

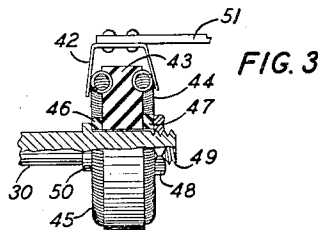
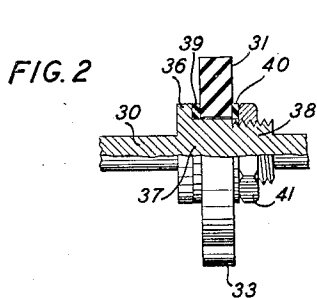
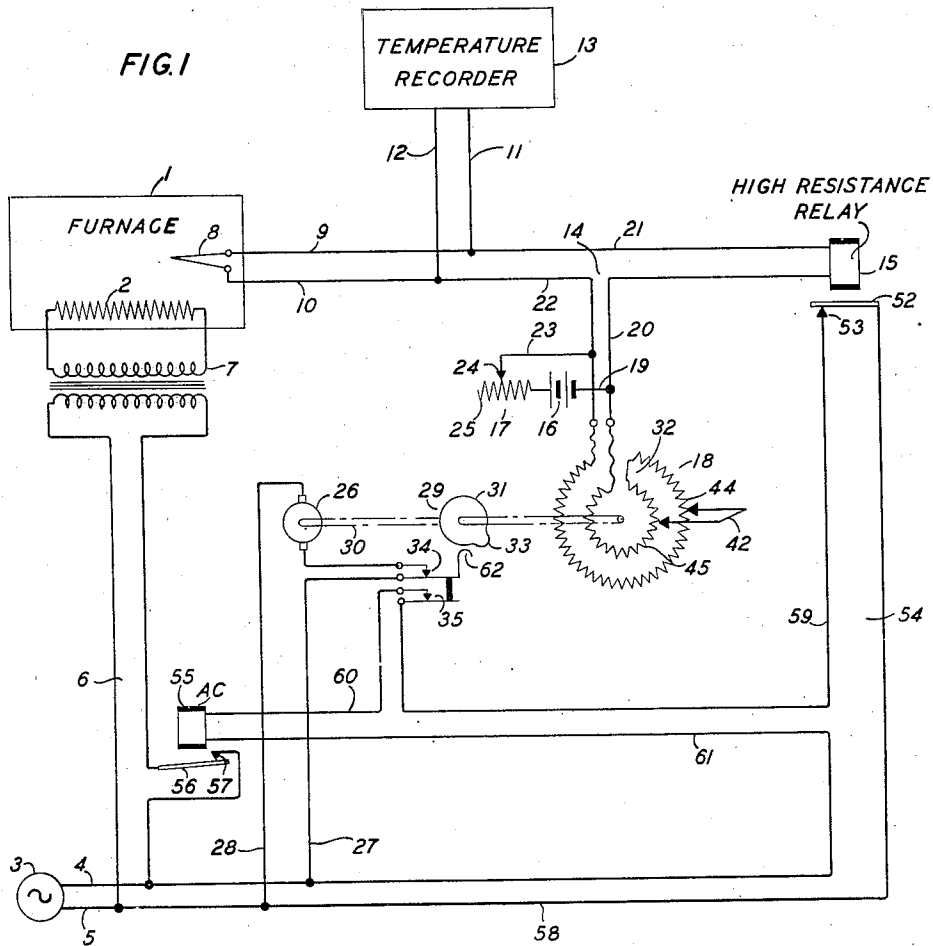
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FURNACE CONTROL APPARATUS

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FURNACE CONTROL APPARATUS

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3 Claims. (Cl. 236-46)

This invention relates to a method of and apparatus for controlling the heating and cooling rates of a furnace.

The object of the invention is to provide a simple method of and very effective means for accurately controlling the heating and cooling rates of a furnace.

In accordance with this invention there is added to the electromotive force of a thermocouple located in the furnace another electromotive force. The application of the second electromotive force is controlled with time and the output of the thermocouple with the second electromotive force added thereto is used in controlling the application of heating energy to the furnace.

In the drawing:

Fig. 1 is a schematic diagram of the system and apparatus employed in practicing the invention; and

Figs. 2 and 3, drawn on enlarged scales relative to Fig. 1, show details of parts shown in Fig. 1.

The furnace 1 shown in Fig. 1 is heated by means of a coil 2 supplied with current from a suitable source of current supply 3 through conductors 4, 5, an obvious circuit 6 and a transformer 7.

A thermocouple 8 extends into the furnace 1 to detect changes in the temperature of the furnace, the thermocouple 8 being connected by means of conductors 9, 10, 11 and 12 to a temperature recorder 13 which may be of conventional type. The thermocouple 8 is also electrically connected to a local circuit 14 containing a high resistance relay 15, a source of current supply 16, rheostat 17 and a potentiometer 18. The source of current supply 16 supplies to the high resistance relay 15 an electromotive force in addition to the electromotive force developed in the thermocouple 8. The circuit for energization of the relay 15 may be traced as follows: local battery 16, conductor 19, conductor 20, winding of relay 15, conductor 21, conductor 9, thermocouple 8, conductor 10, conductor 22, conductor 23, movable contact 24 of rheostat 17, resistance coil 25 of rheostat 17 to battery 16. The potentiometer 18 provides a variable shunt resistance across the lower branch of the local circuit 14 and is arranged to automatically vary with time the electromotive force added to the electromotive force developed in the thermocouple 8 and supplied to the relay 15. The potentiometer 18 is operated by means of a synchronous motor 26 which is supplied with oper-

ating current from the source 3 over the conductors 4, 5, 27 and 28 and through cam controlled contacts of a switch 29. The motor 26 drives a shaft 30 to rotate the cam 31 of the switch 29 and the rotatable coil 32 of the potentiometer 18. The cam 31 of the switch 29 is so supported on the shaft 30 that it may be rotated on the shaft 30 or made to rotate with the shaft and is provided with a projection 33 to operate contacts 34 and 35 of the switch 29.

Fig. 2 shows a convenient way of mounting the cam 31 on the shaft 30. In this case the shaft 30 is enlarged to provide a flange 36, a cylindrical portion 37 and a male threaded portion 38. The cam 31 is journaled on the portion 37 and is held in required position by means of washers 39 and 40 and a nut 41. The washer 39 is interposed between one face of the cam 31 and the flange 36, the washer 40 being interposed between the other face of the cam 31 and the nut 41. The washers 39 and 40 are made of leather or other material suitable for holding the cam 31 against relative rotation on the shaft 30 when the nut 41 is tightened on the threaded portion 38.

The potentiometer 18 comprises the rotatable resistance coil 32 and a fixed contact 42 and may be of any desired form found suitable for the purpose. In this case the potentiometer 18 is shown in the form of a double slide wire potentiometer comprising as shown in Fig. 3 an insulating disc 43, the resistance coils 44 and 45 and a U-shaped wiper contact 42. The disc 43 supports the coils 44 and 45 and is removably mounted on the shaft 30. The disc 43 is journaled on the shaft 30 but is normally held against rotation relative to the shaft 30 by means of friction washers 46 and 47 and a nut 48 which is mounted on a male threaded end 49 of the shaft 30. The washer 46 is interposed between one face of the disc 43 and a flange 50 on the shaft 30, the washer 47 being interposed between the other face of the disc 43 and the nut 48. The wiper contact 42 is supported on a fixed support 51 and bridges the resistance coils 44 and 45.

It will be seen by looking at Fig. 1 that when the resistance coils 44 and 45 are rotated in a clockwise direction and relative to the fixed wiper contact 42 the resistance across the lower branch of the circuit 14 is increased resulting in the application of more of the current from the battery 16 to the high resistance relay 15. When the combined electromotive force of the thermocouple 8 and that supplied from the battery 16 reaches a certain value the high resistance relay

15 is energized to pull its armature 52 away from back contact 53 to open the circuit 54, included in which is the relay 55 controlling the circuit 6 through which current is supplied to the transformer 7. Deenergization of relay 55 releases its armature 56 from front contact 57 and opens the circuit 6 to shut off the current supply to the heating coil 2. The circuit 54 may be traced as follows: source of current supply 3, conductor 5, conductor 58, armature 52 and back contact 53 of relay 15, conductor 59, lower contacts 35 of switch 29, conductor 60, winding of relay 55, conductor 61, conductor 4 to current supply 3.

When the motor 26 is operated to rotate the shaft 30 to cause rotation of the disc 43 of the potentiometer 18 it also causes rotation of the cam 31 of the switch 29. The motor continues to operate until the projection 33 moves an arm 62 controlling the switch contacts 34 and 35. Downward movement of the arm 62 will cause opening of the contacts 34 and 35. Since the motor 26 is supplied with current through the contacts 34, opening of these contacts will cause the motor 26 to stop. Opening of the contacts 35 will cause deenergization of relay 55 to allow its armature 56 to fall away from front contact 57 so that circuit 6 will be opened and the heating coil 2 will be deenergized at the end of the heat treatment even though relay 15 might not at that time be energized to open the circuit 54.

The cam 31 is shown in Fig. 1 with the projection 33 rather close to the arm 62 of the switch 29. Under this condition the furnace 1 would be operated for a relatively short heat treatment of a piece of work in the furnace. The length of the heat treatment may be changed, however, by changing the position of the projection 33 relative to the arm 62. This can be accomplished by loosening the nut 41 and then rotating the cam 31 on the shaft 30 to bring the projection 33 to a required position and then tightening the nut 41.

The electromotive force to be added to the electromotive force of the thermocouple 8 may be set to some required value by a suitable setting of the rheostat 17 and is thereafter varied by operation of the potentiometer 18. In Fig. 1 the electromotive force added to that of the thermocouple 8 is gradually increased since the resistance coils 44 and 45 are rotated in a clockwise direction relative to the fixed wiper contact 42 thus putting more resistance in the shunt across the lower branch of the circuit 14 and as a consequence making more of the electromotive force supplied from the battery 16 to be applied to the relay 15. When the electromotive force from the thermocouple 8 plus that from the battery 16 reaches an operating value for the relay 15 the relay operates to open the circuit 54. Opening of the circuit 54 causes deenergization of relay 55 to cut off the supply of heating current to the coil 2. With its heating current supply cut off, the temperature of furnace 1 and also the electromotive force of the thermocouple 8 decreases. When the combined electromotive forces of thermocouple 8 and that across potentiometer 18 fall below the operate value for relay 15, this relay releases to close circuit 54 which reapplies heating current to the furnace. By increasing the electromotive force supplied to the relay 15 from the battery 16 with time in the manner above described the amount of heating current to the furnace may be so varied that the cooling rate of the furnace may be controlled to give a desired heat treatment.

If it is desired to control the heating rate of the furnace 1 so that the furnace will be brought to a required high temperature at a slower rate than its normal heating rate and at the end of a certain period of time, the disc 43 may be removed from the shaft 30 and then placed back thereon but in a reverse position. In this case clockwise rotation of the disc 43 will cause a gradual lessening of the resistance across the lower branch of the circuit 14 and lessening of the potential supplied to the relay 15 from the battery 16.

By virtue of the method and apparatus devised and herein described the cooling and heating rates of a furnace may be accurately controlled. The novel feature resides in adding to the electromotive force developed in the hot junction of a furnace thermocouple another electromotive force from an external source, controlling the application of the second electromotive force in accordance with a predetermined program and using the combined electromotive forces to control the application of heating energy to the furnace. The second electromotive force may be considered as a control voltage acting upon an electrical device which is also influenced and acted upon by the electromotive force developed in the furnace thermocouple. Since the electrical device acted upon by the combined electromotive forces coming from the furnace thermocouple and the external source of supply is arranged to control the application of heating energy to the furnace the temperature of the furnace may be controlled by merely varying the control voltage in accordance with a predetermined program.

What is claimed is:

1. An apparatus for controlling the temperature of a furnace in accordance with desired programs, comprising in combination, a heating device in the furnace, a circuit including a source of current supply for said heating device, a relay having contacts in said circuit and operable to control the opening and closing of said circuit, a control circuit for said relay, a thermocouple in said furnace, a local circuit including a local source of current supply, a rheostat and a high resistance relay in said local circuit and connected in series with said thermocouple, a potentiometer connected across said local circuit in shunt of said local source of current supply and said rheostat, said high resistance relay being operable by electromotive forces supplied by said thermocouple and said local source of current supply, and said potentiometer being operable to control the electromotive force supplied from said local source of current supply to said high resistance relay by increasing or decreasing the resistance shunting said local source of current supply, contacts in said control circuit controlled by means of said high resistance relay, a motor, a shaft driven by means of said motor and operable to control the operation of said potentiometer, a switch in said control circuit, a cut-out for said motor and means mounted on said shaft and operable to open said switch and the cut-out for said motor at the end of the desired program.

2. An apparatus for controlling the temperature of a furnace in accordance with desired programs, comprising in combination, a heating device in the furnace, a circuit including a source of current supply for said heating device, a relay having contacts in said circuit operable to con-

trol the opening and closing of said circuit, a control circuit for said relay, a thermocouple in said furnace, a local circuit including a local source of current supply, a rheostat and a high resistance relay in said local circuit and connected in series with said thermocouple, a potentiometer connected across said local circuit in shunt of said local source of current supply and said rheostat, said high resistance relay being operable by electromotive forces supplied by said thermocouple and said local source of current supply, said potentiometer being operable to control the electromotive force supplied from said local source of current supply to said high resistance relay by increasing or decreasing the resistance shunting said local source of current supply, contacts in said control circuit and operated by means of said high resistance relay, said high resistance relay operating to open its contacts in said control circuit when the electromotive force produced in said local circuit is a required value, a motor connected to said source of current supply, a cut-out switch for said motor, a switch in said control circuit, a rotatable shaft connected to said motor and said potentiometer and serving as means to operate said potentiometer, a cam supported on said shaft and operable to open said switches at the end of the program and said cam and potentiometer being so supported on said shaft that they may be adjusted to positions for required programs.

3. An apparatus for controlling the temperature of a furnace in accordance with desired programs, comprising in combination, a heating device in said furnace, a circuit including a

source of current supply for said heating device, a relay having contacts in said circuit operable to open and close said circuit, a control circuit for said relay, a thermocouple in said furnace, a local circuit including a local source of current supply, a rheostat and a high resistance relay in said local circuit and connected in series with said thermocouple, a potentiometer connected across said local circuit in shunt of said rheostat and in shunt of said local source of current supply, said high resistance relay being operable by electromotive forces supplied by said thermocouple and by said local source of current supply, said potentiometer being operable to control the electromotive force supplied by said local source of current supply by increasing or decreasing the resistance shunting said local source of current supply, contacts in said control circuit operated by means of said high resistance relay, said high resistance relay operating to open its contacts in said control circuit when the electromotive forces produced in said local circuit reach a required value, a motor, a current-supply circuit for said motor, a cut-out switch in said current-supply circuit, a cut-out switch in said control circuit, a rotatable shaft driven by means of said motor and operating said potentiometer, a cam adjustably supported on said shaft and operable to open said cut-out switches at the end of the program and means mounted on said shaft and adjustably holding said cam and said potentiometer in such positions that the apparatus will operate for a predetermined program.

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