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**G. C. CROWLEY**

**2,530,003**

ELECTRIC CONTROL DEVICE

Filed Feb. 21, 1947

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Fig. 1.

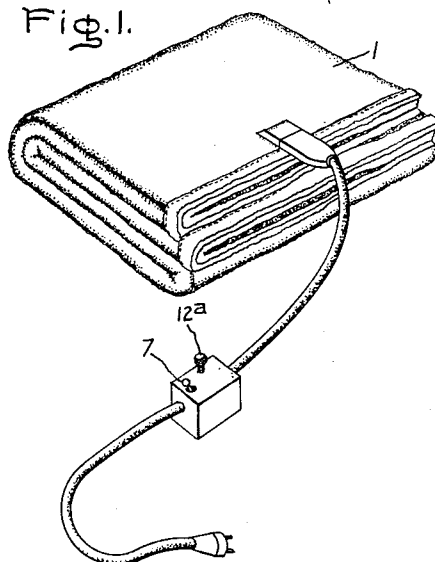
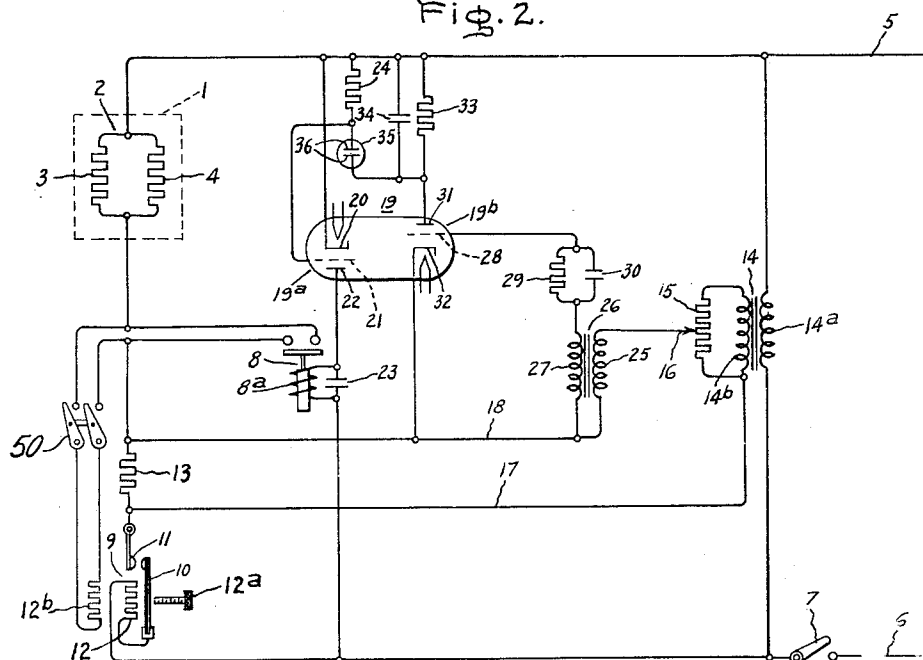


Fig. 2.



Inventor:  
George C. Crowley,  
by *Alfred E. Robert*  
His Attorney.

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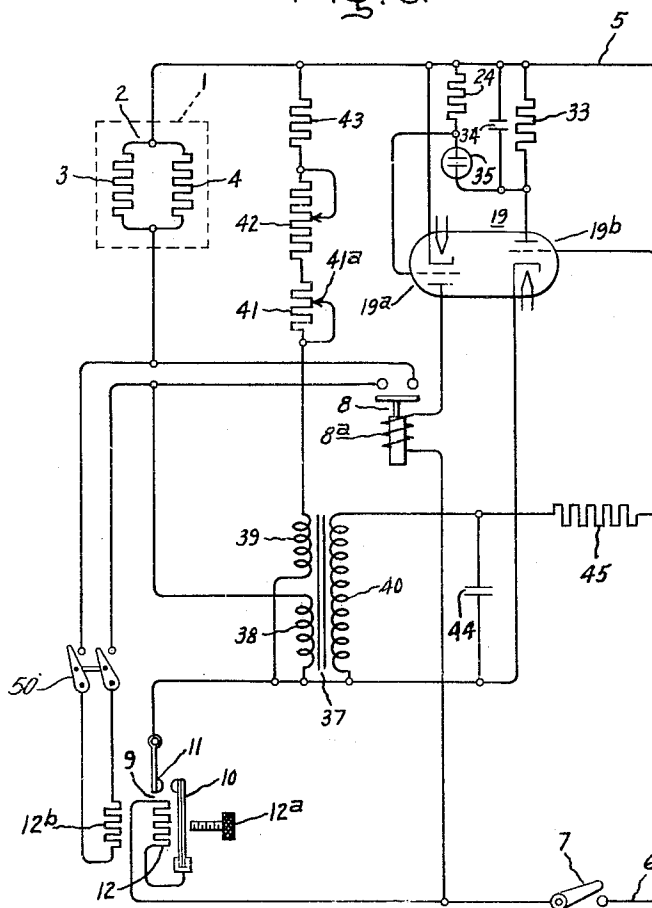
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Fig. 3.



Inventor:  
George C. Crowley,  
by *Alfred E. Robert*  
His Attorney.

## UNITED STATES PATENT OFFICE

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## ELECTRIC CONTROL DEVICE

George C. Crowley, Bridgeport, Conn., assignor to  
General Electric Company, a corporation of  
New York

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4 Claims. (Cl. 219—20)

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This invention relates to electric blankets or the like and control devices therefor; and it has for its object the provision in apparatus of this character of improved means for controlling the heating circuit thereof.

This invention contemplates an improved control for an electric blanket or the like for protecting it against overheating in case the blanket is folded or rolled, either while in use or while not in use but inadvertently plugged into the supply source, and in such manner as to produce an abnormally high temperature therein under normal operating voltage conditions.

It has been the practice heretofore to protect the blanket under such conditions by locating within the blanket body a number of thermostats which are connected in the heating circuit of the blanket so as to interrupt this circuit in response to predetermined abnormally high blanket temperatures. This invention contemplates an improved control system for protecting the blanket which does not require the use of such thermostats, and which protects all parts of the blanket.

For a more complete understanding of this invention, reference should be had to the accompanying drawing, in which Fig. 1 illustrates an electrically heated blanket embodying this invention; Fig. 2 is a diagrammatic representation of the blanket together with the control means therefor arranged in accordance with this invention; Fig. 3 is a diagrammatic representation of the blanket together with a modification of the control means.

Referring to the drawing, this invention has been shown in one form as applied to an electrically heated blanket provided with a blanket body 1 to which is applied heating means 2 which may comprise a pair of resistance elements 3 and 4 connected together in parallel and energized from a suitable source of alternating current supply, the opposite sides of which are denoted in Fig. 2 by the numerals 5 and 6. The resistance conductors 3 and 4 preferably will be arranged into a number of convolutions (not shown) covering the respective halves of the blanket, as shown diagrammatically in Fig. 2. It will be understood that a single heating winding may, if desired, be used instead of two windings in parallel. It will also be understood that the electric blanket will be provided with suitable channels (not shown) in which the resistance conductors 3 and 4 are threaded. Preferably, a blanket body such as described and claimed in the United States patent to I. O. Moberg No. 2,203,918, dated June 11, 1940 may be used.

Inserted in the supply conductor 6 is a suitable manually operable control switch 7; and connected in series circuit with the blanket heaters 3 and 4 is a control relay 8 having an energizing

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winding 8a. This winding when energized closes the relay and when deenergized permits the relay to open.

For convenience of illustration and description, the drawing shows a double pole switch 50 having a pair of terminals connected across the relay contacts. The purpose of this switch and the circuit connected to it will be described later with reference to fully automatic operation. In the immediately following discussion, it will be assumed that the switch 50 is open or that the switch and its circuit are wholly removed from the remainder of the circuit.

Also connected in series with the blanket resistors 3 and 4 is a control device 9 which functions to control the energization of the blanket responsively to room temperature variations so as to hold a substantially constant temperature in the blanket in spite of these variations, in the general manner described and claimed in the United States patent to W. K. Kearsley No. 2,195,958, dated April 2, 1940. As described in the Kearsley patent, this control device comprises a bimetallic thermostatic bar 10 which operates a switch 11 connected in series with the blanket heaters. The element 10 is out of direct thermal relation with the blanket, so as to be unaffected directly by the heat generated therein; it responds to the room temperature. Also, the control 9 includes an auxiliary heater 12 for the bimetallic bar 10, which heater is energized to heat the bar 10 while the relay 8 and switch 11 are closed to energize the blanket, and is deenergized whenever the switch 11 is opened. When the heater 12 has warmed the bimetallic bar 10 sufficiently the latter deflects so as to open the switch 11. The thermostat 10 thus cycles "on" and "off" to energize and deenergize the blanket in response to the operation of the heater 12 to hold a substantially constant temperature in the blanket, the periods of the "on" and "off" cycles being dependent upon the ambient room temperature, all as fully described in the aforementioned Kearsley patent. The thermostat 10 is adjusted by means of an adjustment screw 12a to hold different desired temperatures in the blanket.

In order to control the energization of the blanket heaters 3 and 4 so as to prevent an abnormally high temperature condition in the blanket, I make the blanket resistances 3 and 4 of a material having a relatively high temperature coefficient of resistance, such as copper or a suitable alloy thereof, and I connect in series with the blanket heaters between them and the cycling control element 9, a resistance element 13 which has a substantially negligible temperature coefficient of resistance, and which may be made of any suitable material, such as nichrome. I utilize the voltage drop across this resistance 13

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as it decreases due to an abnormal increase in the resistance of the heaters 3 and 4 to shut off the blanket energization irrespective of the operation of the cycling control 9. That is, as the blanket temperature rises, the resistance of the blanket elements 3 and 4 increases and therefore the total current in the blanket circuit and in resistance 13 decreases. This results in a drop in the voltage across the resistance 13, and it is this voltage drop that I use to protect the blanket against overheating.

Set to oppose the voltage drop across the resistance 13 is a reference voltage, so-to-speak, which voltage is generated by a transformer 14 having a primary winding 14a connected across the supply conductors 5 and 6, as shown, and having a secondary winding 14b. Connected across this secondary winding is a resistor 15 having a slide tap 16. One terminal of resistance 13 is connected with one end of the resistance 15 by means of a conductor 17, while the other terminal of resistor 13 is connected with the adjustable slider 16 by means of a conductor 18. In other words, the opposing reference voltage may be set by means of the slider 16.

Referring back to the relay 8, its winding 8a is controlled by a high vacuum tube 19 of the double triode type having a section 19a which controls winding 8a, and a second section 19b, the function of which will be described later. Section 19a comprises a cathode 20, a grid 21 and an anode 22. The coil 8a, as shown, is connected in series with the anode-cathode circuit of section 19a across supply conductors 5 and 6. A condenser 23 is connected across the coil 8a in order to prevent chattering of the contacts of relay 8.

The grid 21 is connected to the line conductor 5 through a resistance 24. And as the cathode 20 also is connected to the line 5, the grid 21 is connected to the cathode through the resistor 24. Under such conditions current through the anode-cathode circuit is sufficient to energize the coil 8a to close the relay and keep it closed.

Referring back to resistor 13, there is connected in series with its circuit the primary winding 25 of a step-up transformer 26. The secondary winding 27 of this transformer is connected in series with the grid 28 of the second triode section 19b through a grid leak bias circuit consisting of a parallel-connected resistor 29 and condenser 30, as shown. The anode 31 and cathode 32 of this second section are connected in series with a resistor 33 across supply conductor 5 and conductor 18, as shown; and connected across resistor 33 is a condenser 34. The anode circuit is completed from conductor 18 through resistor 13, contacts 11, element 10 and heater 12 to supply conductor 6.

A gas-filled diode 35 having a pair of spaced electrodes 36, such as a neon-filled lamp, is connected between the grid 21 of the first tube section 19a and the anode 31 of the second tube section 19b.

In the normal operation of the blanket system, when the switch 7 is closed the relay 8 closes, it being remembered that the current flow through the anode-cathode circuit of the first tube section 19a is sufficiently great to close the relay and keep it closed. The cycling control device 9 then functions to control the blanket temperature in accordance with the setting of the knob 12a and the ambient room temperature, all as described in the Kearsley patent mentioned above.

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During this normal operation, relay 8 remains closed during the cycling of the control element 9.

Let it now be assumed that for some reason or other the blanket temperature rises above the normal temperature determined by the ambient and the setting of the control element 9, as for example, if the blanket be folded or rolled either while in use or while not in use but inadvertently plugged into the supply source at switch 7. Then the resistance of the blanket elements 3 and 4 will increase, and as a result the current in the heater circuit decreases with the result that the voltage drop across resistance 13 decreases, all as pointed out previously. When this voltage drop decreases, the voltage across the primary winding 25 of transformer 26 also decreases since the voltage drop across resistance 13 is normally greater than the reference voltage. The decreasing voltage on the primary winding 25 is out-of-phase with the anode-cathode circuit of the second tube section 19b. Since the voltage across the primary 25 decreases, that across the secondary 27 decreases and the voltage between the grid 28 and the cathode 32 decreases. This decreasing voltage, also being out-of-phase with the anode-cathode voltage, makes the grid less negative.

As a result of this, the current in the anode-cathode circuit of tube section 19b increases, and this causes the voltage drop across the resistor 33 to increase. This voltage is impressed across the condenser 34, and when it rises to a sufficiently high value, it will cause the neon-filled lamp 35 to "fire". When this tube fires, current flows through it and through the resistance 24.

It should be noted that the condenser 34 is connected across resistor 33 in order to maintain the voltage impressed across resistor 33, when the phase of the line supply reverses, so that there will be voltage to fire the neon lamp during the half cycle that the second tube section 19b is not conducting.

The voltage drop across the resistance 24 is of opposite polarity to the anode-cathode potential of the first tube section 19a at the instant that the anode of this section is positive with respect to the cathode, whereby the current through this section is abruptly decreased, with the result that the coil 8a is deenergized and the relay 8 permitted to open to deenergize the blanket heaters 3 and 4.

The relay 8 (still assuming switch 50 to be open) will remain open until the line switch 7 is operated manually to open the circuit entirely. So long as the line switch 7 is not opened, it will be observed that the cycling control 9 will cease to operate and contacts 11 will remain closed, because heater 12 current now is only the plate current through tube section 19b, which is much less than the blanket heater current required for normal operation of the device 9.

It is to be noted that during normal operation, when the cycling control 9 opens contacts 11, it has no effect upon the relay 8, which remains closed, because this operation of the control 9 simultaneously functions to remove the anode-cathode voltage of the second tube section 19b, and neon lamp 35 cannot fire.

Adjustment of the slider 16 on resistor 15 determines the blanket temperature at which the safety control opens. By increasing the resistance between the slider 16 and conductor 17, the voltage opposing the voltage drop across resistor 13

increases. This lowers the temperature to which the blanket may heat before the safety control operates since a smaller decrease in blanket current permits voltage drop across 13 to become less than the opposing voltage 16, 17. Conversely, by decreasing the resistance between the slider 16 and conductor 17, the voltage opposing the voltage drop across resistor 13 decreases, and this increases the temperature to which the blanket may heat up before the safety control operates.

The components of the system are so selected that the neon lamp 35 fires to open the relay 8 when the differential voltage across the transformer 26 reaches zero, in other words, when the voltage drop across resistance 13 and the reference voltage at resistance 15 are equal. This renders the system independent of line voltage fluctuation.

It will be recalled that with the circuit so far described, the switch 50 being open, the blanket will remain deenergized after an abnormal overheating. This is because when the relay 8 has once been actuated to open its contacts, the voltage drop across the adjustable portion of resistor 15 is always greater than the voltage drop across resistor 13 whereby the tube section 19a is maintained in a non-conducting condition, which condition will persist until the supply line is interrupted. If desired, this may be accomplished by manually opening the supply line switch 7. If thereafter the line switch 7 be closed, the blanket and control circuit will resume functioning as initially unless the condition which caused the overheating such as folding or rolling of the blanket still persists, in which case the relay 8 will again be deenergized to open the circuit.

It may be desirable to provide an automatic means for periodically "testing" the circuit, so to speak, to see whether the condition which caused the overheating has been removed or still persists. For this purpose, I provide an additional heater 12b which, like the heater 12, is also positioned to heat the thermostatic element 10. The heater 12b is connected across one set of terminals of a double pole switch 50 (which in practice may be omitted). The other set of terminals of the switch are connected across the contacts of relay 8 so that, the switch 50 being closed, the heater 12b is short circuited and inoperative when the relay contacts are closed. When the relay contacts are open, however, the heater 12b is in series with the blanket heating windings 3, 4, thereby permitting current to flow from the line through the blanket heating windings, the heater 12b, resistance 13, switch 11, heater 12, to the other side of the line. The resistance of heater 12b, however, is made quite large so that full blanket current will not flow in the circuit but only sufficient to produce enough heat in resistor 12b necessary to cause the thermostat 10 to open switch 11. The heating windings are thus rendered ineffective to heat the blanket. As previously pointed out, opening of the switch 11 removes anode voltage from tube section 19b, thereby cutting off its plate current, removing the grid bias on tube section 19a, permitting the current therein to increase and thereby reenergizing relay 8 to reclose its contacts. The heater 12b is thereby short circuited, so that thermostat 10 cools and recloses switch 11. If the condition which caused the initial abnormal heating has meanwhile been removed, the blanket and its control circuit will resume normal operation. On the other hand, if the abnormal condition has not been removed, the circuit again operates to open

the relay 8 and to reduce the blanket current to that which will pass through the high resistance heater 12b, which again heats thermostat 10. The operation just described is thereupon resumed.

Fig. 3 shows a modification of the control circuit in accordance with my invention. It presents a different way of obtaining a control voltage for the operation of the electronic safety control circuit. The modified circuit eliminates the resistor 13 in series with the blanket and replaces it with a winding on the step-up transformer which energizes the electron tube circuit input. By this modification the total power dissipation of the control is reduced and the cost of the control is less. In Fig. 3 similar elements have been given the same reference numbers as in Fig. 2,

It will be observed that in the circuit of Fig. 3 a step-up transformer 37 is used which has two primary windings 38 and 39 arranged in opposition to each other and a secondary winding 40. Winding 38 is connected in series with the blanket heater elements 3, 4 and the thermostatic switch 9. The current through winding 38, when the relay 8 is closed, is therefore dependent upon the resistance of the heating elements 3, 4 and decreases as the temperature and the resistance of these elements increase. The effect of the winding 38 is consequently to induce in the winding 40 a potential which is dependent upon the resistance and therefore upon the temperature of the heating elements 3, 4. The winding 38 thus provides an alternative to the resistor 13 in Fig. 2 for producing a potential which varies with the temperature of the heating element. A second primary winding 39 is connected to one side 6 of the power supply through the thermostatic switch 9 and to the other side 5 of the power supply through three series resistors 41, 42, 43, of which 41 and 42 are adjustable. Transformer winding 39 is so wound on the transformer core that the voltage induced in the secondary 40 is of opposite polarity to that produced by the winding 38. The resultant voltage of the secondary 40 is, therefore, the magnified difference between the voltages produced by windings 38 and 39.

The potential developed by the secondary 40 is impressed across the grid and cathode of tube section 19b. Grid bias for that tube is obtained by means of condenser 44 connected across the secondary 40 and resistor 45 connected in series with the grid lead from the secondary 40. It will be observed that anode potential for the tube section 19b is provided as in Fig. 2 from the power supply through the thermostatic switch 9 and is zero when the latter is open.

The operation of both vacuum tubes 19a and 19b is identical to that described with reference to Fig. 2. Upon initial closing of the switch 7, the thermostatic switch 9 being normally closed, sufficient plate current flows through tube section 19a to energize coil 8a of the relay 8 to close the relay contacts and thereby connect the blanket heating winding to the power supply. The tube 19b passes plate current only when the voltage developed by the secondary winding 40 is of the proper polarity and magnitude occasioned by an abnormal reduction in the current flowing through primary winding 38 due to an abnormal increase in the temperature and consequently in the resistance of the heating elements 3, 4. When plate current does flow through the tube section 19b, the plate current in the other tube section 19a will be cut off as explained above with reference to Fig. 2. The relay 8 will, therefore, open its contacts and either disconnect the heating

elements 3, 4 from the supply line as when switch 50 is open, or, if the auxiliary thermostat heater 12b is used as shown in Fig. 3, the switch 50 being closed, the heating elements 3, 4 will be connected in series with the high resistance thermostat heater 12b and will thereby be rendered ineffective to heat the blanket. It will be understood that auxiliary heater 12b is used only when automatic restarting is desired as explained above.

In order that the transformer winding 39 will produce a so-called reference voltage of suitable magnitude, the current through the winding 39 is limited by resistance 43 and adjustable resistance 42. Adjustment of the resistance 42 therefore, gives an initial control of the temperature to which the blanket may heat before the safety control operates. An additional adjustable resistance 41 is also connected in series with the primary 39. The resistance 41 preferably has its adjusting element 41a mechanically connected to the screw 12a of the thermostatic recycling switch 9 so that the resistance 41 will be automatically readjusted when the adjustment of the screw 12a is changed.

It will be recalled that the screw 12a provides the adjustment of the thermostat 10 to control the temperature which it is desired to hold in the blanket. When the screw 12a is adjusted for "low" heat, the contacts of the device 9 stay open for relatively long periods of time, whereas when the screw 12a is adjusted for "high" heat, the contacts stay closed a longer period of time. In the latter case the blanket maintains a higher temperature than in the former. Without a suitable compensating element, such as the resistance 41, the electronic safety control must be set (as by resistance 42) so that the blanket circuit will not be opened under normal high heat conditions. This means, however, when the control 9 is set for low heat, that the safety control will not operate until a very large abnormality has occurred in the heat conditions in the blanket. However, by means of the compensating element, resistance 41, which I have provided and which is made simultaneously adjustable with adjustment of the control 9, the temperature at which the safety control circuit will operate can be maintained for all settings of the control 9 at just a few degrees above the maximum temperature normally expected to be reached in the blanket for the respective settings.

While I have shown and described particular embodiments of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A control for an electric heating device having a heating winding with high temperature coefficient of resistance, a resistor in series with said winding whereby a change in the temperature of said winding produces a change in the resistance thereof, and, when energized, a consequent change in the voltage drop across said series resistor, a vacuum tube circuit having a normal current flow in a portion thereof and a control grid means biased by a predetermined change in said voltage drop to produce a change in said current flow, a high resistance device, re-

lay means operated by said change in current for effectively connecting said high resistance device in series with said heating winding and a thermal relay means actuated in response to current flow through said high resistance device after a predetermined time delay, actuation of said thermal relay means effectively removing said grid bias to reestablish said normal current flow in said vacuum tube circuit and thereby operating said relay means for effectively disconnecting said high resistance device from said heating winding.

2. In combination, with an electric blanket having a heating winding adapted to change its resistance in response to a change in its temperature, a power supply for said winding, a resistor, a thermostat responsive to ambient temperature and having contacts operated thereby, a heater for said thermostat, said heating winding, resistor, contacts and heater being connected together in series, a relay having contacts connected to said series circuit and adapted when energized to connect said series circuit to said power supply, a first vacuum tube having anode-cathode and control circuits, said anode-cathode circuit being connected across said power supply and in series with said relay, said control circuit being normally energized from said power supply for permitting current to flow in said anode-cathode circuit thereby energizing said relay, a second vacuum tube having anode-cathode and control circuits, a source of reference voltage derived from said power supply, a transformer having primary and secondary windings, means including said transformer for comparing said series resistor voltage drop with said reference voltage and applying the difference voltage to said second vacuum tube control circuit for producing current flow in said second vacuum tube anode-cathode circuit in response to an abnormal difference voltage, and means in the anode-cathode circuit of said second vacuum tube responsive to current flow therein and connected to the first vacuum tube control circuit for interrupting the current flow in said first vacuum tube anode-cathode circuit, thereby deenergizing said relay.

3. A control for an electric heating device having a heating winding with high temperature coefficient of resistance, a transformer having primary and secondary windings, a primary winding of said transformer being connected in series with said heating winding whereby a change in the temperature of said heating winding produces a change in the resistance thereof and, when energized, a consequent change in the current through said primary winding and in the potential produced thereby in said secondary winding, a vacuum tube circuit having a normal current flow in a portion thereof and a control grid means biased by a predetermined change in said secondary winding potential to produce a change in said current, a high resistance device, relay means operated by such change in current flow for effectively connecting said high resistance device in series with said heating winding, and a thermal relay means actuated in response to current flow through said high resistance device after a predetermined time delay, actuation of said thermal relay means effectively removing said grid bias for reestablishing said normal current flow in said vacuum tube circuit and thereby operating said relay means for effectively disconnecting said high resistance device from said heating winding.

4. A control for an electric heating device having a heating winding with high temperature coefficient of resistance, an impedance in series with said winding whereby a change in the temperature of said winding produces a change in the resistance thereof, and, when energized, a consequent change in the voltage drop across said series impedance, a vacuum tube circuit having a normal current flow in a portion thereof and a control grid means biased by a predetermined change in said voltage drop to produce a change in said current flow, a high resistance device, relay means operated by said change in current for effectively connecting said high resistance device in series with said heating winding, and a thermal relay means actuated in response to current flow through said high resistance device after a predetermined time delay, actuation of said thermal relay means effectively removing said grid bias for re-establishing said normal current flow in said vacuum tube circuit and there-

by operating said relay means for effectively disconnecting said high resistance device from said heating winding.

GEORGE C. CROWLEY.

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