

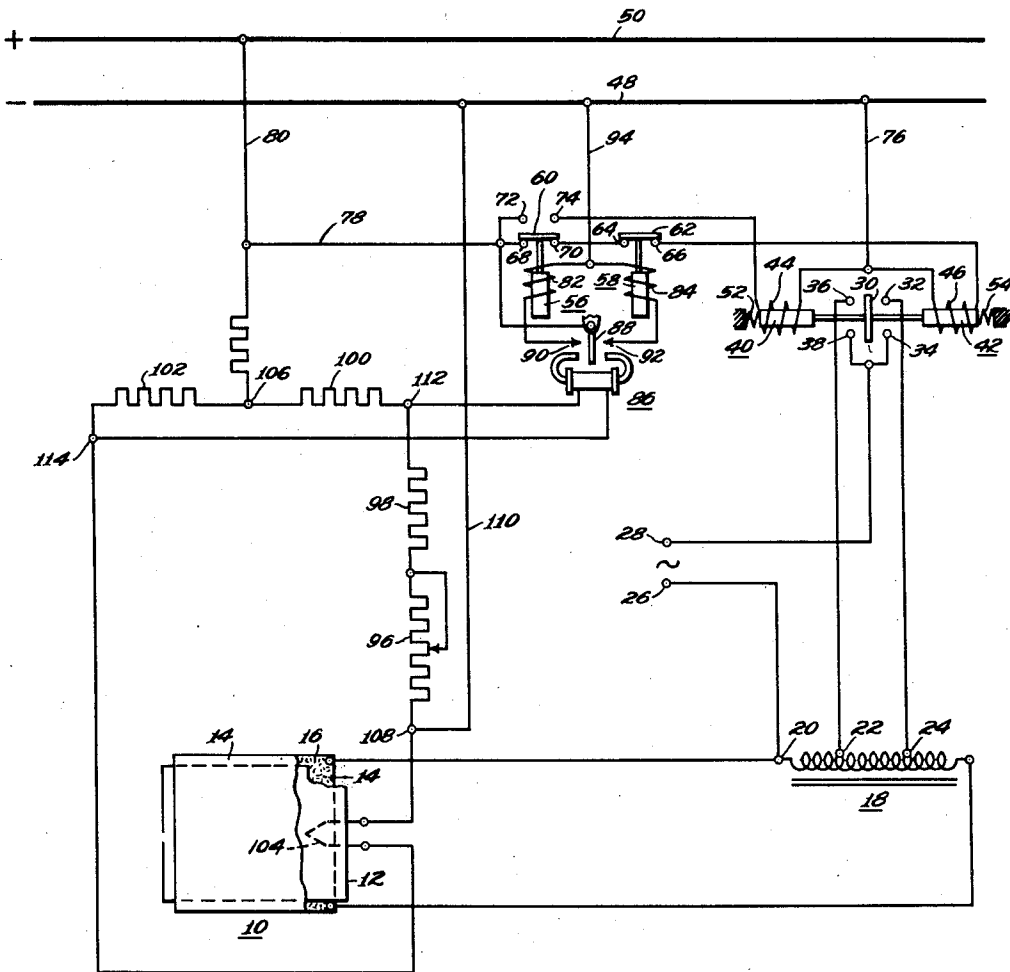
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TEMPERATURE CONTROL SYSTEM

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TEMPERATURE CONTROL SYSTEM

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This invention relates to control systems, and in particular to temperature control systems for preventing the frosting of windows.

Heretofore, the problem of preventing the formation of ice and fog on aircraft windows has always presented difficulties. Recently a window glass manufacturer has produced a window pane formed of laminated sections of plastic and glass in which the surface of one or more panes of glass is coated with a transparent conducting material which, when connected in a suitable electrical circuit, will act as a resistor and dissipate heat within the window.

Systems have been developed for controlling the temperature of, and thereby preventing the formation of ice and fog on, aircraft windows. Such systems are shown in my copending application, Serial No. 750,904 filed May 28, 1947, now Patent No. 2,462,207, issued February 22, 1949, and applications, Serial No. 794,525, now Patent No. 2,465,312, issued March 22, 1949, and Serial No. 794,527, both of which were filed simultaneously with this application.

In practice, the size and configuration of most aircraft windows makes it necessary to use voltages of 300 and higher in order to dissipate sufficient energy for satisfactory window heating under all conditions. In many of the airplane designs it is found that only 120 volt, 400 cycle inverters are available as a power source for heating the windows with the result that difficulty has been encountered in producing satisfactory heating of the windows.

An object of this invention is to provide for controlling the temperature of a window exposed to various weather conditions.

Another object of this invention is to provide in a system for heating a window for controlling the input to the window heater in accordance with changes in temperature of the window from a predetermined temperature.

A more specific object of this invention is to provide a system for heating a window to selectively control the connections of a transformer which supplies a window heater, the selective control being in accordance with changes in temperature of the window from a predetermined temperature.

Other objects of this invention will become apparent from the following description when taken in conjunction with the accompanying drawing, the single figure of which is a diagrammatic view of apparatus and circuits involving the teachings of this invention.

Referring to the drawing, this invention is illus-

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trated by reference to a system for controlling the temperature of a window pane 10. The window pane 10 in this instance is formed of a layer of plastic 12 sandwiched between two layers of glass 14, one layer of glass having a coating 16 formed of a conductive material which will function as a resistor element therebetween. Such a window pane 10 is more fully described in Technical Glass Bulletin No. 15 of the Pittsburgh Plate Glass Company of Pittsburgh, Pa. The composition of layers 12, 14 and 16 may be of many different materials so long as the combination acts as a transparent window pane and the conductive layer 16 functions as a resistor element in the combination.

In order to supply current to the layer 16 of conductive material to effectively heat the window pane 10, the layer 16 is connected across the secondary windings of an auto-transformer 18, the primary windings of which are provided with taps 20, 22 and 24 disposed to be selectively connected through terminals 26 and 28 to a suitable source of power supply such as an inverter (not shown).

In order to control the connections of the primary windings of the transformer 18 to the source represented by the terminals 26 and 28 to control the current supplied to the layer 16, a switching contact member 30 is disposed to be selectively actuated to any one of three positions, such as the neutral, open circuit position illustrated, or to the right to bridge fixed contact members 32 and 34 or to the left to bridge fixed contact members 36 and 38. The switching contact member 30 is disposed to connect the taps 20 and 24 of the primary windings of the transformer 18 to the source of supply when actuated to the right to bridge the contact members 32 and 34, and when actuated to the left, to bridge contact members 36 and 38 to connect the primary windings of transformer 18 connected between the terminals 20 and 22 to the source of the power supply.

The switching contact member 30 is common to two electromagnets 40 and 42 being disposed to be selectively actuated as the windings 44 and 46 are selectively energized from a source of power supply represented by the conductors 48 and 50. As illustrated, the electromagnets 40 and 42 are disposed so that when energized, movement of the solenoids thereof is opposed by spring members 52 and 54, respectively. When the windings 44 and 46 are deenergized, the switching contact member 30 is maintained in the neutral position under the biasing forces of the springs 52 and 54.

In order to selectively control the energization of the windings 44 and 46 of the electromagnets

40 and 42, respectively, a pair of contactors 56 and 58 having contact members 60 and 62, respectively, are disposed for operation to control the connection of the windings 44 and 46 to the supply conductor 50. As illustrated, the contact member 62 of the contactor 58 is disposed to bridge fixed contact members 64 and 66, respectively, when deenergized, whereas the contact member 60 of the contactor 56 is disposed to bridge fixed contact members 68 and 70 in the deenergized position and fixed contact members 72 and 74 in the energized position. Thus with the contactors 56 and 58 deenergized, the contact members 60 and 62 establish a circuit extending from conductor 48 through conductor 76, energizing winding 46 of the electromagnet 42, contact members 66, 62 and 64, 70, 60 and 68 and conductors 78 and 80 to the supply conductor 50 to energize the winding 46.

On the other hand, if the contactor 56 is energized to interrupt the circuit just described, the contact member 60 bridges the contact members 72 and 74 to establish a circuit extending from supply conductor 48 through conductor 76, energizing winding 44 of the electromagnet 40, contact members 74, 60 and 72 and conductors 78 and 80 to the supply conductor 50 to effect energization of the electromagnet 40 and actuate the switching contact member 30 to the left to bridge contact members 36 and 38.

In order to selectively control the energization of the energizing windings 82 and 84 of the contactors 56 and 58, respectively, a polarized relay 86 is disposed to be energized depending upon the temperature of the window pane 10. Thus the polarized relay 86 is provided with a movable armature contact member 88 disposed to be selectively actuated to engage fixed contact member 90 or 92, depending upon the direction of energization of the polarized relay 86. As illustrated, the armature contact member 88 is disposed when actuated to the left to establish a circuit extending from the supply conductor 48, through conductor 94, energizing winding 82 of the contactor 56, contact members 90 and 88 of the polarized relay 86 and conductors 78 and 80 to the supply conductor 50 to effect energization of the contactor 56. Likewise, if the armature contact arm 88 of the polarized relay 86 is actuated to the right to engage contact member 92, it establishes a circuit extending from supply conductor 48, through conductor 94, energizing winding 84 of the contactor 58, contact member 92, armature contact member 88 and conductors 78 and 80 to the supply conductor 50 to effect energization of the winding 84 to actuate contact member 62 of the contactor 58 to an open circuit position.

As illustrated, the polarized relay 86 is disposed to be directly energized in accordance with the unbalance condition of a resistance bridge formed of resistors 96, 98, 100, 102 and 104. As illustrated, the resistors 96, 98 and 100 comprise one leg of the resistor bridge, resistors 102 and 104 forming the other leg, the two legs being connected at their intermediate points 106 and 108 by conductors 80 and 110 to conductors 50 and 48, respectively. As illustrated, the energizing winding of the polarized relay 86 is connected to intermediate taps 112 and 114 in the legs of the resistance bridge.

In this embodiment the resistor 104 is formed of any material having a high temperature coefficient of resistance such as nickel wire, the resistor being represented as being disposed closely adjacent to the window pane 10 and where

possible, embedded in the plastic layer 12 of the window so that the resistance of the resistor 104 will vary directly as the temperature of the window pane 10 varies from a predetermined temperature which is to be maintained. On the other hand, the resistors 96, 98, 100 and 102 are preferably formed of a material having a low temperature coefficient of resistance, such as Advance, the resistor 102 also preferably being positioned so that the leads to the resistors 102 and 104 will be approximately equal to eliminate errors in resistance within the bridge itself. The resistance bridge can be initially balanced by adjusting the resistor 96.

In operation, assuming that the bridge has been properly balanced to maintain a predetermined temperature within the window, the polarized relay 86 is in the deenergized position as illustrated. Under such conditions the energizing winding 46 of the electromagnet 42 is energized to actuate the contact member 30 associated with the electromagnets 40 and 42 toward the right to bridge the contact members 32 and 34 and connect the primary windings between the taps 20 and 24 of the transformer 18 to the source of power supply to supply sufficient current to the conductive layer 16 to maintain the bridge in the balanced condition referred to.

If during flying conditions the temperature of the window pane 10 should decrease from the predetermined temperature which it is desired to maintain requiring more heat to dissipate the frost, etc., from the window pane, then the resistance of the resistor 104 decreases in accordance with the temperature decrease with the result that the bridge is unbalanced. Under such conditions the polarity of the mid terminal 114 of the resistance bridge becomes more positive with respect to the polarity of the mid terminal 112 and current flows from the mid terminal 114, through the winding of the polarized relay 86 to the mid terminal 112.

When the winding of the polarized relay 86 is thus energized, the armature contact member 88 thereof is moved to the left to engage the fixed contact member 90 and thereby establish the circuit for energizing the winding 82 of the contactor 56. When the contactor 56 is thus energized the contact member 60 is actuated to interrupt the energizing circuit to the energizing winding 46 of electromagnet 42 and to a position to engage contact members 72 and 74 to establish the energizing circuit for the energizing winding 44 of the electromagnet 40. When the energizing winding 46 of electromagnet 42 is thus deenergized and the energizing winding 44 of electromagnet 40 is thus energized, the contact member 30 is actuated to the left to disconnect the tap 24 from the source of supply and to engage the contact members 36 and 38 to connect the tap 22 of the primary windings of transformer 18 to the source of supply to thereby increase the flow of current to the conductive layer 16 of the window pane to effect an increase in the temperature of the window pane 10.

If on the other hand the temperature of the window pane 10 should increase, as, for example, where the airplane is stationed on the ground, then the resistance of resistor 104 increases in accordance with the increase in temperature whereby the polarity of the mid terminal 112 becomes more positive with respect to the potential of the mid terminal 114 and current flows through the winding of the polarized relay 86 in a direction to actuate the armature contact mem-

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ber 88 to the right to engage fixed contact member 92 to establish the energizing circuit for the winding 84 of contactor 58. Under such conditions, the contact member 62 of contactor 58 is actuated to an open circuit position and since contactor 56 is deenergized, the windings 46 and 44, respectively, of the electromagnets 42 and 40, respectively, will be deenergized whereby the switching contact member 30 will be maintained in the neutral position shown to disconnect the primary windings of the transformer 18 from the source of power supply and thereby prevent current from flowing through the conductive layer 16 of the window pane.

The system of this invention is very sensitive and has the advantage that any available power supply on an airplane may be used for supplying voltage to the window heaters in that by using the proper relation between the primary and secondary windings of the auto-transformer a suitable high voltage can be obtained. The components of the system are of standard apparatus and the system is economical and can be readily duplicated.

I claim as my invention:

1. In a system for controlling the temperature of a window having a resistor heating element associated therewith, in combination, a transformer disposed to be connected in circuit between the resistor heating element and a source of supply, a tap changing means including a pair of windings disposed to be selectively energized to control the connections of the transformer in said circuit, a pair of contactors disposed to be selectively energized, one of the contactors being disposed when energized to connect one of the windings to be energized, the other one of the contactors being disposed when energized to effect the deenergization of the other one of the windings, said pair of contactors cooperating when deenergized to connect said other one of the windings to be energized, a polarized relay disposed for operation to control the selective energization of the contactors, and a resistance bridge circuit having a resistor associated with the window whereby the resistance thereof varies as the temperature of the window varies, the polarized relay being connected across the resistance bridge cir-

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cuit to be energized in accordance with the electrical unbalance thereof.

2. In a system for controlling the temperature of a window having a resistor heating element associated therewith, in combination, a transformer having a plurality of taps disposed to be connected in circuit between the resistor heating element and a source of supply, a contact member disposed for reciprocating movement to control the connections of the tapped transformer in said circuit, a pair of opposed windings disposed to be selectively energized to control the reciprocating movement of the contact member, means for maintaining the reciprocating contact member in a neutral circuit opening position when the opposed windings are deenergized, a pair of contactors disposed to be selectively energized, one of the contactors being disposed when energized to connect one of the windings to be energized, the other one of the contactors being disposed when energized to effect the deenergization of the other one of the windings, said pair of contactors cooperating when deenergized to connect said other one of the windings to be energized, a polarized relay disposed for operation to control the selective energization of the contactors, and a resistance bridge circuit having a resistor associated with the window whereby the resistance thereof varies as the temperature of the window varies, the polarized relay being connected across the resistance bridge circuit to be energized in accordance with the electrical unbalance thereof.

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