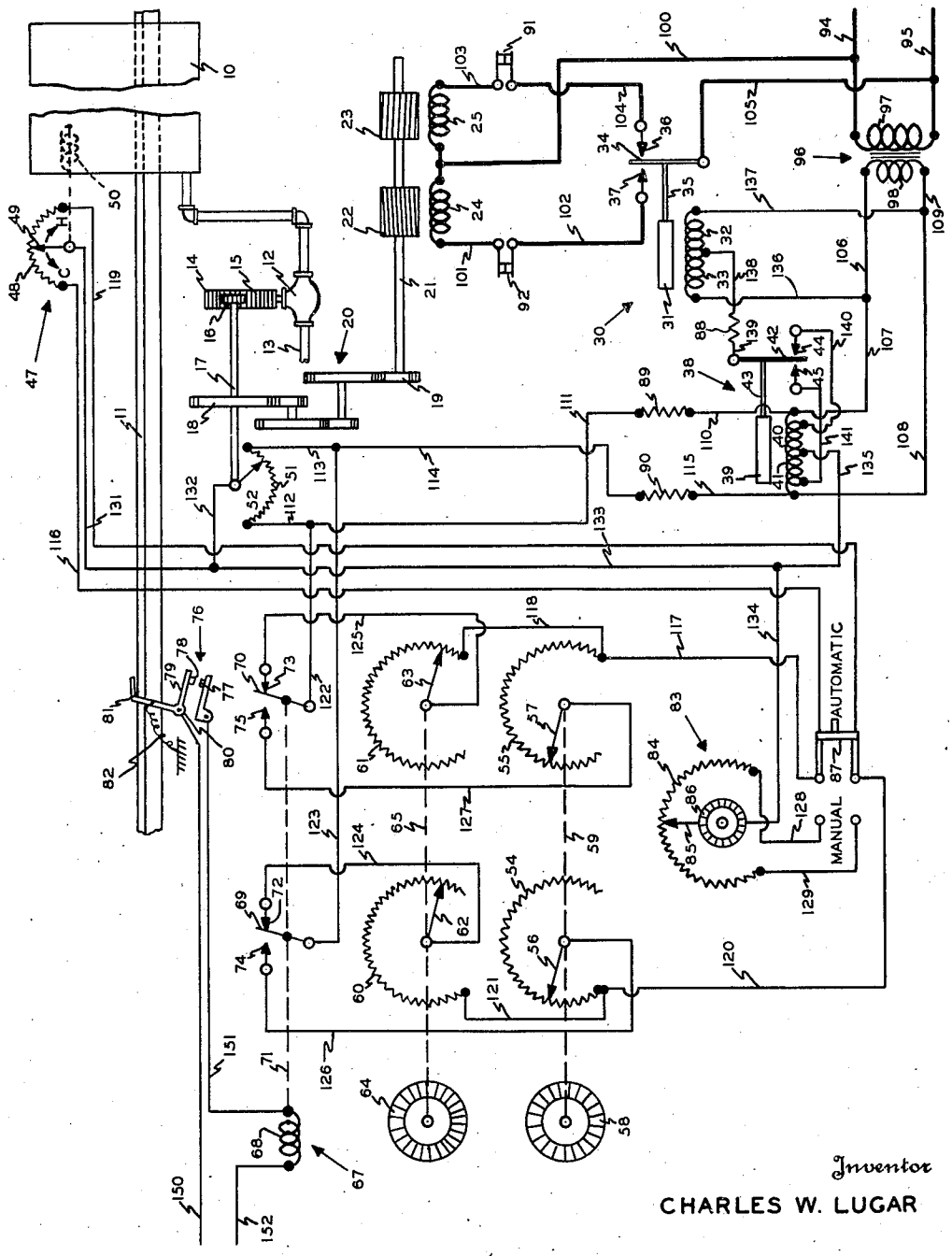
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AUTOMATIC FURNACE CONTROL SYSTEM

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AUTOMATIC FURNACE CONTROL SYSTEM

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The present invention relates to the automatic control of furnaces and particularly to the automatic control of such furnaces as heat treating furnaces wherein it is desired to maintain some furnace condition, such as a temperature, at a predetermined value or within predetermined limits, the furnace normally being subjected to varying loads so as to require varying heat or fuel supply under these varying load conditions.

In the case of a heat treating furnace, for example, there are times during which there is no load whatsoever upon the furnace whereas during other periods the furnace will be subjected to a quite heavy load. In heat-treating processes, it is of course necessary that the furnace temperature be maintained reasonably constant or that it be varied in a predetermined manner in order to obtain the particular treating desired. It is therefore advantageous, particularly where the furnace temperature should be constant during the treatment, to maintain the furnace at a given temperature not only during such times as articles are actually being heat treated but during the standby period as well, so that the furnace will always be ready to treat further articles.

In the past, it has been proposed to control the supply of heat in such a furnace, as by varying the supply of fuel thereto, in accordance with the deviation of furnace temperature within some predetermined range. Now if this range be made quite small, the likelihood of hunting with the result of over-shooting and under-shooting is very great whereas, if this range is made relatively wide, then as the load upon the furnace is increased, the furnace temperature will have a drooping characteristic in that while it will remain within the predetermined relatively wide range, the furnace temperature will approach the lower end of such range as the load thereof is increased.

One of the objects of the present invention is the provision of an automatic control system for a furnace by which the control action of some device responsive to a furnace condition, such as furnace temperature, upon the mechanism for maintaining the furnace condition constant is varied upon changes in the load upon the furnace.

A further object of the invention is the provision of an automatic control system for a furnace by which the position which a furnace control member assumes in accordance with fluctuations in a furnace condition, such as the furnace temperature, is automatically changed a predetermined amount when the furnace is subjected to a load after having been operating under standby conditions.

Other objects of the invention will be found in the drawing, the detailed description and the appended claims.

For a more complete understanding of the invention, reference may be had to the following description and the accompanying single drawing which is a diagrammatic showing of the preferred form of the invention.

Referring to the single drawing, a heat-treating furnace, generally indicated at 10, is provided with a conveyor 11 by means of which articles to be treated may be carried through the furnace and thereby subjected to the furnace temperature. The supply of heat to the furnace 10 is herein shown as being controlled by a valve 12 which controls the flow of fuel through a fuel pipe 13 and to a burner (not shown). The valve 12 includes an operating stem 14 which is provided with teeth 15 that cooperate with a pinion 16 secured to a main operating shaft 17. The main operating shaft 17 carries a gear 18 which is driven by a motor pinion 19 through suitable reduction gearing, generally indicated at 20. The motor pinion 19 is carried by a motor shaft 21 to which is secured a pair of motor rotors 22 and 23 which rotate in opposite directions upon energization of their respective field windings 24 and 25.

Energization of field windings 24 and 25 is controlled by a pilot relay, generally indicated at 30, which comprises a plunger 31 that is controlled by a pair of relay coils 32 and 33. The plunger 31 controls a relay switch arm 34 through the medium of a connecting member 35, the relay switch arm 34 being adapted to alternately engage stationary contacts 36 and 37. The pilot relay 30 is controlled by a balanced relay, generally indicated at 38, which comprises a single plunger 39 that is controlled by a pair of balanced solenoid coils 40 and 41. The plunger 39 controls a flexible switch arm 42 by means of a connecting member 43, the flexible switch arm 42 being adapted to alternately engage contacts 44 and 45.

The solenoid coils 40 and 41 are primarily controlled or unbalanced by means of a furnace condition responsive controller generally indicated at 47. This furnace condition responsive controller, in the present instance, comprises a potentiometer which includes a control resistance winding 48 that is adapted to be traversed by a movable control member or contact 49. The movable control member or contact 49 is herein shown as operated by means of a coiled thermostatic element 50

which responds to the temperature within the heat-treating furnace 10. The unbalancing in the energizations of solenoid coils 40 and 41, as a result of changes in the furnace temperature or by other means to be hereinafter explained, is adapted to be rebalanced by a balancing potentiometer comprising a balancing resistance winding 51 and a balancing contact finger 52 adapted to traverse the same and which is operated by the main operating shaft 17.

The action of the controller 47 upon the balancing relay mechanism 38 during standby periods when the furnace is operating under minimum or no load conditions is determined by means of a first auxiliary resistance means comprising a pair of resistances 54 and 55 which are provided with cooperating contact fingers 56 and 57 that are preferably controlled by a single manually operable adjusting device 58, to which they are connected by means of a shaft 59. Similarly, the action of the controller 47 upon the balanced relay 38 is determined during those periods when the heat-treating furnace 10 is subjected to a load by means of a second auxiliary resistance means which comprises a pair of resistances 60 and 61. A pair of contact arms 62 and 63 respectively cooperate with the resistances 60 and 61 and are preferably simultaneously adjustable by means of a single manual operating device 64 to which they are secured by means of a shaft 65.

One or the other of these auxiliary resistance means is selectively electrically connected in circuit with the controller 47 by means of a relay 67 which includes a relay coil 68 that operates a pair of switch arms 69 and 70 through an armature 71. When relay coil 68 is deenergized, switch arms 69 and 70 respectively engage contacts 72 and 73. Upon energization of relay coil 68, switch arms 69 and 70 are moved from engagement with their respective contacts 72 and 73 and into engagement with a pair of similar contacts 74 and 75. The relay 68 is controlled by a switch 76 which includes a stationary contact 77 and a movable contact 78. The movable contact 78 is carried by a bell crank 79 which is pivoted at 80. One arm of the bell crank 81 extends along side of conveyor 11 and terminates thereabove so as to act as an operator which is adapted to be engaged by articles to be heat-treated which are placed upon the conveyor 11, it being understood that suitable mechanism is provided for causing the conveyor 11 to pass through the furnace 10. The switch 76 is normally maintained in open circuit position by means of a coiled spring 82.

The system of the present invention further includes a manual controller 83 which takes the form of a manually operable potentiometer comprising a resistance 84 and a cooperating contact finger 85 adapted to be manipulated by means of a manual operating device 86. A manually operable reversing switch 87 is capable of placing the automatic controller 47 or the manual controller 83 in control of balanced relay 38.

The system further includes suitable protective resistances 88, 89 and 90 and also preferably includes a pair of limit switches 91 and 92 which prevent excessive movement of valve 12 in any of the usual manners well-known in the art.

High voltage power is supplied to the field windings 24 and 25 by means of line wires 94 and 95 whereas low voltage power is supplied to the control circuits by means of a step-down transformer 96 having a high voltage primary 97 and a low voltage secondary 98.

Line wire 94 is connected to one end of each of field windings 24 and 25 by means of a wire 100. The other end of field winding 24 is connected to contact 37 of pilot relay 30, through limit switch 92, by means of wires 101 and 102 whereas the other end of field winding 25 is connected to the contact 36 of pilot relay 30, through limit switch 91, by means of wires 103 and 104. Line wire 95 is connected to relay switch arm 34 by means of a wire 105.

The solenoid coils 40 and 41, in series, are connected across the secondary 98 of transformer 96 by means of wires 106, 107, 108 and 109. The balancing resistance 51 is connected in parallel with the series connected solenoid windings 40 and 41, through protective resistances 89 and 90, by means of wires 110, 111, 112, 113, 114 and 115. One end of the control resistance 48 is connected to one end of each of the resistances 55 and 61, through the manually operable reversing switch 87, by means of wires 116, 117 and 118, whereas its other end is connected to one end of each of the resistances 54 and 60, through the manually operable reversing switch 87, by means of wires 119, 120 and 121. Relay switch arm 70 is connected to wires 111 and 112 by means of a wire 122 and relay switch arm 69 is connected to wires 113 and 114 by means of a wire 123. Contact 72 is connected to contact arm 62 by means of a wire 124, contact 73 is similarly connected to contact arm 63 by a wire 125, contact 74 is connected to contact arm 56 by means of a wire 126 and contact 75 is connected to contact arm 57 by means of a wire 127. In this manner, with the parts in the position shown, the control resistance 48 is connected in parallel with the series connected solenoid coils 40 and 41 through the protective resistances 89 and 90 and through the effective portions of resistances 60 and 61. On the other hand, when relay coil 68 is energized by means of switch 76, the control resistance 48 is connected in parallel with the series connected solenoid coils 40 and 41 through the protective resistances 89 and 90 and through the effective portions of resistances 54 and 55. The resistance 84 of manually operable potentiometer 83 is connected to the manually operable reversing switch 87 by means of wires 128 and 129 so that upon operation of manually operable reversing switch 87 to the position opposite to that shown in the drawing, the manual potentiometer 83 is substituted for the automatic controller 47. The control member or contact 49 and balancing contact finger 52 and the contact finger 85 are all connected to the junction of solenoid windings 40 and 41 by means of wires 131, 132, 133, 134 and 135.

The relay windings 32 and 33 of pilot relay 30, in series, are connected across the secondary 98 of transformer 96 by wires 106, 136, 137 and 109. The junction of relay coils 32 and 33 is connected to flexible switch arm 42 through protective resistance 88 by means of wires 138 and 139. A small number of turns of solenoid coil 40 is connected to contact 44 by a wire 140 and a small number of turns of the solenoid winding 41 is connected to the contact 45 by means of a wire 141.

Operation

With the parts in the position shown, no articles to be heat-treated are passing through the heat-treating furnace 10 so the switch 76 is open and the relay coil 68 is deenergized. The furnace temperature is at the desired point since the con-

trol member 49 is engaged with the mid-portion of control resistance 48. With this control member 49 engaging the mid-portion of control resistance 48, it will be noted that there is a larger amount of resistance between the outer end of solenoid coil 41 and this control member 49 than there is between the outer end of resistance 40 and the control member 49. This is true since the larger portion of the resistance 60 is effective by reason of the position of its contact arm 62 whereas only a small portion of resistance 61 is effective by reason of the position of its contact arm 63. Therefore, in order for the energizations of solenoid coils 40 and 41 to be equal, the balancing contact arm 52 is engaged with balancing resistance 51 near one end thereof. The valve 12 is therefore only about one quarter open. This amount of opening of valve 12 should maintain the furnace temperature constant under these no-load conditions. If the furnace temperature should rise slightly causing control member 49 to move along control resistance 48 towards the right hand end thereof, the voltage drop across solenoid winding 41 will be increased over that across solenoid winding 40 whereupon plunger 39 will move towards the left and bring flexible switch arm 42 into engagement with contact 45. When this occurs, current from secondary 98 will flow by way of wires 106, 136 and relay winding 33 whereupon the circuit will branch, a part going by way of relay winding 32 and wires 137 and 109 to the other side of secondary 98 whereas the other part will go by way of wire 138, protective resistance 88, wire 139, flexible switch arm 42, contact 45, wire 141, a small number of turns of solenoid winding 41 and wires 108 and 109 to this same side of secondary 98. In this manner, the relay coil 33 is more highly energized than the relay coil 32 and a small additional pull is exerted on plunger 39 by the flow of current through the small number of windings of solenoid coil 41 whereby the flexible switch arm 42 is held more firmly in engagement with contact 45. The larger current flow through relay winding 43 moves the plunger 31 to the left whereupon relay switch arm 34 engages contact 37 to energize field winding 24 as follows: line 95, wire 105, relay switch arm 34, contact 37, wire 102, limit switch 92, wire 101, field winding 24 and wire 100 to line 94. Motor rotor 22 is thereupon rotated in a clockwise direction as viewed from the left whereupon main operating shaft 17 is rotated in a counter-clockwise direction as viewed from the left. This counter-clockwise rotation of main operating shaft 17 moves balancing contact finger 52 toward the left hand end of balancing resistance 51 to rebalance the voltage drops across solenoid windings 40 and 41 whereupon flexible switch arm 42 is again moved to its mid-position, as shown in the drawing, wherein it is disengaged from both contacts 44 and 45. This action therefore rebalances the current flows through relay windings 32 and 33 and the plunger 31 moves to the position shown in the drawing wherein relay switch arm 34 is between and disengaged from both the contacts 36 and 37 whereby field winding 24 is deenergized. This counter-clockwise rotation of main operating shaft 17 in order to rebalance the voltage drops across solenoid windings 40 and 41 also moves valve 12 to a more nearly closed position. Similarly, upon a temperature fall, control member 49 will move along control resistance 48 towards the left hand end thereof whereupon the voltage drop across solenoid winding 40 becomes larger than the voltage drop across solenoid winding 41 and the plunger 39 moves to the right. Such movement of plunger 39 to the right brings flexible switch arm 42 into engagement with contact 44. Current then flows from secondary 98 through wire 109, wire 137, and through relay winding 32 whereupon the circuit branches, one part going by way of relay winding 33 and wires 136 and 106 to the other side of secondary 98, whereas the other part goes by way of wire 138, protective resistance 88, wire 139, flexible switch arm 42, contact 44, wire 140, a small number of turns of solenoid winding 40, and wires 107 and 106 to the same side of secondary 98. In this manner, the contact pressure between flexible switch arm 42 and contact 44 is increased and the relay winding 32 becomes more highly energized than relay winding 33. Plunger 31 therefore moves to the right whereupon relay switch arm 34 engages contact 36 to energize field winding 25 as follows: line 95, wire 105, relay switch arm 34, contact 36, wire 104, limit switch 91, wire 103, field winding 25 and wire 100 to line 94. Motor rotor 23 thereupon rotates in a counter-clockwise direction as viewed from the left whereupon main operating shaft 17 is rotated in a clockwise direction also when viewed from the left. Balancing contact finger 52 therefore moves along balancing resistance 51 towards the right hand end thereof to rebalance the voltage drops across field windings 40 and 41 so as to bring flexible switch arm 42 and relay switch arm 34 to the positions shown in the drawing. Such clockwise rotation of main operating shaft 17 slightly opens valve 12 so as to increase the supply of fuel to furnace 10 and return the temperature thereof to the desired point. In this manner, for each position of the control member 49 upon the control resistance 48, the valve 12 assumes a corresponding position. The relationship between the positon of the valve 12 for any position of the control member 49 can be changed by manipulating the manually operable device 64 so as to change the position of contact arms 62 and 63 upon their cooperating resistances 60 and 61.

Now if articles to be heat treated are placed upon the conveyor 11 for movement through the furnace 10, such articles will engage the operator 81 of switch 76 and cause the same to close. Relay coil 68 is then energized as follows: line wire 150, switch 76, wire 151, relay coil 68 and line wire 152. Switch arms 69 and 70 are therefore moved from engagement with contacts 72 and 73 and are moved into engagement with contacts 74 and 75. The control resistance 48 is thereupon connected in parallel with the series connected solenoid windings 40 and 41 through the effective portions of resistances 54 and 55. It will now be seen that there is a relatively small amount of resistance connected between the right hand end of control resistance 48 and the right hand end of solenoid winding 40 whereas a considerably larger amount of resistance is connected between the left hand end of control resistance 48 and the left hand end of solenoid winding 41. The voltage drop across solenoid winding 40 is therefore immediately increased considerably in respect to the voltage drop across solenoid winding 41 whereupon plunger 39 moves to the right and brings flexible switch arm 42 into engagement with contact 44. Plunger 31 of pilot relay 30 therefore moves to the right, as previously explained, and brings relay switch arm 34 into engagement with contact 36. Field

winding 25 is therefore energized and the main operating shaft 17 is rotated in a clockwise direction as viewed from the left. Balancing contact finger 52 therefore moves along balancing resistance 51 towards the left hand end thereof until the voltage drops across solenoid windings 40 and 41 are again rebalanced, such movement of main operating shaft 17 opening the valve 12 to a further extent.

This opening movement of valve 12 is entirely independent of any temperature change in the furnace 10 and is caused by varying or rearranging the resistances in circuit with the control resistance 48. In this manner, the relationship between the control member 49 and the opening of valve 12 is varied or changed in such manner that the valve 12 is in some position, such as half open position, when the control member 49 is in the central position shown in the drawing. A larger amount of heat is therefore furnished to the furnace 10 in anticipation of the load about to be placed upon the furnace by the articles on the conveyor 11. This increased opening of valve 12 should maintain the furnace 10 at the proper desired temperature and the position which the valve 12 will assume when the control member 49 is in the central position shown in the drawing can be adjusted by manipulation of manually operable device 58. If it were not for this additional opening of valve 12 when a load is placed on the furnace 10, it will be obvious that the furnace temperature would drop considerably and, while such drop would be accompanied by an increase in the fuel supply, still the furnace temperature could never return to the exact desired value while the furnace was subjected to this increased load so that the furnace temperature would have a drooping characteristic. Small fluctuations in the load during the passage of articles through the furnace 10 will of course be followed by adjustments of valve 12 in response to slight changes in the furnace temperature in the same general manner as heretofore set forth in connection with furnace temperature changes under no load conditions. As soon as the articles on the conveyor 11 pass the operator 81 of switch 76, the switch 76 will again move to open circuit position to deenergize relay coil 68 whereupon the relationship between the valve position and the position of the control member 49 will be returned to that shown in the drawing.

In this manner, when the furnace is operating under minimum or no load conditions, the valve 12 is positioned in accordance with the movements of control member 49 but there is an initial or basic relationship between the valve position and the position of control member 49 which has been herein set out as the valve being one fourth open when the control member 49 is in the central position shown in the drawing. On the other hand, as soon as a load is placed on the furnace 10 as indicated by closure of switch 76, while the valve 12 continues to be positioned in accordance with the movements of control member 49, the basic relationship is automatically changed so that the valve 12 is half open when the control member 49 is in the central position shown in the drawing. In this manner, a controller such as the controller 47 having a sufficiently wide range to prevent hunting can be employed without its allowing a falling off or drooping in the furnace temperature upon an increase in the load upon the furnace.

If it should be desired to position the valve 12 manually irrespective of the furnace temperature, the reversing switch 87 is thrown to the position opposite that shown in the drawing whereupon the manually operable potentiometer 83 is substituted for the automatic control potentiometer 47 and the position of the valve 12 can then be adjusted as desired by manipulation of manually operable device 86 of potentiometer 83.

For a more thorough understanding of the general manner in which the valve 12 is positioned in accordance with the movements of control member 49 reference may be had to the copending application of Lewis L. Cunningham, Serial No. 673,246 which was filed May 24th, 1933.

While a specific embodiment of the invention has been herein described, it is to be understood that many modifications could be made therein and I therefore intend to be limited only by the scope of the appended claims.

I claim:

1. The combination with a heat treating furnace and a conveyor for conveying articles to be treated therethrough, of means responsive to the temperature of the furnace, means in control of the heat supplied to said furnace controlled by said furnace temperature responsive means, means associated with said furnace temperature responsive means and heat controlling means for varying the control action of the former upon the latter, and a device controlled by the articles on said conveyor for controlling said last-mentioned means.

2. The combination with a heat treating furnace and a conveyor for conveying articles to be treated therethrough, of means responsive to the temperature of the furnace, a valve in control of the supply of fuel to said furnace controlled by said temperature responsive means, means associated with said temperature responsive means and valve for varying the control action of the former upon the latter, and a device controlled by the presence or absence of a load on said conveyor for controlling said last-named means.

3. The combination with a heating furnace having a conveyor for conveying articles to be heated therethrough, of valve means in control of the flow of fuel to said furnace, a control member movable back and forth over a predetermined path of travel in response to changes in furnace temperature, connections between said control member and valve means by which the latter is positioned in accordance with the movements of the former, means for changing the relationship between said valve means and control member, and a device controlled by the load on said furnace for controlling said relationship changing means.

4. The combination with a heating furnace having a conveyor for conveying articles to be heated therethrough, of valve means in control of the flow of fuel to said furnace, a control member movable back and forth over a predetermined path of travel in response to changes in furnace temperature, connections between said control member and valve means by which the latter is positioned in accordance with the movements of the former, electrical means for changing the position which said valve means will assume for a given position of said control means, and switching means controlled by the load on said furnace for controlling said electrical means.

5. The combination with a heating furnace, of valve means in control of the supply of fuel to

said furnace, a control member movable back and forth along a predetermined path of travel in response to changes in furnace temperature, connections between said control member and valve means by which the former positions the latter in accordance with the movements of the former, means associated with said control member and valve means for changing the position which said valve means assumes for any position of said control member, said change in position of the valve means being such as to allow a greater flow of fuel to said furnace for any position of said control member, and a device responsive to an increased load upon said furnace for rendering said last-named means operative to change the relationship between said control member and valve means.

6. The combination with a heating furnace having a conveyor for conveying articles through the furnace, of means for controlling the supply of heat to the furnace, means responsive to the temperature of the furnace in control of said heat supply controlling means, means for varying the action of said temperature responsive means upon said heat supply controlling means, and a device in the path of movement of the articles placed on said conveyor for controlling said last-named means.

7. The combination with a heating furnace having a conveyor for conveying articles through the furnace, of means for controlling the supply of heat to the furnace, means responsive to the temperature of the furnace in control of said heat supply controlling means, electrically operated means for varying the action of said temperature responsive means upon said heat supply controlling means, and a switch including an operator located in the path of movement of the articles on said conveyor for controlling said electrically operated means.

8. The combination with a heating furnace and a conveyor for conveying articles to be heated thereto, of valve means in control of the supply of heat to the furnace, a furnace temperature responsive control member movable back and forth across a predetermined path of travel in response to variations in furnace temperature, connections between said control member and valve means by which the control member positions said valve means in accordance with the movements of said control member, means associated with said control member and valve means for changing the position which said valve means will assume for any given position of said control member, and a device located in the path of movement of the articles on said conveyor for controlling said means.

9. In combination, electrically operated heat supply controlling means, a temperature responsive variable resistance in control of said electrically operated heat supply controlling means, first and second resistance means adapted to be placed in circuit with said temperature responsive variable resistance means for changing the control action thereof upon said electrically operated heat supply controlling means, and automatic means for selectively placing said first or second resistance means in circuit with said temperature responsive variable resistance means.

10. In combination, electrically operated heat supply controlling means, a temperature responsive variable resistance in control of said electrically operated heat supply controlling means, first and second resistance means adapted to be placed in circuit with said temperature responsive variable resistance means for changing the control action thereof upon said electrically operated heat supply controlling means, automatic means for selectively placing said first or second resistance means in circuit with said temperature responsive variable resistance means, a manually operable variable resistance means, and a manual switch for placing said manually operable resistance means in control of said electrically operated heat supply controlling means.

11. In combination, electrically operated heat supply controlling means, a temperature responsive variable resistance in control of said electrically operated heat supply controlling means, first and second resistance means adapted to be placed in circuit with said temperature responsive variable resistance means for changing the control action thereof upon said electrically operated heat supply controlling means and an automatically controlled switching means for selectively placing said first or second resistance means in circuit with said temperature responsive variable resistance means.

12. The combination with a heating furnace for heating articles, of electrically operated means in control of the supply of heat delivered to said furnace, variable resistance means responsive to the temperature of said furnace for controlling the electrically operated means, auxiliary resistance means adapted to be placed in circuit with the temperature responsive resistance means for varying the control action of said temperature responsive resistance means on said electrically operated means, and means responsive to the load on said furnace for placing said auxiliary resistance means in and out of circuit with said temperature resistance means.

13. The combination with a heating furnace for heating artices, of electrically operated means in control of the supply of heat delivered to said furnace, variable resistance means responsive to the temperature of said furnace for controlling the electrically operated means, auxiliary resistance means adapted to be placed in circuit with the temperature responsive resistance means for varying the control action of said temperature responsive resistance means on said electrically operated means, a relay for placing said auxiliary resistance means in and out of circuit with said temperature responsive resistance means and a switch controlled by the load on the furnace for controlling said relay.

14. The combination with a furnace having a conveyor for conveying articles thereto to be heated thereby, of valve means in control of the supply of fuel to said furnace, furnace temperature responsive variable resistance means for variably positioning said valve means in accordance with furnace temperature, auxiliary resistance means associated with said furnace temperature responsive variable resistance means for varying the control thereof upon said valve means, and a switch located in the path of movement of the articles conveyed to said furnace for controlling the auxiliary resistance means.

15. The combination with a furnace having a conveyor for conveying articles thereto to be heated thereby, of valve means in control of the supply of fuel to said furnace, furnace temperature responsive variable resistance means for variably positioning said valve means in accordance with furnace temperature, first and second auxiliary resistance means adapted to be operatively electrically connected to said furnace temperature responsive resistance means for varying the

control action thereof upon said valve means, and switching means including an operator located in the path of movement of the articles being conveyed to said furnace for selectively connecting said first or second auxiliary resistance means to said furnace temperature responsive resistance means.

16. In combination, a furnace, a member movable to a plurality of positions for varying the operation of said furnace, a control member movable back and forth along a predetermined path of travel in response to changes in a furnace condition, connections between said movable member and control member by which the latter positions the former in accordance with changes in said furnace condition, and means responsive to an increase in the load on said furnace for changing the relative positions of said control member and movable member a predetermined amount.

17. The combination with a furnace adapted to be subjected to varying loads, of a movable member adapted to control the operation of said furnace, electrical motor means in control of said movable member, switching means in control of said motor means, electromagnetic means in control of said switching means, a control resistance means associated with said electromagnetic means for variably energizing the same in response to changes in a furnace condition, an auxiliary resistance means adapted to be placed in circuit with said control resistance means to vary the effect thereof upon the electromagnetic means, and switching means operated upon a change in the load upon said furnace for placing said auxiliary resistance means in circuit with said control resistance means.

18. The combination with a furnace adapted to be subjected to varying loads, of a movable member adapted to control the operation of said furnace, electrical motor means in control of said movable member, switching means in control of said motor means, electromagnetic means in control of said switching means, a control resistance means associated with said electromagnetic means for variably energizing the same in response to changes in a furnace condition, first and second auxiliary resistance means adopted to be placed in circuit with said control resistance means to vary the effect thereof upon said electromagnetic means, and switching mechanism operated in response to changes in the load on said furnace for selectively placing one or the other of said auxiliary resistance means in circuit with said control resistance means.

19. The combination with a furnace having a conveyor for conveying articles to the furnace, of a valve in control of the supply of fuel to the furnace, electric motor means in control of said valve, switching means in control of said electric motor means, normally electrically balanced electromagnetic means in control of said switching means, a control potentiometer connected to said electromagnetic means for varying the energization thereof and responsive to the furnace temperature first and second resistance means adapted to be placed in circuit with said control potentiometer to vary the effect thereof upon said electromagnetic means, switching means including an operator located in the path of movement of the articles on said conveyor for selectively placing one or the other of said resistance means in circuit with said control potentiometer, and a balancing potentiometer for rebalancing the energizations of said normally electrically balanced electrical means controlled by said motor means.

20. The combination with a heating furnace and a conveyor for conveying articles to be heated thereto, of electrically operated heat supply controlling means controlling the heat supplied to said furnace, variable resistance means in control of said electrically operated heat supply controlling means for varying the amount of heat supplied to said furnace, a temperature responsive device associated with said variable resistance means for varying the same, and means actuated by the presence of articles on said conveyor also associated with said variable resistance means for varying the same.

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