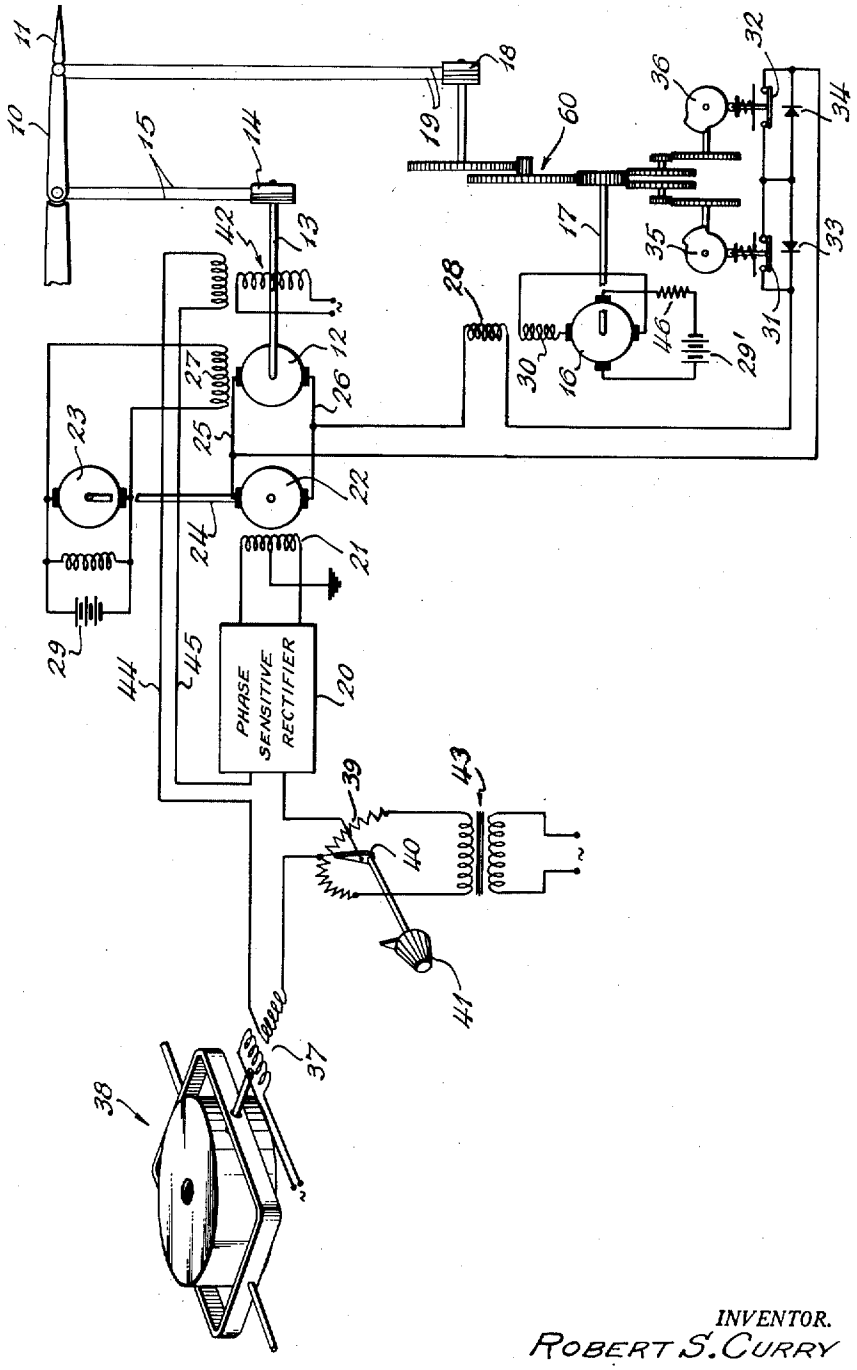
Feb. 8, 1955 R. S. CURRY, JR Re. 23,938

CONTROL SYSTEM FOR AIRCRAFT CONTROL SURFACE AND TAB

Original Filed April 9, 1947



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United States Patent Office

Re. 23,938
Reissued Feb. 8, 1955

23,938

CONTROL SYSTEM FOR AIRCRAFT CONTROL SURFACE AND TAB

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Original No. 2,568,719, dated September 25, 1951, Serial No. 740,417, April 9, 1947. Application for reissue September 20, 1952, Serial No. 310,743

12 Claims. (Cl. 244—82)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates generally to control systems and more particularly to automatic pilots for air-borne or other craft with a main operating surface and an auxiliary or trim tab operating surface.

Primarily, the object of the invention is to minimize any sustained cable loading on the control surfaces of the craft to permit the human pilot to assume control of the craft from the automatic pilot without undue exertion, and to secure a minimum resistance. While such systems have heretofore been used in connection with hydraulic servomotors, as shown in the prior patents to B. G. Carlson, 2,045,579 and 2,183,932, dated June 20, 1936, and December 19, 1937, respectively, my invention relates to an improved means for accomplishing the stated purpose in an electrical servo-system.

The motor controlling the primary surface furnishes the primary control of the craft, while the motor controlling the trim tab may be much smaller and in some types of aircraft is not needed, and also is somewhat intermittent in operation.

One object of the invention is to so design the motor circuits that the trim tab motor may be controlled from the same signal that the main motor is without disturbing the characteristics of the control of the main motor regardless of whether the trim tab motor is present or absent from the circuit. The Ward-Leonard type of control system has come into use for controlling servomotors on aircraft, one such system being shown in the patent to Halpert, Frische, Bird and Esval, No. 2,415,819, dated February 18, 1947, and in an application of Halpert, Serial No. 485,546, filed May 3, 1943, for Automatic Pilot Follow-up Control, now U. S. Patent No. 2,511,846, issued June 20, 1950. In such systems, if an extra variable load of appreciable size were placed on the current supply between the armatures of the generator and the main control motor, the control characteristics of the motor might be seriously affected. According to my invention, however, I reduce the current required for controlling the trim tab motor by furnishing an auxiliary, more or less constant current supply for the armature and only controlling the field thereof from the signal current supplied to the armature of the main motor.

In accordance with the present invention, an electric motor for the main surface and an electric motor for the tab surface are selectively operated from the same corrective signal. The motor connected to the main surface of the craft operates to correct short-time transient errors, such as caused by shifting gusts of wind on the craft and which are usually of fair magnitude. The motor connected to the tab surface operates to correct the craft for any sustained or long-period errors, such as caused by a permanent shift in loading of the craft and which are usually of lesser magnitude.

One of the features of the invention consists in utilizing two motors in a system of the Ward-Leonard type, controlling the motor for the main surface in more or less conventional manner by direct armature control but controlling a field of the other motor.

The invention also relates to the novel features or principles of the instrumentalities described herein, whether or not such are used for the stated objects, or in the stated fields or combinations.

Other features and structural details of the invention will be apparent from the following description when read in connection with the accompanying drawing, wherein the single view shown is a circuit diagram and schematic representation of the components of a control system or automatic pilot embodying the present inventive concepts.

With reference to the drawing, an aircraft is shown with a main control surface **10** and a trim tab control surface **11**. For exemplary purposes, the surface **10** may be considered to be the elevator of the craft. The automatic pilot represented in the drawing is consequently effective to control the craft in pitch about its athwartship axis by operation of the main and trim tab surfaces **10** and **11**.

As shown, the main surface **10** is moved by means of an electric motor **12** operatively connected thereto by way of shaft **13**, cable drum **14** and cable **15**. The trim tab **11** is moved by means of a second and much smaller electric motor **16** that is operatively connected to the surface by shaft **17**, drum **18** and cable **19** through a much larger reduction gear **60** than between motor **12** and drum **14**. In the type of automatic pilot system illustrated, the output of a phase sensitive rectifier indicated generally at **20**, which may be of the type shown in Fig. 2 of U. S. Patent No. 2,511,846, by Percy Halpert, is fed the field winding **21** of a generator **22**. The armature of generator **22** is driven at a constant speed by means of motor **23** which is connected thereto by shaft **24**. Generator **22** provides a signal voltage that is fed to the armature of the direct current motor **12** by way of leads **25** and **26** as is common in the Ward-Leonard system of motor control. Motor **12** turns an amount corresponding to the amplitude or magnitude of the alternating current input signal to the amplifier **20** and in a direction corresponding to the phase of the input signal. The field winding **27** of motor **12** is constantly excited by any source of direct current, shown as a battery **29**.

Generator **22** may be considered to provide a means for producing a control signal for motors **12** and **16**. The armature of motor **12**, leads **25** and **26** and the armature of the generator **22** form a control circuit. As shown, motor **16** has a field winding **28** situated in a second circuit connected in parallel across the leads **25** and **26** of the first circuit. Both motors **12** and **16** are located in a circuit that includes the signal producing means, the armature of first motor **12** and the field winding **28** of second motor **16**. The armature of motor **16** is constantly excited by means such as battery **29'**. A second field winding **30** may provide a means for damping and limiting the speed of operation of motor **16** as shown and claimed in my copending application Serial No. 680,352, filed June 29, 1946, for Servomotors, now U. S. Patent No. 2,474,830, issued July 5, 1949. A series resistor **46** is provided to maintain a constant armature current for motor **16**.

The parallel circuit including field winding **28** has two branches, each of which is shown to include a switch and a selenium type rectifier. The pair of switches and rectifiers are indicated respectively at **31**, **32** and **33**, **34**. Limit switches **31** and **32** are opened by cams **35** and **36** respectively, which are connected through suitable gearing, as indicated, to the shaft **17**. The switches are operated by the cams to open the circuit and thereby limit the range of operation of motor **16**, so that tab **11** is confined to movement within a predetermined angle above and below a null position.

The rectifiers **33** and **34** are used to block current flow in the proper sense to prevent motor **16** from rotating beyond the limit point but will permit operation in the reverse direction to return the system to the null position. The field circuit including the trim tab operating motor **16** is designed to draw about 5% of the power output of the generator **22** under maximum signal conditions. Motor **16** is further designed to operate at a lower voltage than motor **12**. The relation between the respective motors, other controls and the control surfaces is such that the main motor **12** functions to correct the craft for short-time transient errors and the auxiliary motor **16** functions to correct the craft for sustained or long-period errors. In other words, motor **16** will operate to cause a displacement of tab **11**, on receipt of a small continuing signal whereas, for that same voltage the motor **12** would not respond. As such a signal is of the sort resulting from

an out of trim condition causing long period errors, motor **16** or more precisely trim tab **11** may be said to be responsive to long period errors, to which result the reduction gearing **60** contributes. The motor **12**, on the other hand, requiring a much larger signal to operate, i. e., a signal of the type produced by gusts, etc., is quickly responsive to such short time or transient errors so that control surface **10**, having little or no reduction gearing between it and the motor **12**, is likewise quickly responsive to such errors so as to right the craft quickly.

In an automatic pilot with a dual motor control system, the corrective input to rectifier **20** may be obtained from a pickoff **37** at the pitch axis of gyro vertical **38**. The input may also be obtained from a potentiometer **39** with a movable arm **40** settable by manually positioned knob **41** to cause the craft to change elevation. A further input signal may be obtained from a pickoff **42** providing a signal in accordance with the displacement or angular position of shaft **13** or surface **10** from a null position. Pickoffs **37** and **42** may be signal generators of the Selsyn type. As shown, the rotor of pickoff **37** is operatively connected to the rotor case of the gyro vertical **38** to be stabilized thereby. The rotor of Selsyn **42** is adapted to move with movement of shaft **13** or the surface **10**. Center tapped potentiometer **39** is energized from a suitable source by way of transformer **43**. The output of the stator of pickoff **42** provides a displacement repeatback signal that may be fed to amplifier **20** by way of leads **44**, **45** in opposition to the signal input from either pickoff **37** or potentiometer **39** or both. In the described type of automatic pilot, when the signal from pickoff **42** balances the inputs from the other sources, the system attains equilibrium with a net zero input to the rectifier **20**. Otherwise, the rectifier **20** provides an output to the generator **22** which results in operation of either or both of motors **12**, **16** to cause the craft to move about its athwartship axis to a position obviating the errors.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an automatic pilot for aircraft with a main control surface and a trim tab control surface, a first electric motor operatively connected to the main control surface, said first motor having an armature and a constantly excited field, a second electric motor operatively connected to the trim tab control surface, said second motor having a field and a constantly energized armature, means for producing a control signal for said motors, and a circuit having said signal producing means therein including the armature of said first motor and the field of said second motor.

2. In an automatic pilot for aircraft with a main control surface and a trim tab control surface, a first electric motor operatively connected to the main control surface, said first motor having an armature and a constantly excited field, means for producing a control signal for said first motor, a first circuit including said signal producing means and the armature of said first motor, a second electric motor operatively connected to the trim tab control surface, said second motor having a field and a constantly energized armature, and a second circuit including the field of said second motor connected in parallel to said first circuit.

3. An automatic pilot as claimed in claim 2, in which said second circuit further includes a pair of switches operated by said trim tab to open the circuit and thereby limit the range of movement of the trim tab.

4. In a control system of the Ward-Leonard type, the combination of, a first electric motor having an armature and a separately excited field, a second electric motor having a field and a separately energized armature, a generator for producing a control signal for both said motors, and a circuit having said signal producing means therein including the armature of said first motor and the field of said second motor.

5. In a control system, the combination of, a first electric motor having an armature and a constantly excited field, means for producing a control signal for said first motor, a first circuit including said signal producing means

and the armature of said first motor, a second electric motor having a field and a constantly energized armature, and a second circuit including the field of said second motor connected in parallel to said first circuit.

[6. In an automatic pilot for aircraft with a main control surface and a trim tab control surface, means for producing relatively large control signals corresponding to short period aircraft attitude errors and relatively small control signals corresponding to long period aircraft attitude errors, a circuit including said signal means and a first electric motor connected to the main control surface responsive to the short period signals of said signal means, and a second circuit connected in parallel to said first circuit including a second electric motor connected to the trim tab control surface responsive to the long period signals of said signal means.]

[7. An automatic pilot as claimed in claim 6, in which said second circuit further includes a pair of switches operated by said trim tab to open the circuit and thereby limit the range of operation of said second motor.]

8. In an automatic pilot for aircraft, subject to long and short period errors of both relatively large and small magnitude, and having a main control surface provided with a trim tab, means for measuring such errors including an electrical signal generator, a circuit including said generator and an electric motor connected to said main control surface so constructed as to move said surface in response to signals of said generator if relatively large although of short period, and a second circuit connected to said first circuit including a second electric motor connected to said trim tab so constructed as to slowly move said trim tab in response to signals of said generator if of relatively long period although of relatively small magnitude.

9. An automatic pilot as claimed in claim 8, in which said second circuit further includes a pair of switches operated by said trim tab to open the circuit and thereby limit the range of operation of said second motor.

10. In an automatic pilot for aircraft, subject to long and short period errors of both relatively large and small magnitude, and having a main control surface provided with a trim tab, means for measuring such errors including an electrical signal generator, a circuit including said generator and an electric motor connected to said main control surface so constructed as to move said surface in response to signals of said generator if relatively large although of short period, and a second circuit connected to said first circuit including a second electric motor and relatively high reduction gearing connecting said second motor and said trim tab, said second motor and gearing being so constructed as to slowly move said trim tab in response to signals of said generator if of relatively long period although of relatively small magnitude.

11. In an automatic pilot for aircraft, subject to long and short period errors of both relatively large and small magnitude, and having a main control surface provided with a trim tab, means for measuring such errors including an electrical signal generator, electrical means for providing a repeatback signal in accordance with a measure of the displacement of the main control surface from a null position, a circuit including said generator, said repeatback signal means and an electric motor connected to said main control surface so constructed as to move said surface in response to the combined signals of said generator and said repeatback signal means if relatively large although of short period, and a second circuit connected to said first circuit including a second electric motor and relatively high reduction gearing connecting said second motor and said trim tab, said second motor and gearing being so constructed as to slowly move said trim tab in response to the combined signals of said generator and said repeatback signal means if of relatively long period although of relatively small magnitude.

12. In an automatic pilot system having primary and secondary control surfaces for any one of the three axes of attitude control of an aircraft, the combination comprising means for developing a signal voltage upon deviation of the craft from a desired flight attitude, a servomotor operable in response to said signal voltage to move the primary control surface to reestablish the desired flight attitude, means for developing a displacement signal upon operation of said servomotor opposing said signal voltage, said servomotor in response to both signals delivering the required torque to position and maintain in position said primary surface, and a second servomotor

connected with said first motor to position said secondary surface in accordance with the torque requirements of said first motor.

13. In an automatic pilot for aircraft having a main control surface and a trim tab control surface, a first electric motor operatively connected to the main control surface, said first motor having an armature and a constantly excited field, a second electric motor operatively connected to the trim tab control surface, said second motor having a first field, a constantly excited armature and main and quadrature brushes, means for producing a control signal for said motors, a circuit having said signal producing means therein including the armature of said first motor and the field of said second motor, and an opposing second field on said second motor excited from said quadrature brushes.

14. In an electrical control system of the Ward-Leonard type, the combination of, a first electric motor having an armature and a separately excited field, a second electric motor having a first field and a separately excited armature, a generator for producing a control

signal for both said motors, a circuit having said signal producing means therein including the armature of said first motor and said field of said second motor, and a second opposing field for said second motor connected to auxiliary or quadrature brushes on the second motor armature.

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