June 14, 1960 H. W. PATTON 2,941,193

AUTOPILOT MONITOR SYSTEM

Filed July 16, 1956

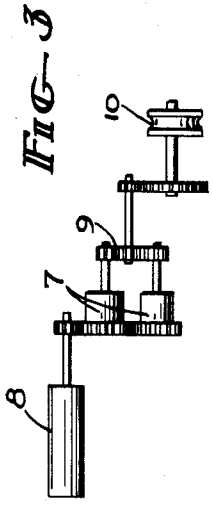


FIG. 3

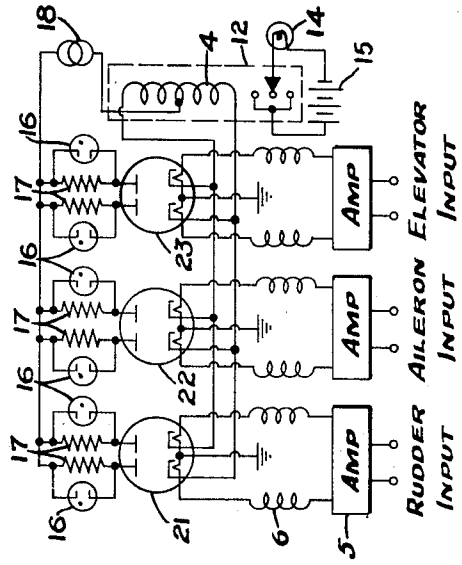


FIG. 2

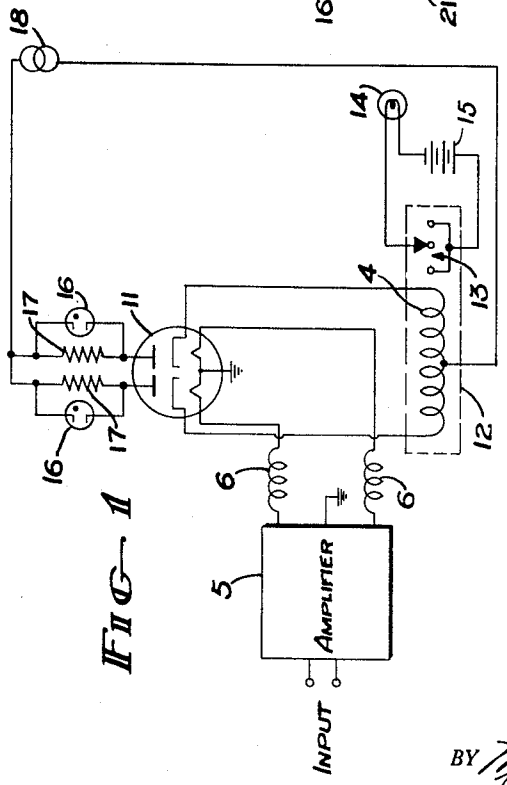


FIG. 1

INVENTOR.
HENRY W. PATTON
BY Moody and Hasler
ATTORNEYS

United States Patent Office 2,941,193
Patented June 14, 1960

2,941,193

AUTOPILOT MONITOR SYSTEM

Henry W. Patton, Cedar Rapids, Iowa, assignor to Collins Radio Company, Cedar Rapids, Iowa, a corporation of Iowa

Filed July 16, 1956, Ser. No. 597,955

3 Claims. (Cl. 340—248)

This invention relates to alarm circuits, and more particularly to an electronic alarm circuit for adaptation with automatic pilot systems.

Automatic pilot systems normally utilize a servo driving mechanism for driving a capstan with control cables wound on the capstan. A continuously running constant speed motor turns two variable clutches. The output from the clutches is coupled by a gear train to the capstan. The constant speed motor normally turns in only one direction, with the clutches controlling the capstan so that the capstan rotates in either direction. The control for rotation of the capstan results when a greater current passes through one clutch than through the other clutch. This current produces a directional torque with the greater torque being applied to the capstan by the clutch with the greater current flowing through it. In an aircraft automatic pilot system a malfunction in the control unit or in the operation of these clutches can result in tragic consequences to the aircraft. This invention provides an alarm circuit which will indicate malfunctioning in the circuit used to control the capstan, yet be relatively insensitive to normal maneuvering.

This invention provides an alarm circuit which will be actuated when the current flowing in one of the two clutches is of a predetermined value for a specified time interval. This current may be in one direction only, due to a large sustained signal, or it may result from a sustained differential signal, causing differences in the currents in the related clutches. These current differences cause the alarm system of this invention to operate.

This invention also provides for normal increase in the average current flow through the clutches, which occurs when there is an increase in the roughness of the weather.

This invention also provides for large momentary command signals which will cause large currents to flow momentarily but will not necessarily of themselves operate the alarm circuit. The alarm circuit of this invention will operate only with a large and relatively prolonged command voltage or current being applied in a single direction.

It is a feature of this invention that the currents flowing through the clutch coils determine the functioning of the alarm circuit. It is a further feature of this invention that only true malfunctioning of the automatic pilot system will operate the alarm circuit, while full clutch currents of a transient nature will not actuate the alarm.

It is an object of this invention to provide an alarm circuit for use in an automatic pilot system which will be responsive to malfunctionings of the automatic pilot system. It is a further object of this invention to provide an alarm circuit where the currents in two clutches are compared and where only a predetermined differential effect for a predetermined length of time will operate the alarm circuit. It is a still further object of this invention to provide an alarm circuit which does not respond to the current flow in the clutch coils caused by strong or large command signals when these signals are of normal

duration. It is another object of this invention to provide an economical alarm circuit for use with automatic pilot systems which may be combined to permit independent operation of any single axis alarm without interfering with the alarms and operations associated with the remaining axes.

These and other objects of this invention will become apparent when the following description is read in conjunction with the drawings, in which

Figure 1 is a schematic diagram of one embodiment of this invention;

Figure 2 is a schematic diagram of this invention as applied to a three-axis control system; and

Figure 3 is a view of one embodiment of a clutch mechanism and gearing used to control the rotation of the capstan.

Referring now to Figure 3, the continuously running motor **8** turns the gears connected to the clutches **7**. The currents flowing through the coils in the clutches **7** determine the direction of rotation and the velocity of rotation of the gear **9**. Gear **9** then rotates capstan **10** in conformity with the signals from the clutches **7**. Rotation of the capstan **10** provides the final mechanical control signals which are delivered to the various airplane controls, such as the elevator, aileron, and rudder.

Figure 1 is a detailed schematic of one embodiment of this invention. The control signals are generated and fed to amplifier **5** as input signals. These input signals are amplified in amplifier **5** and then applied to the coils **6** of the clutches **7**. The signals fed to the clutch coils will cause a current to flow in one of the coils **6** through one half of the filament of tube **11** to ground. Tube **11** is depicted as a double diode which may be replaced by two individual diodes. If an excessively large amount of current flows through either of the clutch coils **6** for an extended period of time, one half of the filament of tube **11** will heat to the emissive point and will cause conduction in this half of the tube. Whenever conduction occurs on either side of tube **11**, a current flows through the coil **4** of neutral center differential relay **12**. This current will actually flow through one half of coil **4** of the relay **12** for each clutch action, i.e., right or left or up or down. The current results from the application of the alternating current voltage from source **18** to the plate circuit of tube **11** which may include gas-filled tubes **16** and parallel connected resistors **17**. When a differential or net magnetic pull is created by currents flowing in either side of relay **12**, the contact arm will close the contacts **13** thereby initiating an alarm. The contacts and contact arm are designated by the numeral **13** in Figure 1. The swinging of the contact arm will operate the alarm through the indicator **14** from the power source **15**.

During normal flight in smooth air the clutch currents flowing through the filament halves are approximately equal and are normally small. Consequently, there is little or no heating of the filament and little tube conduction occurs which would cause operation of the alarm circuitry. In rough air, false operation of the alarm circuit is prevented by the combination of the inverse thermal time delay action of the tube filaments and the differential action of relay **12**. While larger average clutch command signals will cause greater current flow through the filament halves, the heating effect averaged over several seconds tends to equalize. This equalization means that the same heating occurs in both filaments, which results in equal plate currents through the tube halves. With equal plate currents through the tube halves no differential action of coil **4** of relay **12** will occur, and undesired tripping of the alarm is prevented.

Figure 2 indicates a system for connecting a combina-

tion of three of the control circuits of this invention together with one alarm indicator, and applying them to a single three-axis automatic pilot system. The clutch signals are applied to and operate on each of the tubes **21**, **22**, and **23** exactly as they operated on tube **11** in the above description. One of the tubes, **21**, is rudder controlled; another tube, **22**, is for the aileron control circuit; and the last tube, **23**, is for the elevator control circuit. It is to be noted that the alarm circuit is connected to the cathodes of all three tubes so that one alarm circuit may show faults in any of the chosen command circuits.

The gaseous tubes **16** are optional, and are used in the plate circuits of the tubes **11** paralleled by the load resistors **17** to provide quick or snap action when the current flow in the plate circuit attains a certain value of potential. This results in a sudden increase of currents in the cathode circuit due to the conduction of the tubes **11**. This increase in current flow beyond the danger point reduces the hesitation and false operation of differential relay **12**. Thus, when the command signal is clearly erroneous, the ionization of tube **16** permits the quick sounding of the alarm circuit of this invention.

Although this invention has been described with respect to a particular embodiment thereof, it is not to be so limited, as changes and modifications may be made therein which are within the full intended scope of the invention as defined by the appended claims.

What is claimed is:

1. In an aircraft autopilot system of the type including directional control signals, an amplifier for amplifying said control signals and clutch means including clutch driving coils and monitor means for controlling the output from a drive motor which positions the flight surfaces of said aircraft in response to said control signals; a malfunction monitoring system comprising electron discharge means including at least two plates, two cathodes and two heater elements, each of said clutch driving coils individually serially connected through one of said heater elements to said control signals, a differential current-sensing means, said cathodes connected to opposite ends of said differential current-sensing means, a source of electromotive force having one side connected to said plates and the other side connected to the center of said current-sensing means, switch means responsive to differential current flow in said differential current-sensing means, an alarm device and a source of power connected to said alarm device by said switching means when a differential current flows in said differential current-sensing means.

2. In an aircraft autopilot system of the type including directional control signals, an amplifier for amplifying said control signals, and clutch means including clutch driving coils and monitor means for controlling the output from a drive motor which positions the flight surfaces of said aircraft in response to said control signals; a malfunction monitoring system comprising an electron discharge device having at least two plates, two cathodes and two heater elements, said driving coils individually serially connected through said heater elements to said control signals, a differential current-sensing means comprising a center-tapped coil, said cathodes connected to opposite ends of said differential current-sensing means, a source of electromotive force having one side connected to said plates and the other side connected to the center tap of said coil, switch means responsive to differential current flow in said differential current-sensing means, an alarm device and a source of power connected to said alarm device by said switching means for providing warning signals when a differential current flows in said differential current-sensing means sufficient of value to actuate said switch means.

3. In an aircraft autopilot system of the type including directional control signals, an amplifier for amplifying said control signals, and clutch means including clutch driving coils and monitor means for controlling the output from a motor means which controls the flight of said aircraft in response to said control signals; a malfunction monitoring system comprising an electron discharge device having at least two plates, two cathodes and two heater elements, said clutch driving coils individually serially connected through said heater elements to said control signals, a differential current-sensing means comprising a center-tapped coil, said cathodes connected to opposite ends of said differential current-sensing means, a source of electromotive force having one side connected to each of said plates through identical circuits comprising a resistance and a gas-filled electron discharge device connected in parallel, switch means responsive to a predetermined value of differential current flow in said differential current-sensing means, an alarm device and a source of power connected to said alarm device by said switching means for providing warning signals when a prescribed differential current is flowing in said differential current-sensing means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,662,207	Hollister	Dec. 8, 1953

FOREIGN PATENTS

671,912	Great Britain	May 14, 1952