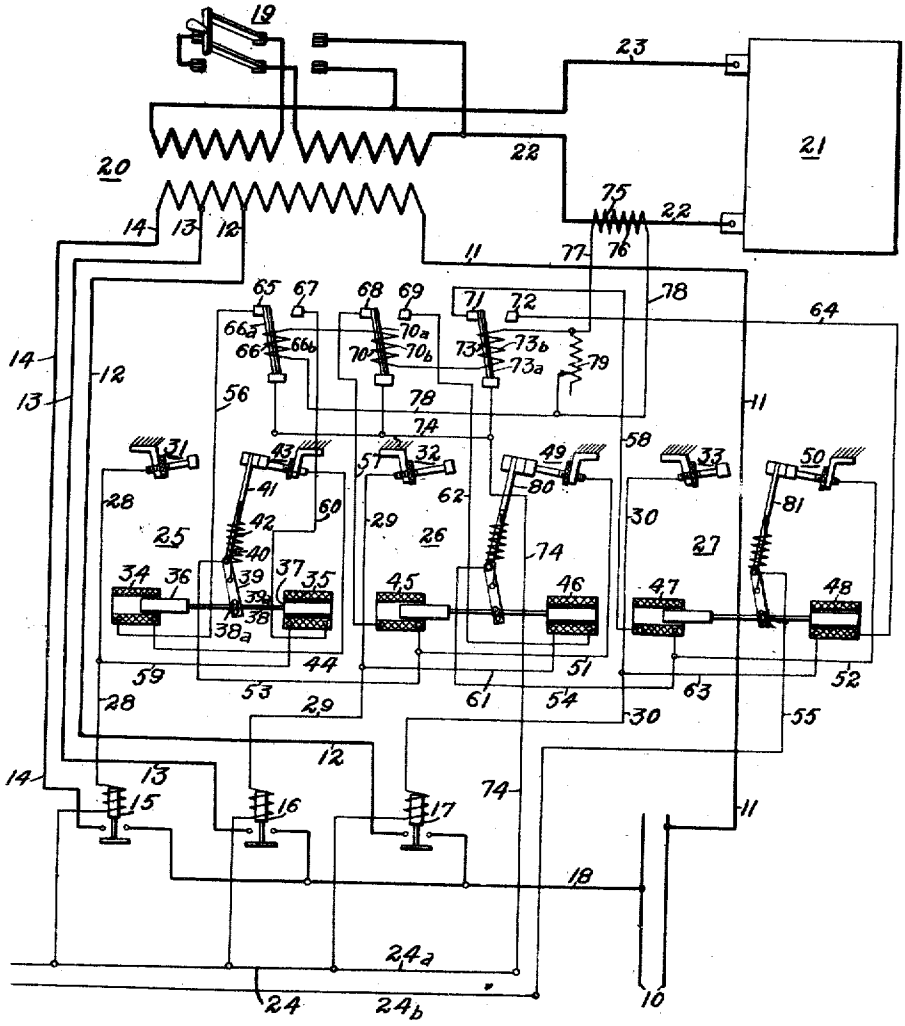
F. THORNTON, JR.

CONTROL SYSTEM FOR ELECTRIC FURNACES.

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1,349,391. Patented Aug. 10, 1920.



WITNESSES:

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CONTROL SYSTEM FOR ELECTRIC FURNACES.

1,349,391. Specification of Letters Patent. Patented Aug. 10, 1920.

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To all whom it may concern:

Be it known that I, FRANK THORNTON, Jr., a citizen of the United States, and a resident of Mansfield, in the county of Richland and State of Ohio, have invented a new and useful Improvement in Control Systems for Electric Furnaces, of which the following is a specification.

My invention relates to electric furnaces and particularly to methods of control for electric-resistance furnaces.

One object of my invention is to provide an automatic system of control for an electric-resistance furnace where the resistor has a negative-temperature-resistance coefficient.

Another object of my invention is to provide an automatic control system for electric-resistance furnaces that shall be simple and easily adjusted and that may be kept in working order by the workmen operating such furnaces.

In operating electric-resistance furnaces that have a negative-temperature-resistance coefficient, it is necessary to apply a higher voltage to the resistor when cold than is required when the resistor is hot. Where a transformer is used to reduce the line voltage to the value required by the furnace, this variable voltage may be obtained by progressively changing the number of effective turns in the primary winding of the transformer, and my invention relates to methods of accomplishing this.

In practising my invention, I provide a transformer having a plurality of spaced taps on the primary winding and a plurality of electrically operated switches to control the connection of the supply circuit to the primary winding, actuating these switches by a corresponding number of double-contact, double-coil relays. These relays are, in turn, controlled by a corresponding number of double-contact, quick-acting thermostats that are caused to operate by a plurality of heating coils of different heating capacities. These heating coils are connected in series and to a source of electromotive force so arranged as to send a current through the heating coils that is directly proportional to the current in the resistor of the furnace. This source of electromotive force may be a current transformer or a series resistance of suitable value connected to a conductor carrying the current traversing the resistor. The relays are electrically interlocked so that not more than one switch may be closed at one time.

The single figure of the drawing is a diagrammatic view of apparatus and circuits embodying my invention. As shown in the drawing, a supply circuit 10 energizes the primary winding of a transformer 20, through a conductor 11, connected to one of the conductors of circuit 10, and selectively controlled conductors 12, 13, or 14, a suitable switch (not shown) being used to interrupt the circuit when the furnace is not in operation. The conductors 12, 13 and 14 terminate at corresponding contact terminals of the electrically operated switches 17, 16 and 15, respectively, the other corresponding contact terminals of these switches being connected to a common return conductor 18 that is connected to the other conductor of the supply circuit 10. The secondary winding of the transformer 20 is divided into halves that may be connected in series or in parallel by a suitable switch 19 and energizes the furnace 21 through two conductors 22 and 23.

A control supply circuit 24 is provided to energize the coils of the electrically operated switches 15, 16 and 17, the circuits through these coils being controlled by double-contact, double coil relays 25, 26 and 27. Corresponding terminals of the coils of switches 15, 16 and 17 are connected to conductor 24^a and the other corresponding terminals to conductors 28, 29 and 30, respectively. Conductor 28 terminates in an adjustable contact terminal 31 of the relay 25, and, similarly, conductors 29 and 30 terminate, respectively, in adjustable contact terminals 32 and 33 of the relays 26 and 27. As relays 25, 26 and 27 are alike, a description of the construction of relay 25 will suffice for the three. Two coils, 34 and 35, are placed a relatively small distance apart, with their axes in alinement. Two soft iron cores, 36 and 37, are operatively connected together by a metal rod 38 of such length that, when the core 37 is wholly within coil 35, the core 36 is partially withdrawn from coil 34. A metal bar 39, is pivotally connected to a stud or pin 40, and has a slot 39^a near its other end. A pin 38^a, secured to rod 38 and projecting through the slot 39^a, serves to actuate the free end of bar 39. A contact lever 41 is also pivot-

ally connected to stud 40 and is provided, at its free end, with two contact-terminal pieces or lugs, in the usual manner. A tension spring 42 is pivotally connected to bar 39 and contact lever 41, at points near their mid-lengths, and operates to preclude lever 41 from moving until bar 39 has been moved, by means of cores 36 and 37 and the connecting rod 38, through the greater part of its turning movement, when it will cause contact lever 41 to turn relatively quickly on its pivot stud 40, thus providing a quick-break switch.

One terminal of coil 34 is connected to an adjustable contact terminal 43 by means of a conductor 44, and, similarly, one terminal of a coil 45 is connected to an adjustable contact terminal 49 by means of a conductor 51, and one terminal of a coil 47 is connected to an adjustable contact terminal 50, by means of a conductor 52. The other terminals of coils 34, 45 and 47 are connected, respectively, to contact terminals 65, 68 and 71 of thermostats 66, 70 and 73, by means of conductors 56, 57 and 58. One terminal of coil 35 is connected to conductor 28 by means of a conductor 59. The corresponding terminal of coil 46 is connected to conductor 29, by means of a conductor 61, and the corresponding terminal of coil 48 is connected to conductor 30, by means of a conductor 63. The other terminal of coil 35 is connected to a contact terminal 67 of a thermostat 66, by means of a conductor 60. The corresponding terminal of coil 46 is connected to a contact terminal 69 of a thermostat 70, by means of a conductor 62, and the corresponding terminal of a coil 48 is connected to the contact terminal 72 of a thermostat 73, by means of a conductor 64. The contact lever 41 is connected to one of the terminals of coil 45, by means of conductor 53, and a contact lever 80 is connected to the corresponding terminal of coil 47, by means of a conductor 54, and a contact lever 81 is connected to conductor 24^b of the control circuit 24, by means of a conductor 55.

Double-contact thermostats 66, 70 and 73 are provided, with their stationary contact terminals connected as stated above, while the fixed end of bi-metallic strips 66^a, 70^a and 73^a are connected to a conductor 74 that is connected to conductor 24^a of the control circuit 24. The strips 66^a, 70^a and 73^a engage the contact terminals 65, 68 and 71, respectively, when cold, and, when heated, become disengaged therefrom and immediately engage contact terminals 67, 69 and 72, respectively. Heating coils 66^b, 70^b and 73^b, that are associated with the respective thermostats 66, 70 and 73, are connected in series and are energized by the secondary coil 76 of a current transformer 75 connected to the conductor 22. If desired, the current transformer may be replaced by a series resistance, as the object of this part of the device is to cause a current to flow through the heating coils that is in direct proportion to the current flowing through the resistor of the furnace. Coil 73^b has the greatest watts loss of the three coils, and coils 70^b and 66^b have each a progressively smaller watts loss. A rheostat 79 is provided in shunt with the heating coils so as to enable the operator to divert part of the current and thus control the working temperature of the furnace, as will hereinafter be more fully described.

Assuming that the position of the various parts is as shown in the drawing, if it is desired to place the control system in operation, the proceeding is as follows: close switch 19 to connect the two halves of the secondary winding of transformer 20 in parallel and energize circuits 10 and 24 by closing the respective control switches (not shown in the diagram). A circuit will be established as follows: from conductor 24^a of circuit 24, through conductor 74, strip 73^a, contact terminal 71, conductor 58, coil 47, and thence, through conductor 52, contact terminal 50, lever 81, conductor 55, to conductor 24^b of circuit 24. A second circuit will be established, as follows: from conductor 24^a, conductor 74, strip 70^a, contact terminal 68, conductor 57, coil 45, and thence, through conductor 51, contact terminal 49, lever 80, conductors 54 and 52, contact terminal 50, lever 81, conductor 55, to conductor 24^b of circuit 24. A third circuit comprises conductor 74, strip 66^a, contact terminal 65, conductor 56, coil 34, conductor 44, contact terminal 43, lever 41, conductors 53 and 51, contact terminal 49, lever 80, conductors 54 and 52, contact terminal 50, lever 81 and conductor 55, to conductor 24^b of circuit 24. These circuits will energize the three coils 34, 45 and 47, causing them to attract their respective soft iron cores, and will operate to give the contact levers 41, 80 and 81 a turning movement on their respective pivots, and the free ends of these levers will engage the respective contact terminals 31, 32 and 33.

A control circuit will be established, through the operating coil of switch 17, as follows: from conductor 24^a of circuit 24, through the coil of switch 17, conductor 30, contact terminal 33, lever 81, and conductor 55, to conductor 24^b of circuit 24. This will cause switch 17 to operate and establish a circuit, as follows: from one conductor of circuit 10, through conductor 18, the contact terminals and contact bridging member of switch 17, conductor 12, a part of the primary winding of the transformer 20 and conductor 11, to the other conductor of circuit 10. As a relatively small number of turns of the primary winding of transformer 20 is included in the circuit, the sec-

ondary voltage of the transformer will be relatively high and will cause a current to flow through the cold resistor of the furnace 21. The temperature of the resistor will increase and the resistance will, therefore, decrease, resulting in an increase in the current value. An electromotive force will be induced in the secondary winding 76 of the transformer 75 that will cause a current to flow through the heating coils 66^b, 70^b and 73^b in series and also through the rheostat 79 if same is connected in circuit. As heating coil 73^b has the largest watts loss of the three coils, the thermostat strip 73^a will be caused to move first and will be disengaged from its contact terminal 71 and immediately will engage contact terminal 72. This operation will interrupt the control circuit through the coil of switch 17, permitting this switch to open and deënergize the transformer. As soon as strip 73^a engages contact terminal 72, the following control circuit is established: from conductor 24^a of circuit 24, through conductor 74, strip 73^a, contact terminal 72, conductor 64, coil 48, conductors 63 and 30, contact terminal 33, lever 81 and conductor 55, to conductor 24^b of circuit 24. This will cause coil 48 to attract its coöperating core member and will result in contact lever 81 having a turning movement, causing its free end to engage contact terminal 50. A new control circuit is thereby established, as follows: from conductor 24^a of circuit 24, through the coil of switch 16, conductor 29, contact terminal 32, lever 80, conductors 54 and 52, contact terminal 50, lever 81 and conductor 55, to the conductor 24^b of circuit 24. This will cause switch 16 to operate and close a circuit, as follows: from one conductor of circuit 10, through conductor 18, the contact terminals and contact bridging member of switch 16, conductor 13, the primary winding of transformer 20 and conductor 11, to the other conductor of the supply circuit 10. A relatively large number of turns of the primary winding will, therefore, be included in the circuit, and the secondary voltage impressed on the resistor of the furnace 21 will be correspondingly decreased.

If the resistance of the furnace 21 continues to decrease, with a corresponding increase of current through it and through the conductor 22, the derived current through the secondary winding 76 and through the heating coils 66^b, 70^b and 73^b will increase and, at a predetermined value of current, the amount of heat generated in the coil 70^b will cause the strip 70^a to be disengaged from its coöperating contact terminal 68 and to immediately engage contact terminal 69. A circuit will thereby be established, as follows: from conductor 24^a of circuit 24, through conductor 74, strip 70^b, contact terminal 69, conductor 62, coil 46, conductors 61 and 29, contact terminal 32, lever 80, conductors 54 and 52, contact terminal 50, lever 81 and conductor 55, to conductor 24^b of circuit 24. This will cause coil 46 to attract its coöperating core member and cause the contact lever 80 to be disengaged from contact terminal 32 and immediately to engage contact terminal 49. This operation serves to interrupt the circuit through the coil of switch 16, thereby causing said switch to open and interrupt the circuit through the primary winding of transformer 20 and deënergize the same.

A new control circuit has been established by the turning movement of lever 80, as follows: from conductor 24^a of circuit 24, through the coil of switch 15, conductor 28, contact terminal 31, lever 41, conductors 53 and 51, contact terminal 49, lever 80, conductors 54 and 52, contact terminal 50, lever 81 and conductor 55 to conductor 24^b of circuit 24. This will cause switch 15 to operate and close a circuit, as follows: from one conductor of circuit 10, conductor 18, the contact terminals and contact bridging member of switch 15, conductor 14, the primary winding of transformer 20 and conductor 11, to the other conductor of circuit 10. A still larger number of turns of the primary winding will be included in the circuit, and, therefore, the secondary voltage will be still smaller. Within normal limits, the secondary voltage should now be low enough to permit only such current to flow through the resistor as will maintain the temperature at a constant value. If, however, the temperature rises still further, resulting in a further decrease of resistance, and, hence, an increase of current, the derived current in the heating coils, and especially in the heating coil 66^b, will become large enough to cause the strip 66^a to be disengaged from the contact terminal 65 and to engage contact terminal 67. This action will result in closing a new control circuit, as follows: from conductor 24^a of circuit 24, through conductor 74, strip 66^a, contact terminal 67, conductor 60, coil 35, conductors 59 and 28, contact terminal 31, lever 41, conductors 53 and 51, contact terminal 49, lever 80, conductors 54 and 52, contact terminal 50, lever 81 and conductor 55, to conductor 24^b of circuit 24. This will cause relay 25 to operate, and lever 41 will engage contact terminal 43, interrupting the circuit through the coil of switch 15, causing it to operate and interrupt the circuit through the primary winding of transformer 20. The transformer will, therefore, be deënergized and the furnace 21, as well as the heating coil 66^b, will begin to cool, and, after a predetermined lower temperature has been reached, the strip 66^a will be disengaged from contact terminals 67 and engage contact terminal 65.

The control circuit through the coil of switch 15 will be reëstablished, and this switch will operate to close the circuit through conductor 14, thereby reënergizing the transformer 20 and causing current to again flow through the resistor.

If it is desired to change the operating temperature of the furnace, the rheostat 79 may be adjusted to accomplish this object. As the adjusting handle of the rheostat is moved to decrease the resistance included in the circuit in shunt with the heating coils, more current will be diverted from the heating coils, and, therefore, the current through the resistor of furnace 21 must be greater before the thermostats will operate in the manner described above. Switch 19 may be used to connect the two halves of the secondary winding of transformer 20 in parallel or in series to enable extreme voltage requirements to be met, and is not a part of my invention.

It is clear that various modifications and changes may be made without departing from the spirit and scope of my invention, and I desire that only such limitations shall be placed thereon as are imposed by the prior art or are specifically set forth in the appended claims.

I claim as my invention:

1. In an electrical heating system, the combination with a variable source of energy and a heating element having a negative-temperature-resistance coefficient the temperature of which is to be regulated, a supply circuit, a transformer having a plurality of spaced taps on the primary winding, and a plurality of electromagnetically operated switches for controlling the connections of the supply circuit to the primary winding of the transformer, of a plurality of plural-position switches for actuating said electromagnetically operated switches, and temperature-actuated means for controlling said plural-position switches.

2. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient the temperature of which is to be regulated, a supply circuit, a transformer having a plurality of spaced taps on the primary winding, and a plurality of electromagnetically operated switches for controlling the connection of the supply circuit to the primary winding of the transformer, of a plurality of plural-position switches for actuating said electrically-operated switches, temperature-controlled means for controlling said plural-position switches, and an auxiliary heating element out of thermal communication with the main heating element for actuating said temperature-controlled means.

3. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a plurality of spaced taps on the primary winding, and a plurality of electrically-operated switches for controlling the connection of the supply circuit to the primary winding of said transformer, of plural-position switches for actuating said electrically-operated switches, thermostats for controlling said plural-position switches, and an auxiliary heating element out of thermal communication with the main heating element for actuating said thermostats.

4. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a plurality of spaced taps on the primary winding, and a plurality of electrically operated switches for controlling the connections of the supply circuit to the primary winding of the transformer, of a plurality of plural-position switches for causing said electrically operated switch to operate in predetermined order, thermostats for actuating said plural-position switches, and an auxiliary heating element out of thermal communication with the main heating element for actuating said thermostats.

5. In an electrical heating circuit, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a plurality of spaced taps on the primary winding, and a plurality of electrically operated switches for controlling the connection of the supply circuit to the primary winding of said transformer, of plural-contact relays for causing said electrically operated switches to operate on predetermined order, a plurality of double-contact thermostats for actuating said relays, and an auxiliary heating element out of thermal communication with the main heating element for actuating said thermostats.

6. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having an adjustable primary winding, and a plurality of electromagnetically operated switches for controlling the number of turns of the primary winding connected to said supply circuit, of plural-contact relays for operating said electromagnetically operated switches, a plurality of double-contact thermostats for actuating said relays, and an auxiliary heating element having a plurality of sections of different heating capacities out of thermal communication with the main heating element for actuating said thermostats.

7. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance

coefficient, a supply circuit, a transformer having a primary and a secondary winding, said primary winding being provided with spaced taps and said secondary winding being connected to said main heating element, and electromagnetic switches governing the connection of the supply circuit to said taps, of plural-contact relays for causing said electrical switches to vary the number of turns of the primary winding connected to said supply circuit, a plurality of double-contact thermostats for actuating said relays, and an auxiliary heating element out of thermal communication with the main heating element and receiving current in proportion to, and derived from, the current in said main heating element for actuating said thermostats.

8. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a primary winding and a secondary winding, said primary winding being provided with spaced taps and said secondary winding being connected to said main heating element, and electromagnetic switches governing the connection of the supply circuit to said taps, of plural-contact relays for causing said electromagnetic switches to vary the number of turns of the primary winding connected to said supply circuit, a plurality of double-contact thermostats for actuating said relays, an auxiliary heating element out of thermal communication with the main heating element and receiving current in proportion to, and derived from, the current in said main heating element for actuating said thermostats, and means for varying the proportion between the two current values.

9. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a primary and a secondary winding, said primary winding being provided with spaced taps and the secondary winding being connected to said main heating element, and electromagnetic switches governing the connection of the supply circuit to said taps, of plural-contact, plural-coil relays for causing said electromagnetic switches to progressively increase the number of turns of the primary winding connected to the supply circuit, a plurality of double-contact thermostats adapted to control said relays, and an auxiliary heating element out of thermal communication with the main heating element for actuating said thermostats in predetermined order.

10. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a primary and a secondary winding, said primary winding being provided with spaced taps and said secondary winding being connected to the main heating element, and electromagnetic switches governing the connection of the supply circuit to said taps, of plural-contact, plural-coil relays for controlling said electromagnetic switches, a plurality of double-contact thermostats adapted to control said relays, and an auxiliary heating element out of thermal communication with the main heating element for actuating said thermostats in predetermined order, whereby a substantially constant current is maintained in said main heating element.

11. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a primary winding provided with spaced taps and a secondary winding connected to said main heating element, and a plurality of electromagnetic switches for selectively connecting said taps to said supply circuit, of plural-contact, plural-coil relays for controlling said electromagnetic switches, means, comprising a thermostat, for actuating one of said relays, to cause its coöperating electromagnetic switch to open and to interrupt the circuit through the primary winding of said transformer, and an auxiliary heating coil for controlling said thermostat, said auxiliary heating coil being energized by a current derived from, and proportional to, the current in the main heating element and arranged to cause said thermostat to operate whenever the current through said main heating element exceeds a predetermined value.

12. In an electrical heating element, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a primary winding provided with spaced taps and a secondary winding connected to said main heating element, and a plurality of electromagnetic switches for selectively connecting said taps to the supply circuit, of plural-contact, plural-coil relays for controlling said electromagnetic switches, a double-contact thermostat for actuating one of said relays, an auxiliary heating element for controlling said thermostat, said auxiliary heating element being energized by a current derived from, and proportional to, the current in the main heating element, and arranged to cause said thermostat to actuate one of said relays to cause its coöperating electromagnetic switch to interrupt the circuit through the primary winding of said transformer whenever the current through said main heating element exceeds a predetermined amount and to restore the circuit through the pri-

mary winding after a predetermined lower temperature is reached.

13. In an electrical heating system, the combination with a main heating element having a negative-temperature-resistance coefficient, a supply circuit, a transformer having a primary winding provided with spaced taps and a secondary winding connected to said main heating element, and a plurality of electromagnetic switches governing the connection of said supply circuit to said taps, of a plurality of double-contact, double-coil, relays for controlling the operation of said electromagnetic switches, said relays being electrically interlocked to preclude more than one electromagnetic switch being closed at one time, a plurality of double-contact thermostats adapted to actuate said relays, and an auxiliary heating coil out of thermal communication with the main heating coil for controlling said thermostats.

14. In an electrical heating system, the combination with a variable source of energy and a main heating element having a negative temperature-resistance coefficient adapted to be energized from said source of energy, of means for selectively varying the effect of said source of energy on said heating element, said means comprising a plurality of plural-position relays, thermostats for controlling said relays, and an auxiliary heating element out of thermal communication with the main heating element and receiving current in proportion to, and derived from, the current in said main heating element for actuating said thermostats.

15. In an electrical heating system, the combination with a variable source of energy and a main heating element having a negative temperature-resistance coefficient adapted to be energized from said source of energy, of means for selectively varying the effect of said source of energy on said heating element, said means comprising a plurality of plural-position relays, thermostats for controlling said relays, an auxiliary heating element out of thermal communication with the main heating element and receiving current in proportion to, and derived from, the current in said main heating element for actuating said thermostats, and means for varying the proportion between the two current values.

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

FRANK THORNTON, JR.