

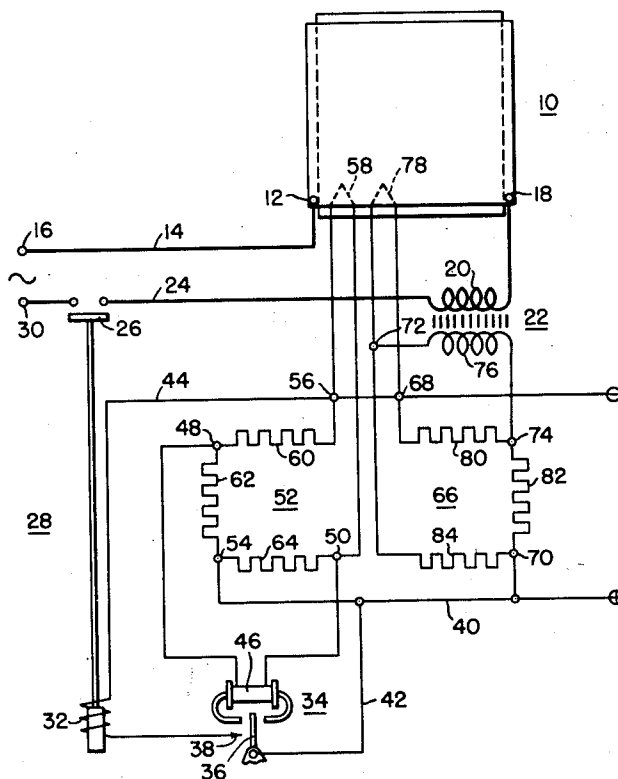
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TEMPERATURE REGULATING SYSTEM

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TEMPERATURE REGULATING SYSTEM

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This invention relates to regulating systems, and in particular to systems for regulating and controlling the temperature of windows for aircraft. This application is related to Serial No. 160,612, filed May 8, 1950, which has the same inventor and assignee as the present application.

An object of this invention is to provide in a regulating system for controlling the temperature of a window exposed to various weather conditions, for obtaining a variable heating of the window to a predetermined temperature, the heating effect increasing as the window temperature approaches a predetermined temperature to be maintained.

Another object of this invention is to provide in a regulating system for controlling the temperature of a window exposed to various weather conditions, for controlling the reactance of a saturable reactor in the power circuit to the heating element for the window in accordance with the temperature of the window and thereby effect an increase in the heating effect as the window temperature increases towards a predetermined temperature which is to be maintained.

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 involved in teachings of this invention.

Referring to the drawing, this invention is illustrated by reference to a system for controlling the temperature of a window pane 10. The window pane 10 is of a well known sandwich type having the heating element (not shown) imbedded therein disposed to be energized for effectively heating the window pane. Such window panes are illustrated in my Patent No. 2,462,207, issued February 22, 1949, and are more fully described in Technical Glass Bulletin No. 15 of the Pittsburgh Plate Glass Company of Pittsburgh, Pennsylvania.

In order to supply current to the heating element (not shown) of the window pane 10, a terminal 12 of the heating element is connected as by a conductor 14 to a terminal 16 of a source of power (not shown), another terminal 18 of the heating element being disposed to be connected through the alternating current windings 20 of a saturable reactor 22, conductor 24, and a contact member 26 of a contactor 28 to the other terminal 30 of a source (not shown) of alternating current supply. The contactor 28 is also provided with an energizing winding 32 which is disposed to be energized to control the

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operation of the contactor 28 to and from a circuit closing position.

In order to control the energization of the winding 32 of the contactor 28, a polarized relay 34 is provided having a pivoted armature contact member 36 disposed to be operated into and out of engagement with a fixed contact member 38 for establishing an energizing circuit for the winding 32. This energizing circuit extends from one terminal represented by the positive symbol of a source of direct current power, through conductors 40 and 42, the armature contact member 36 of the polarized relay 34, fixed contact member 38, the energizing winding 32, and conductor 44 to the other terminal represented by the negative symbol of the direct current source of supply. The polarized relay 34 is of the usual construction, being provided with an energizing winding 46 which in this instance, is connected across the output terminals 48 and 50 of a resistance bridge or Wheatstone bridge circuit 52 to be energized in accordance with the conditions of balance of the bridge circuit 52.

The resistance bridge circuit 52 is composed of a plurality of elements forming the legs thereof, and is connected at the input terminals 54 and 56 thereof through conductors 40 and 44 respectively, to the source of direct current supply represented by the positive and negative symbols. In this embodiment, one leg of the resistance bridge circuit 52 includes a temperature sensitive element 58 formed of material such as nickel, having a high temperature coefficient of resistance, the other legs of the resistance bridge being formed of resistors 60, 62 and 64 of material having a low temperature coefficient of resistance such as Advance metal. The temperature sensitive element 58 is disposed in juxtaposition with respect to the window pane 10 so that the resistance of the temperature sensitive element 58 will vary directly as the temperature of the window pane 10 varies. In practice, the temperature sensitive element 58 is preferably imbedded between the layers of glass forming the sandwich type of window pane 10 so as to be directly affected by the temperature developed by the heating element (not shown) in the window pane 10.

In order to vary the heating effect of the window pane 10 as the temperature of the window pane is increased from a relatively low temperature towards the temperature which is to be maintained in the window pane 10, another bridge circuit 66 is disposed with its input terminals 68 and 70 connected across the direct cur-

rent source represented by the positive and negative symbols and having its output terminals 72 and 74 connected across the direct current windings 76 of the saturable reactor 22. In this instance, the resistance bridge 66 is similar to the bridge 52 described hereinbefore, in that a temperature sensitive element 78 is included in one of the legs of the resistance bridge, the temperature sensitive element 78 also being formed of material having a high temperature coefficient of resistance. The other legs 80, 82 and 84 of the resistance bridge 66 are preferably formed of the material having a low temperature coefficient of resistance so that the balance of the bridge circuit is directly affected by the response of the temperature sensitive element 78 to the temperature of the window pane 10. In practice, the resistance of the bridge circuit 66 is preferably so adjusted that when the window pane 10 is cold, there is only a slight unbalance in the bridge circuit 66 whereby a low output voltage is applied to the direct current control winding 76 of the saturable reactor 22.

In operation, when heat is initially to be applied to the window pane 10, the window pane 10 generally is cold. Under such conditions, the resistance bridge circuit 66 is slightly unbalanced as referred to hereinbefore, so that a very low voltage is applied to the direct current control winding 76 of the saturable reactor 22 and almost full reactance of the saturable reactor 22 is applied to the energizing circuit for the heating element (not shown) of the window pane 10. Under such cold operating conditions of the window pane 10, the resistance bridge circuit 52 is also so unbalanced that the polarized relay 34 is energized to actuate the armature contact member 36 into engagement with fixed contact member 38 to energize the winding 32 of the contactor 28 and actuate the contact member 26 thereof to a circuit closing position. Under such conditions the heating element (not shown) is connected to the source of alternating current supply, but since the saturable reactor 22 has a high reactance, the voltage applied to the heating element (not shown) of the window pane 10 is maintained at a low value.

As energy is thus supplied to the heating element (not shown) of the window pane 10, and the temperature thereof increases, the resistance of the temperature sensitive element 78 also increases whereby a larger unbalance of the bridge circuit 66 is provided with the result that a larger voltage is applied to the control winding 76 of the saturable reactor 22. The increase in current thus flowing in the control winding 76 thereof tends to saturate the core of the saturable reactor 22 to thereby reduce the reactance in series with the heating element (not shown) of the window pane 10. In this manner, the voltage initially applied to the heating element of the cold window pane 10 is low and as the temperature of the window pane 10 gradually increases, the voltage applied also gradually increases.

The resistance bridge 52 is initially so adjusted or designed that for all temperature conditions of the window pane 10 up to the temperature which is to be maintained, the resistance bridge 52 will be so unbalanced as to maintain the armature contact member 36 of the polarized relay 34 in contact engaging position with the fixed contact member 38 to maintain the energizing circuit for the winding 32 of the contactor 28. At such predetermined temperature for the window pane 10, the resistance bridge 66 is so greatly unbalanced

that sufficient current flows in the control winding 76 of the saturable reactor 22 to reduce the reactance of the winding 20 of the saturable reactor 22 to a very low value whereby practically full voltage is applied from the source of alternating current power to the heating element (not shown) of the window pane 10.

As will be appreciated, after the temperature of the window pane 10 has reached the predetermined temperature which is to be maintained, under which conditions the reactance of the saturable reactor 22 is at a very low value, the control of the temperature of the window pane 10 is thereafter regulated by the response of the resistance bridge circuit 52 to changes in temperature of the window pane 10. Thus, as the temperature of the window pane 10 increases above the predetermined value which is to be maintained, the resistance of the temperature sensitive element 58 is so changed as to tend to effect a balance of the resistance bridge circuit 52. Under such balanced conditions the armature contact member 36 of the polarized relay 34 is actuated to a circuit opening position to interrupt the energizing circuit of the winding 32. As the winding 32 is deenergized, the contact member 26 of the contactor 28 drops to a circuit opening position to interrupt the energizing circuit for the heating element (not shown) of the window pane 10. Of course, if the temperature of the window pane 10 tends to decrease from the predetermined value which is to be maintained, the balance of the resistance bridge 52 is so affected that the polarized relay 34 is again so energized as to again establish the energizing circuit for the energizing winding 32 of the contactor 28 to actuate contact member 26 thereof to a circuit closing position to establish the energization for the heating element (not shown) of the window pane 10. The temperature of the window pane 10 is thus maintained at a predetermined temperature.

It is thus seen that the saturable reactor 22 and the resistance bridge circuit 66 function to modulate or vary the heating effect of the window pane 10 as it is being brought to a predetermined temperature so that when the window pane 10 is cold the heating effect is less than when the temperature of the window pane approaches the temperature which is to be maintained. By controlling the heating effect of the window pane in this manner, a more uniform heating of the window pane 10 is obtained, and the slow gradual increase in the heating effect eliminates damage to the window caused by hot spots in the window pane when initially heated. The resistance bridges 52 and 66 thus cooperate very effectively for controlling the heating effect, and after a predetermined temperature has been obtained, prevent overheating of the window pane. This control is obtained with standard components and the system described can be readily reproduced for obtaining the control.

I claim as my invention:

1. In a system for regulating the temperature of a window having a resistor heating element associated therewith, in combination, terminals for applying thereto a source of power, a variable impedance means, a contactor for connecting the variable impedance means in series circuit relationship with the resistor heating element across the terminals, a relay for actuating the contactor, a resistance bridge circuit having a temperature sensitive element disposed in juxtaposition to the window to control the balance of the bridge circuit in accordance with the tem-

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perature of the window, the bridge circuit being in balance when the temperature of the window is at its regulated value and its output being connected to the relay to control its energization in accordance with whether the temperature of the window is above or below its regulated value, and another resistance bridge circuit connected to the variable impedance means and being only slightly unbalanced when the window is cold, said another resistance bridge circuit also having a temperature sensitive element disposed in juxtaposition to the window to control the balance of said another bridge circuit and thereby control the impedance of the variable impedance means in accordance with the temperature of the window to control the flow of current in the window heating element when the contactor is actuated to connect the window heating element to the source of power to thereby gradually increase the temperature of the window at a predetermined rate.

2. In a system for regulating the temperature of a window having a resistor heating element associated therewith, in combination, terminals for applying thereto a source of power, a saturable reactor having an alternating current winding and a direct current control winding for varying the impedance of the alternating current winding, a contactor for connecting the alternating current winding in series circuit relationship with the resistor heating element across the terminals, a relay for actuating the contactor, a resistance bridge circuit having a temperature sensitive element disposed in juxtaposition to the window to control the balance of the bridge circuit in accordance with the temperature of the window, the bridge circuit being in balance when the temperature of the window is at its regulated value and its output being connected to the relay to control its energization in accordance with whether the temperature of the window is above or below its regulated value, and another resistance bridge circuit connected to the direct current control winding of the saturable reactor and being only slightly unbalanced when the window is cold, said another resistance bridge circuit also having a temperature sensitive element disposed in juxtaposition to the window to control the balance of said another bridge circuit in accordance with the temperature of the window and thereby control the impedance of the alternating current winding to gradually increase the current flow to the resistor heating element at a predetermined rate when the contactor is actuated to connect the window heating element to the source of power.

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3. In a circuit for regulating the temperature of a window pane having a heating element associated therewith, the combination comprising, terminals for applying thereto alternating current energy, a saturable reactor comprising an alternating current winding and a control winding for varying the impedance of the alternating current winding, a contactor for connecting the alternating current winding in series circuit relationship with the heating element across the terminals, a Wheatstone bridge one leg of which comprises a heat sensitive element disposed in juxtaposition to the window pane for controlling the balance of the bridge in accordance with the temperature of the window pane, a relay connected to the output of the bridge for actuating the contactor in response to an unbalance of the bridge to thereby maintain the temperature of the window pane at its regulated value, the bridge being in balance when the temperature of the window pane is at its regulated value, another Wheatstone bridge having a heat sensitive element also disposed in juxtaposition to the window pane for gradually further unbalancing said another Wheatstone bridge as the temperature of the window pane increases, the output of said another Wheatstone bridge being connected to the control winding to control the impedance of the alternating current winding in accordance with the temperature of the window to thereby increase the temperature of the window pane at a predetermined rate when the contactor is actuated to connect the heating element to the terminals which have applied thereto alternating current energy, and circuit means for applying a substantially constant voltage to the inputs of the two Wheatstone bridges.

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