E. M. BOUTON.

FURNACE REGULATOR SYSTEM.

APPLICATION FILED APR. 9, 1919.

1,349,361.

Patented Aug. 10, 1920.

2 SHEETS—SHEET 1.

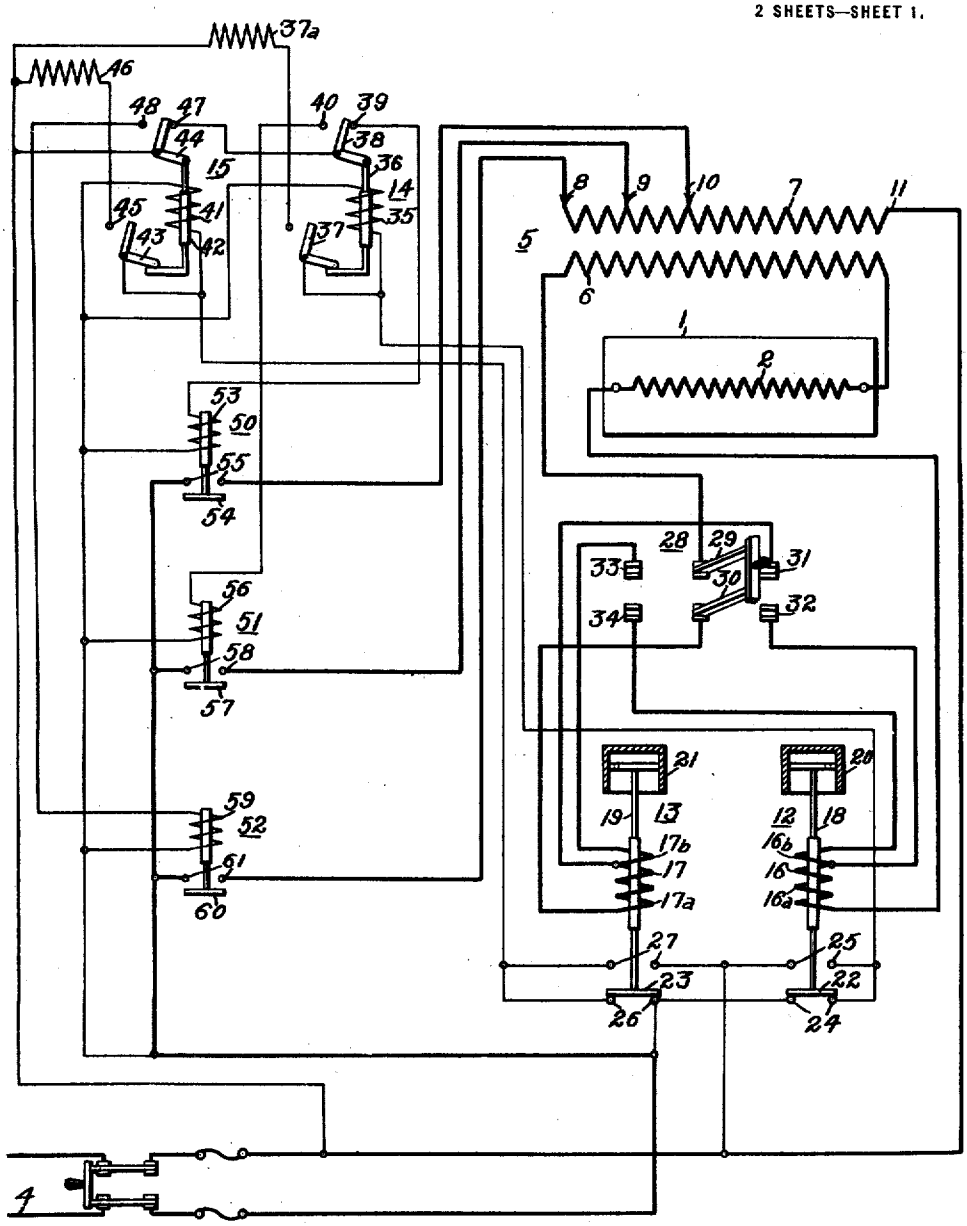


Fig. 1.

WITNESSES:

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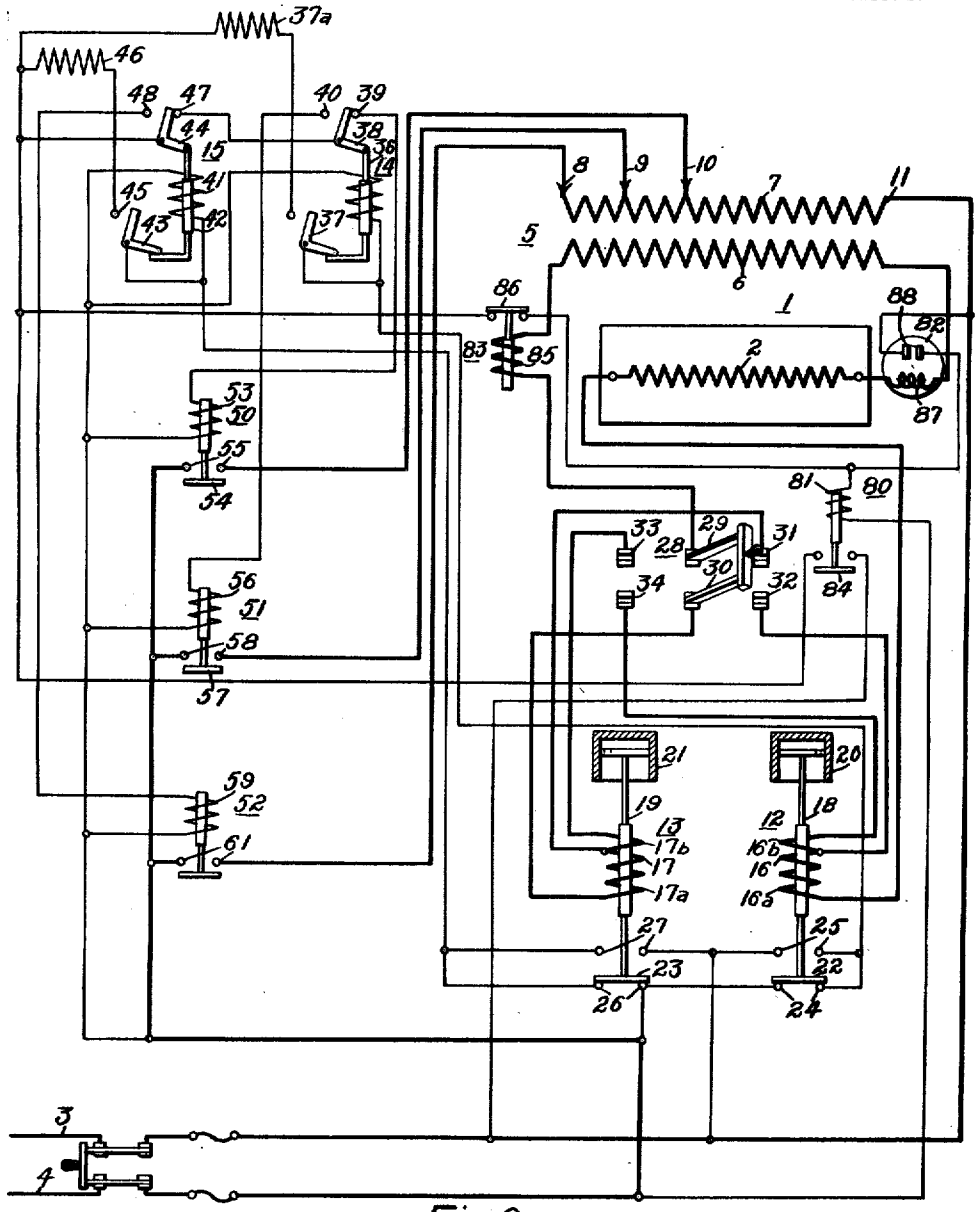


Fig. 2.

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FURNACE-REGULATOR SYSTEM.

1,349,361. Specification of Letters Patent. Patented Aug. 10, 1920.

Application filed April 9, 1919. Serial No. 288,676.

To all whom it may concern:

Be it known that I, EDGAR M. BOUTON, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Furnace-Regulator Systems, of which the following is a specification.

My invention relates to regulator systems and particularly to systems for maintaining substantially constant current-flow through electric furnaces.

One object of my invention is to provide a furnace-regulator system of the above-indicated character that shall automatically maintain a substantially constant current flow through the furnace in a simple and economical manner under variable-load conditions, be substantially free from any so-called hunting action and protect the furnace against any abnormal circuit conditions.

In electric furnaces, and particularly in electric furnaces provided with resistors having negative temperature coefficients, it is essential that the current-flow through the furnace shall be maintained substantially constant in order to prevent subjection of the material being treated to abnormal temperature conditions. Moreover, it is desirable to so operate the furnace automatically that constant supervision of, and attention to, it shall not be necessary.

In a furnace regulator constructed in accordance with my invention, the current-flow through the furnace resistor is maintained substantially constant by automatically varying the voltage of the current supplied to the furnace in accordance with the current flowing through the furnace resistor. Moreover, automatic means is provided for preventing an abnormal current-flow through the furnace resistor and for preventing the operation of the furnace in case the furnace resistor has been heated above a predetermined temperature.

In the furnace system utilized for describing my invention, a transformer, having an adjustable primary winding and a secondary winding, is provided for connecting a heating resistor to a supply circuit. In series with the secondary winding of the furnace resistor a plurality of current relays, which are selectively operated by the current flowing through the furnace resistor, are provided for operating a plurality of auxiliary relays. The current relays are relatively slow acting and are prevented from chattering by any suitable means, such, for example, as dash pots connected to their core armatures, and the auxiliary relays are provided with holding circuits which are closed on operation of the relays and which are under the control of the current relays. Thus, upon release of a current relay, the circuit of the auxiliary relay associated with it is opened. The auxiliary relays control a plurality of switches which vary the number of effective turns included in the primary winding of the transformer and thus regulate the current flow through the furnace resistor. Moreover, if so desired, the furnace resistor may be protected against an abnormal current-flow through it, and means may be provided for preventing the closing of the circuit of the furnace resistor in case the resistor is heated above a predetermined temperature.

In the accompanying drawings, Figure 1 is a diagrammatic view of a furnace regulator system embodying my invention, and Fig. 2 is a regulator system similar to the system illustrated in Fig. 1 and provided with additional protective means.

Referring to Fig. 1 of the drawings, an electric furnace 1, provided with a resistor 2 preferably having a negative temperature coefficient, is adapted to be connected across a supply circuit, comprising conductors 3 and 4, by means of a transformer 5. The transformer 5 embodies a secondary winding 6, which is connected in circuit with the furnace resistor 2 and a primary winding 7, which is provided with a plurality of taps 8, 9, 10 and 11 extending from it. The tap or terminal 11 is preferably directly connected to the supply conductor 3, and the taps 8, 9 and 10 are selectively connected to the supply conductor 4, as will be hereinafter set forth, for regulating the current-flow through the furnace resistor 2.

Two current relays 12 and 13 are operated in accordance with the current flowing through the furnace resistor 2 and serve to govern the operation of two auxiliary relays 14 and 15. The current relays 12 and 13 respectively embody energizing coils 16 and 17, which are divided into parts 16^a and 16^b and 17^a and 17^b, core armatures 18 and 19, which are provided with dash pots

20 and 21, and switch members 22 and 23. The switch member 22 is adapted to bridge either the contact members 24 or the contact members 25, according to the operative position of the relay 12, and the switch member 23 is adapted to bridge the contact members 26 or the contact members 27, according to the operative position of the relay 13. The current relays, being operated by alternating currents, are inclined to chatter somewhat; but, by reason of the fact that it takes less current to hold a relay in an operative position than to operate it and by reason of the slow action caused by the dash pots, they are held in operative position sufficiently to effect operation of the auxiliary relays.

A two-pole, double-throw switch 28 is provided for selectively connecting the energizing windings 16 and 17 of the relays 12 and 13 in circuit with the furnace resistor 2. The switch 28 embodies two knife-blade members 29 and 30 which are connected to two contact terminals 31 and 32 when it is desired to connect only the portions 16^a and 17^a of the windings 16 and 17 in circuit with the resistor 2 and thus operate the furnace at a high temperature. The knife blades 29 and 30 are also adapted to engage two contact terminals 33 and 34 when it is desired to connect the complete windings 16 and 17 in circuit with the resistor 2 and thus operate the furnace at a lower temperature.

The auxiliary relay 14 embodies an energizing winding 35 which is connected across the supply conductors 3 and 4 upon bridging of the contact terminals 25 by means of the switch member 22 when the relay 12 is operated. The auxiliary relay 14 is further provided with a core armature 36, which, upon operation, engages an interlock switch member 37 to complete a holding circuit from the supply conductors 3 and 4 through a resistor 37^a and the winding 35 of the relay. The core armature 36 is further connected to a switch member 38 which engages the contact terminal 39 when the relay is in a released position and engages a contact terminal 40 when the relay is in an energized position.

The auxiliary relay 15 embodies an energizing winding 41 which is connected across the supply conductors 3 and 4 upon bridging of the contact terminals 27 by the switch member 23 when the current relay 13 is operated. The winding 41 operates on a core armature 42 which operates two contact members 43 and 44. The switch member 43 engages a contact terminal 45 upon operation of the auxiliary relay to complete a holding circuit from the supply conductors 3 and 4 through a resistor 46 for maintaining the auxiliary relay 15 in an operative position until the switch member 23 becomes disengaged from the contact terminal 27 and bridges the contact terminals 26. The switch member 44 engages a contact terminal 47 when the auxiliary relay is in a deënergized position and engages a contact terminal 48 when the relay is in an operative position.

Three switches 50, 51 and 52 are provided for selectively connecting the transformer taps 8, 9 and 10 to the supply conductor 4 and are selectively operated by the auxiliary relays 14 and 15. The switch 50 embodies an energizing winding 53 which is connected across the supply conductors 3 and 4 when the contact members 38 and 44 respectively engage contact terminals 39 and 47. A switch member 54 is operated by the winding 53 for bridging contact terminals 55 to connect the transformer tap 10 to the supply conductor 4. The switch 51 embodies a winding 56 which is connected across the supply conductors 3 and 4 when the switch member 38 engages the contact terminal 40. The winding 56 operates a switch member 57 to bridge contact terminals 58 and connect the transformer tap 9 to the supply conductor 4. The switch 52 embodies a winding 59, which is connected across the supply conductors 3 and 4 when the switch member 44 of the auxiliary relay 15 is in engagement with the contact terminal 48. The winding 59 operates a switch member 60 which bridges contact terminals 61 for connecting the transformer tap 8 to the supply conductor 4.

Assuming the various parts of the system to be in the position shown and the switch 28 to be operated so that the knife blades 29 and 30 engage the contact terminals 31 and 32, then a circuit is completed from the supply conductor 3 through the switch member 44, contact terminal 47, switch member 38, contact terminal 39 and winding 53 of the switch 50 to the supply conductor 4. Thereupon, the switch 50 is operated and a circuit is completed from the supply conductor 4, through the contact terminals 55—which are bridged by the switch member 54 of the switch 50—transformer tap 10 and the secondary winding 7 to the supply conductor 3. The transformer 5 is energized and a circuit is completed through the furnace resistor 2 which is traced from one terminal of the secondary winding 6, through the resistor 2, winding 16^a of the current relay 12, contact terminal 32, knife blade 30, winding 17^a of the current relay 13, contact terminal 31 and the knife blade 29 to the other terminal of the secondary winding 6.

The current relays 12 and 13 are set to be operated at different current values, the relay 12 operating at one current value and the relay 13 operating at a somewhat higher current value. Thus, in case the current flow through the resistor 2 is raised above a certain predetermined value, then the current relay 12 is operated to reduce the volt-

age of the current which is supplied to the transformer 5. Upon operation of the current relay 12, the switch member 22 becomes disengaged from the contact terminals 24 and bridges the contact terminals 25 to complete a circuit from the supply conductors 3 and 4, through the winding 35 of the auxiliary relay 14. The auxiliary relay 14 is operated and a holding circuit therefor is established by the interlock switch 37. The holding circuit is traced from supply conductor 3, through the resistor 37ª, interlock switch 37 and the winding 35 to the supply conductor 4. The switch member 38, upon operation of the auxiliary relay 14, becomes disengaged from the contact terminal 39 and engages the contact terminal 40 and thus releases the switch 50 and completes a circuit through the winding 56 of the switch 51. The circuit through the winding 56 is traced from the supply conductor 3, through the switch member 44, contact terminal 47, switch member 38, contact terminal 40 and the winding 56 to the supply conductor 4. Upon release of the switch 50, the transformer tap 10 is disconnected from the supply conductor 4 and, upon operation of the switch 51, the transformer tap 9 is connected to the supply conductor 4. Thus, the number of effective turns in the primary winding 7 of the transformer 5 has been increased, and accordingly, the voltage supplied to the secondary winding 6 is so reduced as to reduce the current flow through the resistor 2.

In case the lowering of the voltage supplied to the secondary winding 6 by the increased number of turns included in the primary winding does not reduce the secondary current and such current is raised by furnace conditions to a second predetermined value, then the current relay 13 is operated to further reduce the voltage impressed upon the secondary winding 6.

Upon operation of the current relay 13, the switch member 23 becomes disengaged from contact terminals 26 and bridges the contact terminals 27 to connect the energizing winding 41 of the auxiliary relay 15 across the supply conductors 3 and 4. The auxiliary relay 15 is operated and a holding circuit therefor is completed by the interlock switch 43. The holding circuit is traced from the supply conductor 3 through the resistor 46, contact terminal 45, contact member 43 and the winding 41 to the supply conductor 4. The switch member 44, upon operation of the relay, becomes disengaged from the contact terminal 47 and engages contact terminal 48 to release the switch 51 and complete a circuit through the winding 59 of the switch 52. The switch 51 disconnects the transformer tap 9 from the supply conductor 4 and the switch 52 connects the transformer tap 8 to the supply conductor 4, thus, the number of effective turns included in the primary winding 7 have been increased and the voltage impressed upon the secondary winding 6 has been reduced.

In describing my invention, only two current relays 12 and 13 and a corresponding number of auxiliary relays have been illustrated but it is to be understood that, if so desired, the number of current relays and auxiliary relays may be increased in order to effect a greater range of voltage change for regulating the furnace resistor. The last tap of the transformer winding is preferably located at a point such that the input into the electric furnace is less than the radiating capacity of the furnace at no load, and, consequently, there will be no tendency to a further current increase by reason of the resistor having a negative temperature coefficient.

In case the two current relays 12 and 13 are each in an operative position, and the current-flow through the furnace resistor 2 is reduced to such point as to release the current relay 13, then the switch member 23 becomes disengaged from the contact terminals 27 and bridges the contact terminals 26. Thereupon, the winding 41 of the auxiliary relay 15 is short-circuited to effect the release of the relay 15. Consequently, the holding circuit through the winding 41 is broken, and the switch member 44 opens the circuit through the circuit 59 of the switch 52 and completes a circuit through the winding 56 of the switch 51. Thus, the switch 52 is released to disconnect the transformer tap 8 from the supply conductor 4, and the switch 51 is operated to connect a transformer tap 9 to the supply conductor 4. Consequently, the number of effective turns included in the transformer winding 7 is reduced and the voltage impressed upon the secondary winding 6 is increased to effect a corresponding increase in the current-flow through the resistor 2.

Assuming a further reduction in the current-flow through the furnace resistor 2, the current relay 12 is released, and the switch member 22 becomes disengaged from the contact terminals 25 and bridges the contact terminals 24. Thereupon, the winding 35 of the auxiliary relay 14 is short-circuited to release the relay. The interlock switch 37 opens the holding circuit through the winding 35, and the switch member 38 becomes disengaged from the contact terminal 40 and engages the contact terminal 39 to release the switch 51 and operate the switch 50. Thus, the transformer tap 9 is disconnected from the supply conductor 4 and the transformer tap 10 is connected to the supply conductor 4. Consequently, the number of effective turns included in the primary winding 7 is further reduced to in-

crease the voltage impressed upon the secondary winding 6 and, accordingly, to increase the current flow through the resistor 2.

In case the switch 28 is thrown to its reverse position to connect the switch blades 29 and 30 to the contact terminals 33 and 34, then the complete windings 16 and 17 of the curent relays 12 and 13 are included in circuit with the furnace resistor 2. Consequently, the relays 12 and 13 will be operated at lower current values in order to reduce the current flow which is maintained in the furnace.

In Fig. 2, a system is disclosed which is similar to the system disclosed in Fig. 1 with the exception that certain additional protective means are provided for insuring the furnace against damage by reason of an excessive current-flow through it or overheating by reason of continued operation at too high temperature. In the system shown in Fig. 2, like parts to those shown in Fig. 1 are indicated by similar reference characters, and only so much of the system shown in Fig. 2 as differs from the system shown in Fig. 1 will be described in detail.

Referring to Fig. 2, a no-voltage relay 80 is provided for governing the circuit through the switch members 44 and 38, which effects the operation of the switch 50 to connect the transformer 5 across the supply conductors 3 and 4. The relay 80 embodies a winding 81 which is initially connected across the supply conductors 3 and 4 by means of a thermal device 82 and which is provided with a holding circuit through an overload relay 83. The winding 81 controls a switch member 84 for the purpose above set forth.

The overload relay 83 embodies a winding 85 which is connected in series with the secondary winding 6 and the furnace resistor 2. The winding 85 controls a switch member 86 which connects the winding 81 of the no-voltage relay 80 through the switch member 84 across the supply conductors 3 and 4.

The thermal device 82 embodies a heating coil 87, which is included in series with the furnace resistor 2, and a switch member 88, which is normally adapted to complete a circuit from the supply conductors 3 and 4 through the energizing winding 81 of the no-voltage relay 80. The thermal device 82 is completely described in a copending application of Henry D. James, Serial No. 308,723, filed July 5, 1919, and, accordingly, a detailed explanation thereof is deemed unnecessary in this application. It may be noted, however, that, upon excessive heating of the coil 87, the switch 88 is opened and will not be closed again until the heating coil 87 has been cooled to a predetermined point.

Assuming the parts of the system shown in Fig. 2 to be in the position illustrated, a circuit is completed from the supply conductor 4, through the winding 81 of the no-voltage relay 80, switch 88 of the thermal device 82, to the supply conductor 3. The no-voltage relay 80 is operated and a circuit is completed from the conductor 3, through the switch member 84, switch member 44, contact terminal 47, switch member 38, contact terminal 39 and the winding 53 of the switch 50, to the supply conductor 4. The switch 50 is operated to connect the transformer 5 across the supply conductors 3 and 4, and further operation of the current relays 12 and 13, the auxiliary relays 14 and 15 and the switches 50, 51 and 52 is similar to the operation of those parts as set forth in describing Fig. 1.

In case an excessive current-flow passes through the circuit including the secondary winding 6 and the furnace resistor 2, then the overload relay 83 is operated to break the holding circuit of the no-voltage relay 80, thereupon the no-voltage relay 80 is released and, accordingly, the transformer 5 is disconnected from the supply circuit to deënergize the furnace.

When the no-voltage relay 80 has been released, it is impossible to again start the furnace until the circuit of the energizing winding 81 for the no-voltage relay is completed through the thermal device 82. Thus, in case the furnace has been operated at an excessively high temperature, it will be impossible to again connect the transformer 5 across the supply conductors 3 and 4 until the heating coil 87 of the thermal device 82 has been cooled to such point as will permit the closing of the switch 88 and the consequent operation of the no-voltage relay 80.

Modifications in the system and in the arrangement and location of parts may be made within the spirit and scope of my invention and such modifications are intended to be covered by the appended claims.

I claim as my invention:

1. In a furnace-regulator system, an electric furnace, a transformer for connecting the furnace to a supply circuit, and means controlled by the value of the current flowing through the furnace for automatically varying the effective turns of said transformer to maintain a substantially constant current-flow through the furnace.

2. In a furnace-regulator system, a transformer having a primary and a secondary winding, a furnace resistor connected in circuit with said secondary winding, and means controlled by the current flowing through the secondary winding for varying the number of effective turns in the primary winding of the transformer.

3. In a furnace-regulator system, a trans-

former having a primary and a secondary winding, a furnace resistor inserted in circuit of the secondary winding of said transformer, and means, comprising a plurality of relays in series with said secondary winding, for varying the number of effective turns in the primary winding to maintain a substantially constant current - flow through the furnace resistor.

4. In a furnace-regulator system, a transformer having a primary and a secondary winding, a furnace resistor connected in circuit with said secondary winding, means, comprising current relays connected in circuit with said secondary winding, for varying the number of effective turns in the primary winding, and means for varying the number of effective turns in the windings of said current relays to vary the value of current flow maintained in said secondary winding.

5. In a furnace-regulator system, the combination with a transformer having a primary and a secondary winding, a resistor connected to said secondary winding, and a plurality of current relays connected to said secondary winding and selectively operated in accordance with the current-flow through said resistor, of a plurality of auxiliary relays controlled by said current relays, and means controlled by said auxiliary relays for varying the number of effective turns in the primary winding to maintain a substantially constant current - flow through said resistor.

6. In a furnace-regulator system, a transformer having a primary and a secondary winding, a furnace resistor connected in circuit with said secondary winding, current relays selectively operated in accordance with the current flow through said secondary winding, auxiliary relays operated by said current relays, means controlled by the auxiliary relays for completing a holding circuit for themselves and for varying the number of effective turns in said primary winding, and means controlled by said current relays for breaking said holding circuits.

7. In a furnace-regulator system, a furnace resistor, a supply circuit, a transformer for connecting the resistor to the supply circuit, current relays operated in accordance with the current flowing through said resistor, means for varying the number of effective turns in the windings of said relays, and means controlled by said relays for varying the number of effective turns in said transformer to maintain a substantially constant current-flow through the furnace resistor.

8. In a furnace-regulator system, the combination with a transformer having a primary winding and a secondary winding, a furnace resistor connected in series with said secondary winding, and current relays selectively operated in accordance with the current flow through said secondary winding, of a plurality of auxiliary relays operated by said current relays, means for holding said auxiliary relays in closed position when operated, and switches controlled by said auxiliary relays for varying the number of effective turns of said primary winding to maintain a substantially constant current-flow through the furnace resistor.

9. In a furnace-regulator system, a supply circuit, a furnace resistor, means for connecting said resistor to the supply circuit and for automatically varying the current-flow through the resistor, means for disconnecting the resistor from the supply circuit in case of abnormal circuit conditions, and means for preventing the connecting of the resistor to the supply circuit in case of abnormal thermal conditions in the resistor circuit.

10. In a furnace-regulator system, a furnace resistor, a supply circuit, means comprising a no-voltage relay and a transformer for connecting said resistor to the supply circuit, means for varying the number of effective turns of said transformer to control the current-flow through said resistor, and means comprising an overload relay for releasing the no-voltage relay to disconnect the resistor from the supply circuit under certain operating conditions.

11. In a furnace-regulator system, a furnace resistor, a supply circuit, means comprising a no-voltage relay for connecting said resistor across the supply circuit, means, comprising an overload relay, for releasing the no-voltage relay under certain operating conditions, and means, comprising a thermal device, for preventing the operation of the no-voltage relay until said resistor has reached a predetermined temperature.

12. In a furnace-regulator system, a furnace resistor, a supply circuit, means for connecting said resistor to the supply circuit, an overload relay controlled by said connecting means and serving to disconnect the resistor from the supply circuit under certain circuit conditions, and means for preventing the operation of said connecting means under certain thermal conditions of the furnace resistor.

13. In a furnace-regulator system, a furnace resistor, a supply circuit, means for connecting said resistor to the supply circuit and for regulating the current-flow through the resistor, an overload relay for disconnecting the resistor from the supply circuit under certain circuit conditions, and means for preventing the operation of said connecting means in case the furnace resistor has been heated above a predetermined temperature.

14. In a furnace-regulator system, a fur-

nace resistor, a supply circuit, means comprising a no-voltage relay for connecting said resistor to the supply circuit, an overload relay for deënergizing the no-voltage relay in case the current flow through the resistor is raised above a predetermined value, and means, comprising a thermal device, for effecting an initial operation of the no-voltage relay and for preventing the operation of the no-voltage relay under certain thermal conditions of the resistor.

15. In a furnace-regulator system, a furnace resistor, a supply circuit, means comprising a no-voltage relay for connecting said resistor to the supply circuit, an overload relay for deënergizing said no-voltage relay under certain circuit conditions and having an energizing winding controlled in accordance with the operative position of said no-voltage relay, and a thermal device for preventing the operation of the no-voltage relay under certain conditions.

16. In a furnace-regulator system, the combination with a supply circuit, a transformer having a primary and a secondary winding, and a furnace resistor connected in circuit with said secondary winding, of a no-voltage relay for connecting said transformer across the supply circuit, means controlled by said no-voltage relay for varying the number of effective turns in said primary winding to govern the current-flow through said resistor, an overload relay controlled by said no-voltage relay and serving to open the circuit of the resistor under certain circuit conditions, and thermal means controlled by the current flow through said resistor for preventing the operation of said no-voltage relay under certain circuit conditions.

17. In an electrical heating system, the combination with a variable source of energy and a heating element having a negative temperature-resistance coefficient adapted to be energized from said source of energy, of means comprising plural-position switches for selectively varying the effect of said source of energy on said heating element.

In testimony whereof, I have hereunto subscribed my name this 29th day of March 1919.

EDGAR M. BOUTON.