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C. A. BODDIE.
FURNACE REGULATOR SYSTEM.
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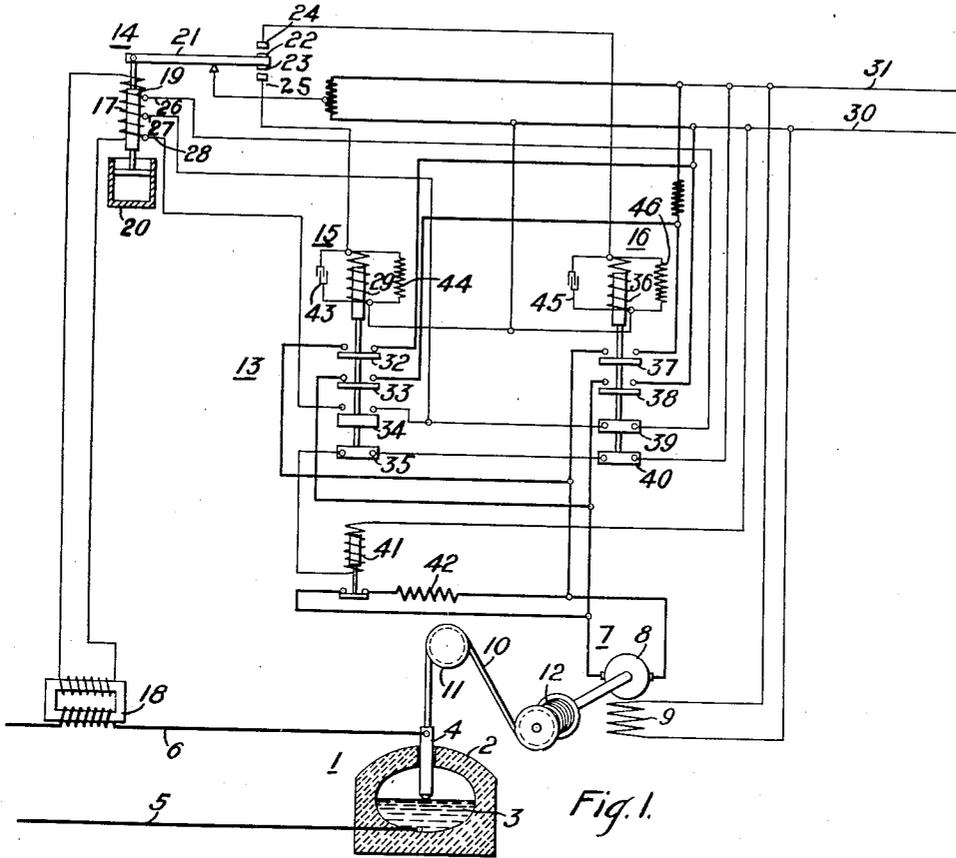


Fig. 1.

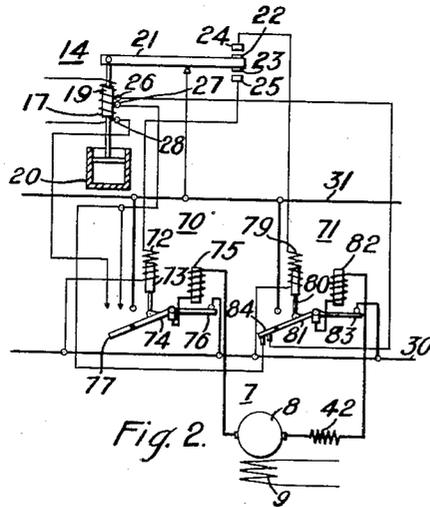


Fig. 2.

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FURNACE-REGULATOR SYSTEM.

Application filed April 4, 1919. Serial No. 287,612.

To all whom it may concern:

Be it known that I, CLARENCE A. BODDIE, a citizen of the United States, and a resident of Pittsburgh, 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 regulator systems for governing the operation of electric furnaces.

One object of my invention is to provide a furnace-regulator system that shall be simple and effective in operation to maintain a fixed arc between the movable electrode and the bath of material being treated and one that shall be provided with means for ensuring the regulator against any so-called "hunting action."

In an electric furnace of the movable-electrode type, it is necessary to keep adjusting the electrode, relative to the bath of material being treated, in order to maintain the power supplied to the furnace substantially constant. Adjustment of the electrode by hand is impracticable, inasmuch as it requires the constant attention of an operator to regulate such furnace and, moreover, it is difficult to obtain satisfactory or close regulation of the furnace by such method.

Heretofore, the regulation or adjustment of the movable electrode has been accomplished by means of a regulator which is operative in accordance with the current flowing through the furnace or in accordance with the voltage obtaining between the movable electrode and the bath of material being treated. However, such operation has proven defective in many cases by reason of failure to provide reliable and effective means for preventing a hunting action by the regulator.

In a furnace-regulator system constructed in accordance with my invention, the movable electrode is raised and lowered, relative to the bath of material being treated, by means of a motor which is controlled by the current flowing through the furnace in a manner to prevent overtravel or the so-called hunting action by it.

In detail, my regulator system comprises a main control electromagnet which is operated directly in accordance with the current flowing through the furnace and two

switches which are governed by the main control electromagnet. The two switches are provided with main switch members for operating the electrode motor in a forward and in a reverse direction in order to adjust the positioning of the movable electrode. The switches are further provided with interlock switch members for establishing a braking circuit through the electrode motor upon release of the switches and with two interlock switch members for varying the number of effective turns in the winding of the main control magnet in a manner to prevent a hunting action by the regulator.

The two interlock switch members which control the number of effective turns included in the winding of the main control magnet are respectively mounted on the two motor-controlling switches and increase or decrease the number of effective turns in the winding of the main control magnet according to whether the movable electrode is being lowered to increase the current-flow through the furnace or is being raised to decrease the current-flow to the furnace. Thus, in case the current flow through the furnace is above normal value, the main control magnet is energized for operating one of said main switches to effect rotative movement of the electrode motor in such direction that the electrode is raised from the bath of material being treated to decrease the current-flow through the furnace. Simultaneously with the operation of the electrode motor, one of said interlock switch members is operated to short-circuit a portion of the winding of the main control magnet and, accordingly, to permit the de-energization of the electrode motor just previous to obtaining normal current-flow in the furnace. Thus, the regulator is prevented from over-travelling and, if the furnace current is still above normal value, the above operation is repeated.

When the current-flow through the furnace is below normal value, then the number of effective turns included in the winding of the main control magnet is decreased upon actuation of the electrode motor, inasmuch as the electrode motor, during such operation, is stopped by increasing the energization of the main control electromagnet.

In the accompanying drawing, Figure 1 is a diagrammatic view of a furnace-regu-

lator system constructed in accordance with my invention, and Fig. 2 is a modification of the furnace system illustrated in Fig. 1.

Referring to Fig. 1 of the drawing, an electric furnace 1, comprising a receptacle 2 containing a bath of material 3 and a movable electrode 4, is connected to a supply circuit comprising conductors 5 and 6. The movable electrode 4 is raised and lowered by a motor 7, comprising an armature 8 and a field winding 9, in any suitable manner, as by a flexible connector 10, a pulley 11 and a drum 12, which is rigidly mounted upon the armature shaft of the motor. The field winding 9 is connected across a supply circuit comprising conductors 30 and 31.

A regulator 13 for operating the motor 7 in accordance with the current flowing through the furnace is provided, and comprises chiefly a main control electric magnet 14 and two electrically operated switches 15 and 16. The main control magnet 14 embodies an energizing coil 17, which is connected to the supply conductor 6 by means of a current transformer 18, and a core armature 19, the operation of which is adjusted by means of a dash-pot 20. The core armature 19 is pivotally connected to a contact arm 21 having main contact terminals 22 and 23 mounted on it. The two contact terminals are respectively moved to engage contact members 24 and 25 in accordance with the operation of the main contact magnet. The energizing coil 17 of the magnet 14 is provided with three taps 26, 27 and 28 extending therefrom for a purpose to be described hereinafter.

The electrically operated switch 15 embodies an energizing coil 29 which is connected across the supply conductors 30 and 31, by the engagement of the main contact members 23 and 25, and two main switch members 32 and 33 which connect the motor 7 across the supply conductors 30 and 31 for operating it in a counter-clockwise direction to raise the member 4. The switch 15 is further provided with two interlock switch members 34 and 35. The interlock switch member 34 serves to short circuit that portion of the winding 17 which is included between the taps 27 and 28 whenever the switch 15 is operated to energize the motor 7.

The electric switch 16 embodies an energizing coil 36, which is connected across the supply conductors 30 and 31 by the engagement of the main contact members 22 and 24, two main switch members 37 and 38 which connect the motor 7 across the supply conductors 30 and 31 for rotating it in a clockwise direction to lower the electrode 4 and two interlock switch members 39 and 40. The interlock switch member 39 serves, upon operation of the switch 16, to open the short-circuit normally existing

across the taps 26 and 27 of the winding 17. The two interlock switch members 35 and 40 serve to connect the supply conductors 30 and 31 to a relay 41 upon release of the two switches 15 and 16. The relay 41, upon operation, completes a dynamic braking circuit for the motor 7 through a resistor 42.

In order to improve the operation of the main contact members, the winding 29 of the switch 15, is shunted by a condenser 23 and a resistor 44, and the winding 36 of the switch 16 is shunted by the condenser 45 and a resistor 46.

Assuming the system to be in the position shown in Fig. 1 and the current-flow through the furnace 1 to be raised above normal value, then the main control magnet 14 is energized in a manner to connect the main contact members 23 and 25. Upon engagement of the contact members 23 and 25, a circuit is completed which extends from the supply conductor 31, through the contact arm 21, contact terminals 23 and 25 and the energizing coil 29 of the switch 15 to the supply conductor 30. Thereupon, the switch 15 is operated to complete a circuit from the supply conductors 30 and 31 through the motor 7 to operate it in a counter-clockwise direction. The circuit through the motor extends from the supply conductor 30 through the main switch member 32, armature 8 of the motor 7 and the main switch member 33 to the supply conductor 31. Thus, the motor 7 is operated in a counter-clockwise direction to raise the electrode 4 from the bath of material 3 and to reduce the current flow through the furnace.

If the motor 7 were controlled solely by the effect upon the main control magnet 14 of the current supplied to the furnace, the main control magnet 14 would not be operated to stop the motor 7 until normal current obtained in the supply conductors 5 and 6. Consequently, by reason of the inertia of the various moving parts of the regulator, it is seen that the motor 7 would overtravel to raise the electrode 4 beyond the desired point and, accordingly, to reduce the current-flow in the furnace below normal value. In order to prevent such overtravel, the interlock switch 34 is provided for changing the number of effective turns included in the winding 17 of the main control magnet 14. Thus, when the switch 15 is operated, the interlock switch member 34 short-circuits that portion of the winding 17 which is included between the taps 27 and 28 and, consequently, the main control magnet 14 is operated to separate the main contact members 23 and 25 and stop the motor just previous to the obtaining of normal current-flow through the furnace.

In case the current flow through the fur-

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nace drops below normal value, then the main control magnet 14 is operated to effect engagement between the main contact members 22 and 24. Upon engagement of the contact members 22 and 24, a circuit is completed from the supply conductors 30 and 31 through the energizing coil 36 of the switch 16. Thereupon, a circuit is completed from the supply conductors 30 and 31 through the main switch members 37 and 38 for operating the motor 7 in a clockwise direction to effect a lowering of the electrode 4. Simultaneously with the operation of the motor 7, the interlock switch member 39 opens the short-circuit which exists across the taps 26 and 27 of the winding 17 in order to change the setting of the main control magnet 4 in a manner to prevent any hunting action by the regulator. Thus, just previous to the raising of the current-flow through the furnace to normal value by lowering the electrode 4, the main control magnet 14 is operated to effect the separation of the main contact members 22 and 24. Thereupon, the motor 7 is de-energized in a manner to prevent any overtravel by it.

It will be noted that at each operation of the motor 7, the two interlock switches 35 and 40 serve to operate the relay 41 to complete a dynamic-braking circuit for effecting a quick stopping of the motor.

In the modification illustrated in Fig. 2, parts corresponding to those shown in Fig. 1 are indicated by like reference characters, and only so much of the system as differs materially from the system shown in Fig. 1 is illustrated.

Referring to Fig. 2, two electrically operated switches 70 and 71 are provided for operating the motor 7 in a manner somewhat similar to the operation of the motor 7 by the switches 15 and 16. The switch 70 serves to connect the motor across the supply conductors 30 and 31 for operating it in a counterclockwise direction to raise the electrode of the furnace. The switch 70 is provided with interlock switch members for short-circuiting a portion of the winding 17 of the main control magnet 14 and for establishing a braking circuit through the armature 8 upon the simultaneous release of the two switches 70 and 71. The switch 71 serves to connect the motor 7 across the supply conductors 30 and 31 to rotate it in a clockwise direction for effecting a lowering of the electrode. The switch 71 further is provided with interlock switch members for opening a short-circuit across a portion of the winding 17 of the main control magnet 14 and for establishing a braking circuit through the armature 8 upon the simultaneous release of the two switches.

The switch 70 embodies an energizing winding 72 which is connected across the supply conductors 30 and 31 by the engage-

ment of the contact members 23 and 25, a core armature 73 which is pivotally connected to a switch arm 74 and a holding coil 75 which is connected in series with the motor armature 8. The switch arm 74 is provided with an extension 76 and an insulated interlock switch 77 which, respectively, serve to establish a braking circuit through the armature 8 and a short circuit across a portion of the winding 17, according to the position of the switch arm 74. The holding coil 75 serves to hold the switch arm in a released position.

The switch 71 embodies an energizing coil 79 which is connected across the supply conductors 30 and 31 by the engagement of the contact members 22 and 24, a core armature 80 which is pivotally connected to a contact arm 81 and a holding coil 82 which serves to maintain the switch arm 81 in a released position upon de-energization of the energizing coil 79. The switch arm 81 is provided with an extension 83 and an interlock switch member 84 which respectively serve to establish a dynamic-braking circuit through the armature 8 and to open a short-circuit which initially exists across a portion of the winding 17 of the main control magnet 14.

In case the current flowing through the furnace is reduced below normal value, the main control magnet 14 is operated to engage the contact members 22 and 24. Upon engagement of the contact members 22 and 24, a circuit is completed for energizing the winding 79 to operate the switch 71. Thereupon, a circuit is completed through the motor 7 which extends from the supply conductor 31, through the switch arm 81, holding coil 82, armature 8, holding coil 75 and the switch arm 74, to the supply conductor 30. It will be noted that, upon operation of the switch 71, the interlock switch member 84 opens the short-circuit existing across the taps 26 and 27 of the winding 17 in a manner exactly similar to the operation of the interlock switch member 39 which is associated with the electrically operated switch 16. Upon release of the switch 71, a braking circuit is completed which extends from one terminal of the armature 8 through the holding coil 82, switch member 81, portion of the supply conductor 30, switch arm 74 and the holding coil 75 to the other terminal of the armature 8.

The switch 70 operates in a similar manner upon an abnormal current-flow through the furnace but, in this case, the interlock switch member 77 serves to short-circuit a portion of the winding 17 in a manner similar to the operation of the interlock switch member 34 which is operated by the electrically operated switch 15.

Modifications in the system and 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:

- 5 1. In a regulator system, a supply circuit, a main control magnet having two operative positions, and means controlled by said magnet, when in either of said operative positions, for varying the current flow through said supply circuit and for simultaneously increasing or decreasing the number of effective turns in the winding of said magnet to prevent hunting action.
- 10 2. In an electric furnace, the combination with an electrode motor, and a magnet operated only in accordance with the current flowing through the furnace, of means controlled by said magnet for controlling the operation of said motor; for varying the number of effective turns in the winding of said magnet, and for establishing a motor braking circuit under certain conditions.
- 15 3. In an electric furnace, an adjustable electrode, means for operating said electrode, a main control electromagnet for governing the operation of said electrode-operating means, and means for varying the number of effective turns in the winding of said magnet to prevent hunting action when the electrode is being lowered and raised.
- 20 4. In an electric furnace, the combination with a movable electrode, a motor for operating said electrode, and a main control magnet operated in accordance with the current flowing through the furnace, of means comprising two switches controlled by said main control magnet for operating said motor in a forward and in a reverse direction, for increasing or decreasing the number of effective turns in the winding of said magnet to prevent a hunting action by the regulator, and for establishing a braking circuit for said motor when both of said switches are released.
- 25 5. In an electric furnace having an adjustable electrode, an electric motor for operating said electrode, switches for controlling the direction of rotation of said motor, a main-control electromagnet operated in accordance with the current flowing through the furnace, and means for varying the number of effective turns in the winding of the main-control magnet according to which of said switches is operated to prevent hunting action during the raising and the lowering of the electrode.
- 30 6. In an electric furnace having an adjustable electrode, an electric motor for raising and lowering said electrode, switches for controlling the direction of rotation of said motor, a main control electromagnet operated in accordance with the current passing through the furnace for selectively operating said switches, and means controlled by said switches for simultaneously varying the energization of the main-control magnet during the raising and the lowering operation of the electrode.
- 35 7. In an electric furnace, the combination with a movable electrode and a motor for raising and lowering the electrode, of a magnet operated in accordance with the current flowing through the electrode, means controlled by said magnet for governing said motor and for simultaneously varying the number of effective turns of said magnet to prevent hunting action during the raising and the lowering of the electrode.
- 40 8. In an electric furnace, the combination with a movable electrode, and means for operating said electrode, of a main control electromagnet operated in accordance with the current flowing through the furnace, and means controlled by said magnet for governing said electrode-operating means and for simultaneously selectively increasing or decreasing the number of effective turns in the windings of said magnet according to whether said electrode is being lowered or raised.
- 45 9. In an electric furnace, an adjustable electrode, means for raising and lowering said electrode, a magnet for governing the operation of said means, and means for selectively varying the energization of said magnet to prevent hunting action during the raising and the lowering of the electrode.
- 50 10. In an electric furnace, a movable electrode, means for raising and lowering said electrode, a magnet operated in accordance with the current flowing through the furnace for controlling said means, and means for automatically opposing the initial operation of said magnet when the electrode is being raised or lowered to prevent hunting action.
- 55 11. In an electric furnace, a movable electrode, means for raising and lowering said electrode in accordance with furnace conditions, and auxiliary means controlled by said first-mentioned means and serving to automatically oppose its initial operation.

In testimony whereof, I have hereunto subscribed my name this 25th day of March, 1919.

CLARENCE A. BODDIE.