

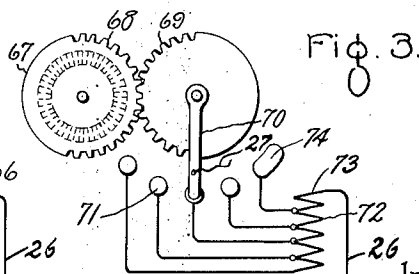
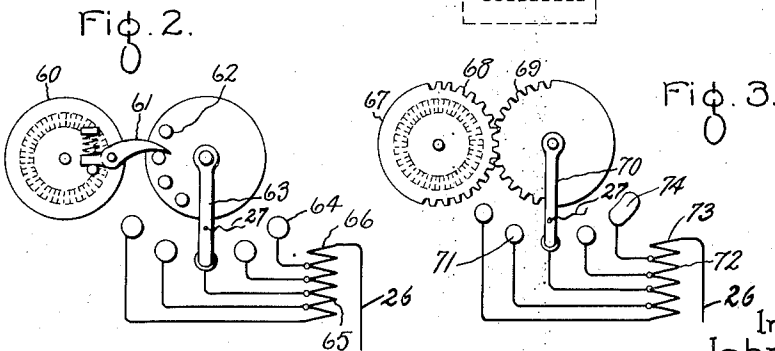
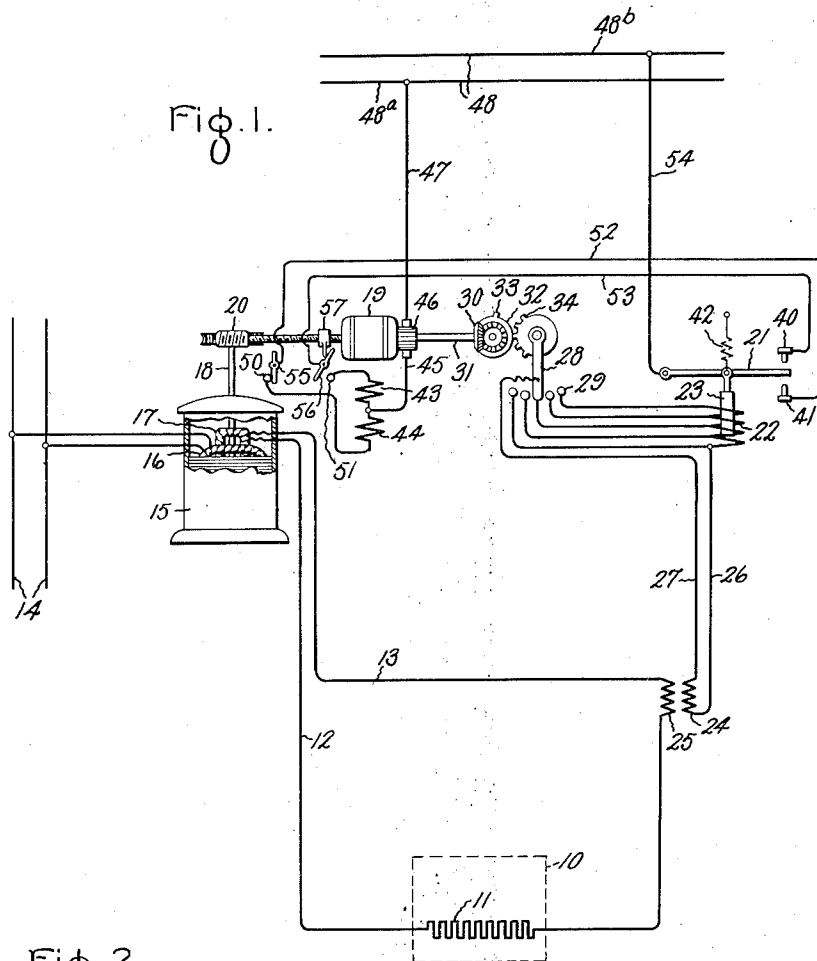
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REGULATOR FOR ELECTRIC HEATERS

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UNITED STATES PATENT OFFICE.

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REGULATOR FOR ELECTRIC HEATERS.

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To all whom it may concern:

Be it known that I, JOHN A. SEEDE, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Regulators for Electric Heaters, of which the following is a specification.

My invention relates to regulators for electric heaters and has for its object the provision of means for regulating the heater in such manner that the power input variations are confined to comparatively narrow limits.

More particularly my invention relates to regulators for electric heaters provided with a heating resistor having a marked temperature coefficient of resistance, for example, a resistor made of carbon which has a negative temperature coefficient of resistance. Another example of such a heating resistor is provided in furnaces by the use of the charge itself as the resistor, where the resistance of the charge decreases as the heating or chemical action progresses. In accordance with my invention I control the power input by regulating the voltage applied to the resistor in response to the current in the resistor and change the setting of the current responsive device when the voltage is changed.

For a more complete understanding of my invention reference should be had to the accompanying drawing in which Fig. 1 is a diagrammatic view of a regulator for electric heaters embodying my invention; while Figs. 2 and 3 are fragmentary views of modifications of my invention.

Referring to Fig. 1 of the drawing, in one embodiment of my invention the electric furnace 10 to be regulated is provided with a resistor 11 which has a marked negative temperature coefficient of resistance. Obviously, however, my invention is applicable to resistors having a positive temperature coefficient of resistance. The resistor 11 is connected through conductors 12 and 13 to a suitable source of electrical supply 14, a voltage regulator 15 being interposed in the connections 12 and 13 between the resistor and the supply source 14. Any suitable type of voltage regulator may be used. The regulator 15 is shown diagrammatically as an induction regulator having a fixed coil 16 and a movable coil 17 inductively cooperat-

ing with the coil 16 and rotatable with relation thereto on its supporting shaft 18. It will be understood that rotation of shaft 18 changes the inductive relation of the coil 17 with relation to the coil 16 and varies the voltage impressed on the resistor in a well known manner. The regulator 15 is actuated by an electric motor 19 which is operatively connected to the shaft 18 by means of suitable gearing 20 shown as comprising a worm and worm gear.

The electric motor 19 is controlled by means of a contact arm 21 actuated by an operating coil 22 which is provided with an armature 23 pivotally connected to the arm 21. This operating coil 22 is connected in series with the secondary 24 of a current transformer having its primary 25 connected in circuit with the resistor 11. One terminal of the coil 22 is connected by conductor 26 directly to one terminal of the secondary 24. The other terminal of the secondary is connected by the conductor 27 to the contact arm 28 which is arranged to successively engage with a series of contacts 29 forming taps for the coil 22, the arrangement being such that as the contact arm moves toward the right more turns are inserted in circuit with the secondary 24 of the current transformer. The contact arm 28 is operatively connected to the motor 19 by means of gears comprising a bevel gear 30 on the shaft 31 of the motor driving a gear 32 provided with a single tooth 33 which is arranged to engage teeth 34 of a gear secured to the arm 28. Cooperating with the contact arm 21 are two stationary contacts 40 and 41 between which the contact arm moves. A spring 42 is connected to the contact arm and tends to pull it upward into engagement with contact 40. When the electromagnetic attraction of coil 22 for the armature 23 is strong enough to overcome spring 42, the contact arm will be moved to a position midway between the stationary contacts and when a stronger attractive force is applied to the armature the contact arm will be pulled downward into engagement with contact 41.

Preferably, the motor 19 is of a series type and is provided with two oppositely wound series fields 43 and 44 which have their adjacent terminals connected to a conductor 45 which leads through the armature 46 of the motor and thence through conductor 47 to a

supply main 48^a forming one side of a suitable electric supply source 48. The opposite terminals of the field coils 43 and 44 are connected through limit switches 50 and 51 by way of conductors 52 and 53 to the stationary contacts 40 and 41 respectively. The contact arm 21 is connected by a conductor 54 to a supply main 48^b forming the other side of the supply source 48. It will be thus observed that when the contact arm 21 is moved upward into engagement with contact 40, a circuit for motor 19 is closed from supply main 48^b through conductor 54, the contact arm, conductor 53, field coil 43, and thence through the armature of the motor and conductor 47 to supply main 48^a, whereby the motor is caused to rotate in a direction to increase the voltage impressed on the resistor 11. When the contact arm 21 is pulled downward into engagement with contact 41, a circuit is closed from supply main 48^b through conductor 54, the contact arm, conductor 52, field coil 44, and thence through the armature of the motor and conductor 47 to the supply main 48^a, whereby the motor is caused to rotate in the opposite direction and decrease the voltage impressed on the resistor.

The winding 17 of the voltage regulator has a range of movement of 180 degrees from maximum voltage position to minimum voltage position and when it has been moved to either of these positions by the motor, the motor circuit is automatically broken by one or the other of the limit switches 50 and 51. The limit switches may be of any suitable type, and they are shown diagrammatically as comprising contact arms 55 and 56 which normally cooperate with stationary contacts and which are moved to disengagement from the contacts and open the motor circuit by means of a traveling nut 57 on the threaded shaft 31 of the motor. As shown in the drawing the induction regulator is in its maximum voltage position and the nut 57 is holding contact arm 56 in open circuit position to prevent further rotation of the motor in this direction, although the motor circuit may be closed to cause rotation in the opposite direction to reduce the voltage. In this position of the regulator it will be noted that the tooth 33 is substantially 90° of angular movement removed from engagement from the teeth 34.

In the operation of the regulator shown in Fig. 1, the contact arm 28 will be initially set on some one of the contacts 29, except the one farthest to the right, depending on the temperature at which the furnace is desired to operate. The circuit to the resistor 11 will then be closed from the source 14 through a suitable switch (not shown) and the furnace will heat up. As the temperature increases, the resistance of the re-

sistor 11 will decrease so that the current in the resistor will correspondingly increase. Upon the occurrence of a predetermined maximum current in the resistor corresponding to a certain temperature, the magnetic attraction of coil 22 will be sufficient to pull contact arm 21 downward into engagement with contact 41 whereby the motor is caused to operate in a direction to decrease the voltage. Eventually as the voltage is decreased by operation of the motor, the tooth 33 will engage with one of the teeth 34 and move the contact arm 28 to the right into engagement with the next stationary contact 29. This occurs at a point substantially midway of the two extreme positions of the voltage regulator. When the contact arm 28 is moved to the right, more turns of coil 22 are included in the circuit with the secondary 24 so that the contact arm 21 is held more firmly downward into engagement with contact 41. The motor 19 then continues to operate to reduce the voltage until the current in the resistor has been lowered to such a value that the contact arm 21 is pulled upward by spring 42 out of engagement with contact 41, whereby the motor circuit is opened. Also, the motor may be stopped by the opening of limit switch 50 should the voltage regulator reach the minimum voltage position.

This reduced voltage, however, is not sufficient to maintain the desired temperature of the furnace and therefore the furnace cools with resulting decrease in current in the resistor 11 due to its negative temperature coefficient. When the current in the resistor reaches a predetermined minimum value, the contact arm will be pulled upward by spring 42 into engagement with contact 40 whereby the motor will be caused to operate in a direction to increase the voltage. As the voltage is increased the tooth 33, eventually, will again engage one of the teeth 34 and move the contact arm 28 to the left back to its original position. This decreases the number of turns of coil 22 in circuit with secondary winding 24, and the motor continues to operate until the current in the resistor has been raised to such a value that the contact arm is pulled downward by coil 22 out of engagement with contact 40, whereby the motor circuit is opened.

Also, the motor circuit may be opened by limit switch 51 should the regulator reach the maximum voltage position. The temperature of the furnace will now increase and as the furnace continues to operate the cycle previously described will be repeated. It will be observed that the voltage is first gradually decreased to a certain value whereby a maximum value of current is maintained in the resistor, and is then decreased in one step to a lower value at

which the furnace cools, whereupon the voltage is gradually increased to a certain value whereby a minimum value of current is maintained in the resistor, after which the voltage is increased in one step back to a higher value at which the furnace temperature increases. In this manner it will be observed that the variations in power input are confined to relatively narrow limits so that a desirable load is obtained.

In the modified form shown in Fig. 2 the gear 60, corresponding to gear 32 of Fig. 1, is provided with a pawl 61 which engages with one of the pins 62 as the gear 60 rotates in a clockwise direction so as to move the contact arm 63 to the right into engagement with the next tap 64 of the operating coil 65, corresponding to coil 22 of Fig. 1. In this modification the taps 64 are so arranged that turns are cut out when the contact arm 63 is moved toward the right whereby the motor circuit is immediately reversed and the regulator moved back toward maximum voltage position until the motor circuit is opened by contact arm 21 or limit switch 50 as previously described. When gear 60 moves in a counter clockwise direction the ratchet 61 slips by the pins 62. In this modification therefore the regulator will be moved back and forth from maximum position to a position midway between the maximum and minimum positions until the contact arm 63 has cut out as many turns of coil 65 as possible whereupon the motor will be controlled by the remaining turns 66 to drive the regulator to the minimum voltage position where it will remain during the remainder of the heat.

In the modified form of my invention shown in Fig. 3 the gear 67, corresponding to gear 32 of Fig. 1, has teeth 68 over one-half of its periphery which cooperate with similar teeth 69 carried by the contact arm 70 which it actuates. Contacts 71 forming taps on the coil 72, corresponding to coil 22 of Fig. 1, are arranged in this modification also so that turns of coil 72 are cut out when contact arm 70 is moved toward the right. In this form of my invention the motor will be controlled to move the regulator gradually from maximum voltage to minimum voltage position and at the same time the heating current will be gradually increased, the coil 72 being cut out in such small steps that the motor is not reversed in going from one step to another. At the end of the heat the contact arm 21 is held down by the remaining turns 73 so that reversal of the motor is prevented. To prevent the opening of the circuit of coil 72, the contact 74 farthest to the right is elongated in the form of a segment. The arrangement of this modification of my invention is such that a very nearly constant power input is maintained throughout the entire heat.

While I have described my invention as embodied in concrete form and as operating in a specific manner in accordance with the provisions of the patent statutes, it should be understood that I do not limit my invention thereto, since various modifications thereof will suggest themselves to those skilled in the art without departing from the spirit of my invention, the scope of which is set forth in the annexed claims.

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

1. A regulator for electric resistance heaters in which the heating resistance changes as the heating operation proceeds comprising means responsive to the current in said resistance for varying the voltage impressed on said resistance inversely in proportion to the current so as to maintain a substantially constant power input.
2. A regulator for electric resistance furnaces in which the heating current increases as the heating operation proceeds comprising means responsive to said current for reducing the voltage impressed on the heating resistance in proportion to the increase in said current so as to maintain a substantially constant power input.
3. A regulator for electric resistance heaters in which the heating current increases as the heating operation proceeds comprising means responsive to the current in said resistance for reducing the voltage impressed on said resistance as the current increases and for decreasing its own sensitivity to said current in such manner that the current increases inversely in proportion to the decrease in voltage, whereby a substantially constant power input is maintained.
4. A regulator for electric resistance heaters in which the heating resistance changes as the heating operation proceeds, comprising means responsive to the current in said heating resistance for concurrently varying the voltage impressed on the resistor and its own current setting, whereby a substantially uniform power input is maintained.
5. A regulator for electric resistance heaters in which the heating resistance changes as the heating operation proceeds, comprising means for regulating the voltage impressed on said heating resistance, means responsive to the current in said heating resistance for controlling said voltage regulating means, and means operated concurrently with said voltage regulating means for changing the setting of said current responsive means, whereby a substantially uniform power input is maintained.
6. A regulator for electric resistance heaters in which the heating resistance changes as the heating operation proceeds, comprising means for regulating the voltage impressed on said heating resistance, a motor for actuating said voltage regulating means,

control means for said motor responsive to the current in said resistance, and means actuated by said motor for changing the current setting of said control means when the voltage is varied, whereby a substantially uniform power input is maintained.

7. A regulator for electric resistance heaters in which the heating resistance changes as the heating operation proceeds, comprising in combination with a source of electrical supply for said resistance, a voltage regulator interposed in the connections between said source and said resistance, a motor operatively connected to said voltage regulator, means for controlling said motor including an operating coil energized in accordance with the current in said resistor, and means driven by said motor for changing the number of effective turns included in said coil.

8. A regulator for electric resistance heaters in which the heating resistance changes as the heating operation proceeds, compris-

ing in combination with a source of electrical supply for said resistance, a voltage regulator interposed in the connection between said source and said resistance, an electric motor operatively connected to said voltage regulator, limit switches for opening the circuit of said motor in the maximum and minimum voltage positions of said regulator, a contact device for controlling said motor, an operating coil for controlling said contact device energized in accordance with the current in said resistance, taps on said coil, a contact arm cooperating with said taps so as to vary the number of effective turns in said coil, and a driving connection between said contact arm and said motor, whereby operation of said motor to change the voltage impressed on said resistance varies the effective turns in said coil.

In witness whereof, I have hereunto set my hand this 6th day of May, 1924.

JOHN A. SEEDE.