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AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

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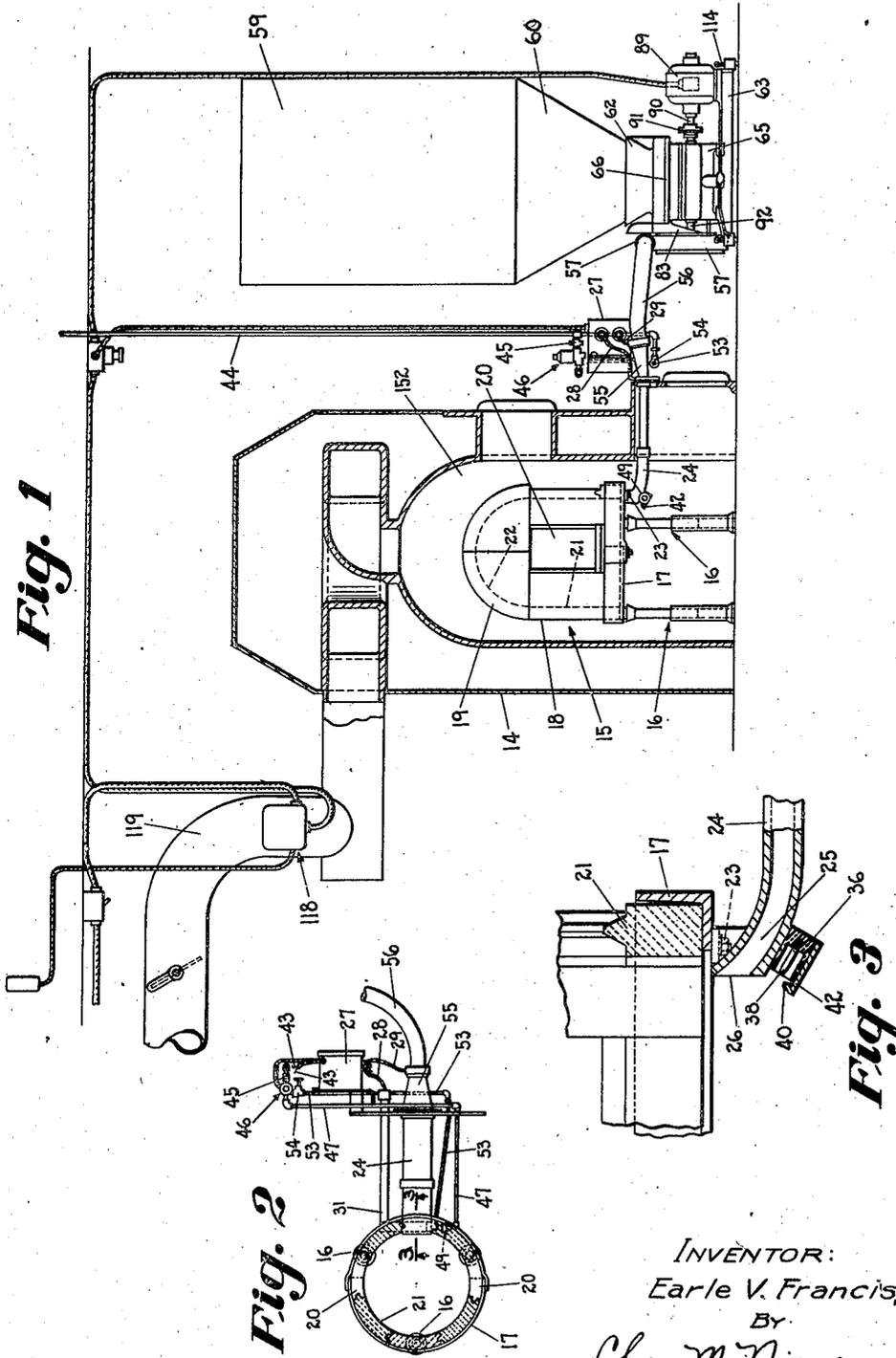


Fig. 1

Fig. 2

Fig. 3

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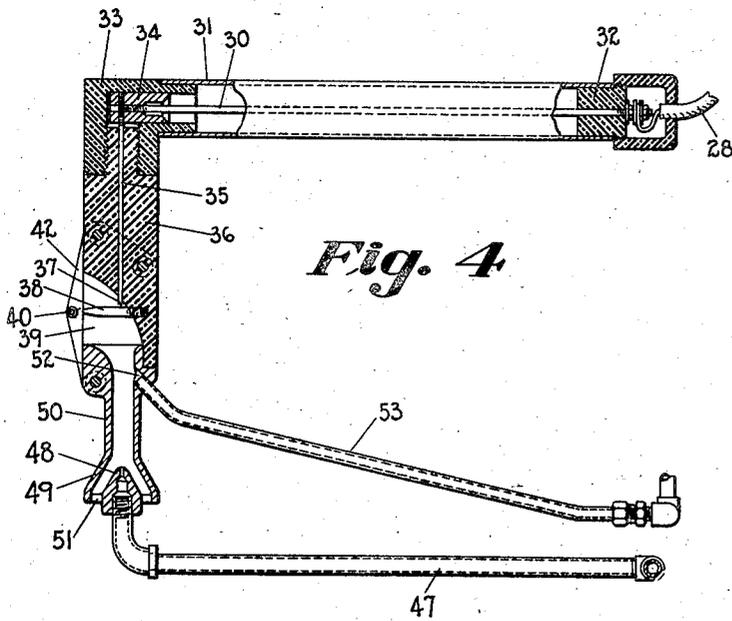
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*Fig. 4*

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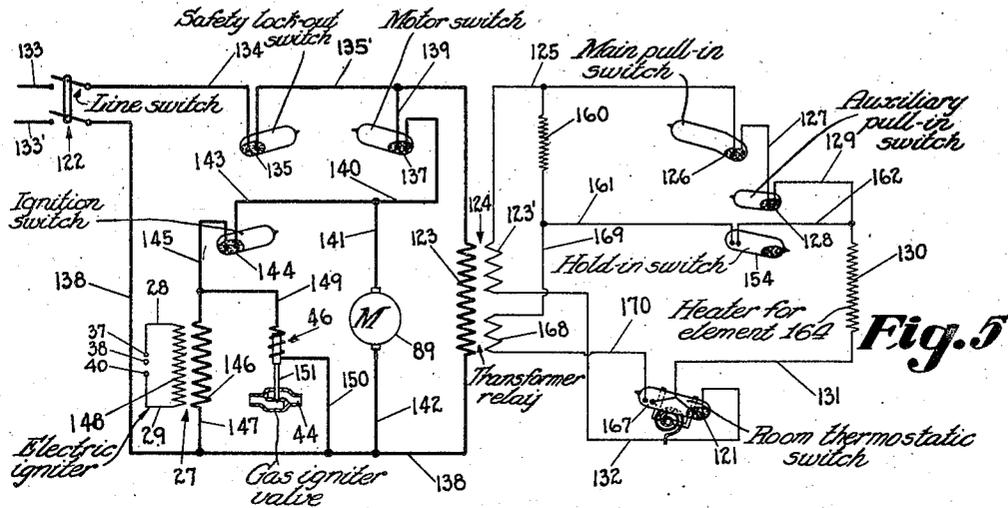
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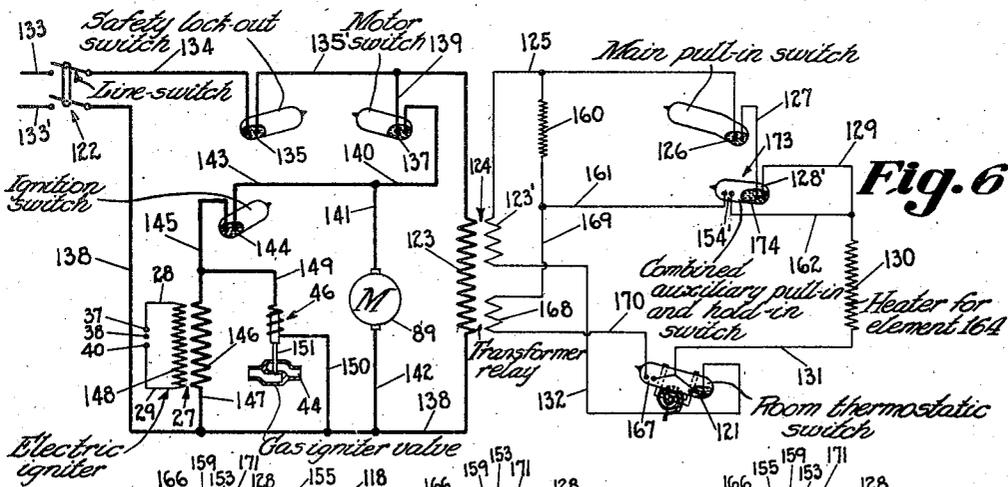
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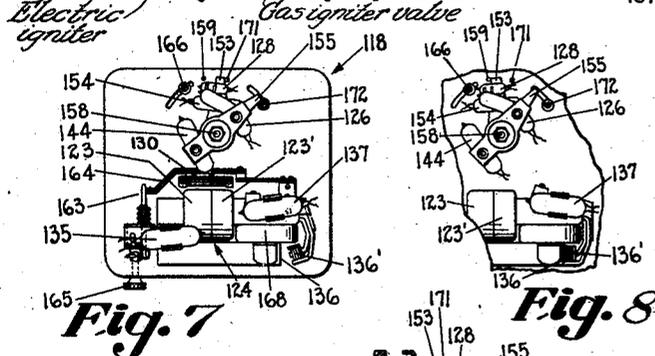
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**Fig. 5**

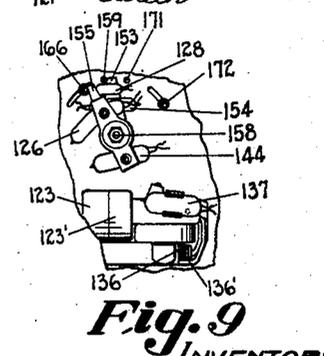


**Fig. 6**

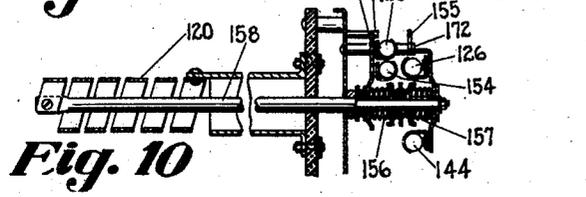


**Fig. 7**

**Fig. 8**



**Fig. 9**



**Fig. 10**

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# UNITED STATES PATENT OFFICE

2,102,618

## AUTOMATIC SYSTEM FOR SUPPLYING PULVERIZED FUEL TO FURNACES

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Application January 23, 1933, Serial No. 652,975

2 Claims. (Cl. 158—28)

My invention relates to automatic systems for controlling the supply of pulverized fuel to furnaces and one of the objects of the invention is the provision of improved and efficient thermostatically controlled apparatus for starting and stopping the operation of a furnace and feeding a mixture of powdered coal and air thereto in accordance with temperature requirements.

A further object of the invention is the provision of improved ignition mechanism associated with a nozzle for projecting a mixture of air and pulverulent combustible material into a furnace combustion chamber.

A further object of the invention is the provision of an improved and efficient system of electrical control of the delivery of fuel to a furnace and providing safety features for the efficient operation of the furnace.

Another object of the invention is to provide a system for burning pulverized coal in a domestic furnace, in which a preliminary combustion chamber is provided within the main furnace combustion chamber which allows for free escape of ashes and hot gases of combustion, and in which combined gas and electric means is provided to ignite the pulverized coal until said preliminary combustion chamber has its interior walls heated to a temperature sufficient to support combustion of the pulverized coal, after which said ignition means is shut off, while the pulverized coal is continued to be fed to said furnace as dictated by thermostatic control means.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Referring to the accompanying drawings, Fig. 1 is an elevational view of an automatic thermostatically controlled heating system embodying my invention;

Fig. 2 is a sectional plan view of my improved preliminary combustion chamber with the fuel delivery nozzle and ignition mechanism connected thereto and shown in plan view;

Fig. 3 is an enlarged sectional elevation (on line 3—3 of Fig. 2) of a portion of the structure shown in Fig. 2;

Fig. 4 is an enlarged plan view partly in section of the electric and gas ignition mechanism embodied in the construction shown in Figs. 1 and 2;

Fig. 5 is a wiring diagram of the circuits and connections for the heating system shown in Fig. 1;

Fig. 6 is a wiring diagram with a modification;

Fig. 7 is an elevational view of the switch panel

upon which is mounted a group of stack switches and, in addition, a combined transformer and relay for operating a motor control switch, and a thermal time limit cut-out switch.

Fig. 8 represents the position of the switches of Fig. 7 during the starting period of the heating system;

Fig. 9 is a view similar to Fig. 8 but showing the position of the switches during the running period; and

Fig. 10 is a sectional elevation of the thermostatic stack element for operating the switches shown at the upper portion of Fig. 7.

In Fig. 1, 14 designates a furnace of the vertical type which may be either in a hot air heating system, vapor heating system or steam heating system. While my improvements are particularly adapted to be installed in connection with a furnace already in operation for the burning of coal in the ordinary way, it should be understood that my system may be permanently or detachably connected to a furnace when initially installed. The only changes necessary for the installation of my improved apparatus in connection with a previously installed furnace are the removal of the usual fire grate and the provision of suitable openings for the connections shown in Fig. 2. My improved preliminary combustion device 15 is mounted on vertical adjustable standards 16, 16 and comprises a supporting ring 17 on which is mounted a cylindrical casing 18 with a semi-spherical top or cover 19 mounted thereon as shown in Fig. 1. Rectangular side openings 20, 20 are provided in the diametrically opposite sides of the preliminary combustion device 15 and the walls of the latter are formed by sections of fire resisting material as shown at 21 in Figs. 1 and 2 and at 22 in Fig. 1.

Secured to the bottom of the ring 17 at 23 adjacent the front portion of the furnace 14 is a flattened pipe 24 which is provided with an upwardly projecting passage 25 to afford a nozzle 26 for the mixture of pulverized coal and air to be projected upwardly through the lower circular opening in the bottom of the combustion device 15.

The ignition apparatus associated with the nozzle 26 is shown in Figs. 1 to 4 inclusive and comprises a transformer 27 the secondary leads 28 and 29 of which are respectively connected to the insulated rod 30 and the metal portion of the pipe 24. The rod 30 extends through a tube 31 the ends of which are mounted on insulating members 32 and 33. The forward end of the rod 30 is screw-threaded into the contacting

block 34 so as to electrically connect the rod 30 to another rod 35 which is mounted in the insulating member 36. The rod 35 may also be screw-threaded through the connector block 34 as shown in Fig. 4. The exposed terminal 37 of the rod 35 is located as shown in Fig. 4 adjacent the metal pin 38 which has one end embedded in insulated member 36 with the other end extending to the center of the opening 39 to a position adjacent the upper end of the terminal 40. The latter as shown in Figs. 3 and 4 is mounted on the metal holder 42 which in turn is supported by the pipe 50. The lead 29 of the transformer 27 being grounded on the pipe 24 is in electrical connection with the terminal 40 while the lead 28 is connected to the insulated terminal 37. There are, therefore, two spark gaps in series with each other, one being relatively short to produce a hot spark while the other gap between the terminals 38 and 40 is relatively long to effect a flaming arc. When the primary of the transformer is closed through the terminals 43, 43 a hot spark will be produced between the terminals 37, 38 and at the same time a flaming arc will be produced between the terminals 38, 40. The terminals 37, 38, and 40 are composed of metal of a composition usual in spark plugs.

A gas supply pipe 44 is connected through a regulating valve 45 to the electro-magnetically operated valve 46. The latter is connected by means of the pipe 47 to the gas jet 48 which projects into the flaring mouth 49 of the pipe 50, the latter being in communication with the chamber having opening 39 and the upwardly extending passage way 25 leading to the nozzle 26. Air openings 51 are provided at the rear of the mouth 49 as shown in Fig. 4. As hereinafter explained the electro-magnetic valve 46 will be opened at the same time that the ignition transformer 27 is operated to produce the sparks between the terminals 37 and 38 and between the terminals 38 and 40.

If the electric ignition mechanism is omitted or is out of operation a constantly burning gas pilot flame at 52 may be relied on to ignite the gas flowing from the gas jet 48 when the electro-magnetic valve 46 is opened. The pilot tube 53 is connected to a pilot regulating valve 54. The pipe 53 is connected through the valve 54 to the supply pipe 44 in advance of the regulating valve 45 so that the pilot flame may be cut off without interfering with the operation of the electro-magnetic valve 46.

The outer end of the flat pipe 24 is metallically connected to the metal connector 55 and the latter is connected at its outer end to the pipe 56 which leads to and is connected to the fan casing 57 of the pulverized fuel feed mechanism 66.

The powdered fuel such as pulverized coal is adapted to be stored in the large bin 59 the lower end of which is conical or hopper shaped as shown at 60 in Fig. 1. The lower end of the hopper 60 is secured as shown in Fig. 1 to a hopper shaped casting 62 of the pulverized fuel feeding mechanism 66 which is disclosed in detail in my divisional application Serial No. 727,270 filed May 24, 1934, said application being a division of my application Serial No. 652,347 filed January 18, 1933. Said mechanism 66 is mounted on a base comprising a casting 63, by the housing 65. A chute 83 is provided for delivering pulverized fuel from the feeding mechanism 66 to the fan in casing 57. Leveling screws 114 are provided to level the base 63.

An electric motor 89 mounted on the base frame 63 has its armature shaft 90 connected by the coupling 91 to the shaft 92. Said shaft 92 drives the feeding mechanism 66 and also drives the fan in the casing 57 which fan delivers a mixture of pulverized fuel and air to the pipe 56.

The stack switch device 118 is mounted on the flue 119 which leads from the furnace 14 as shown in Fig. 1. Fig. 7 shows the front of the stack switch device 118 with the cover removed and Fig. 10 is a sectional elevation of the upper portion of the stack switch device 118 including the stack switch element 120 which projects into the flue 119 to be heated thereby.

By referring to Fig. 5 it will be seen that when the room thermostat switch 121 is moved to closed position while the main line switch 122 is closed a circuit will be completed from the secondary winding 123' of the transformer-relay 124 through the conductor 125, main pull-in mercury switch 126, conductor 127, auxiliary pull-in mercury switch 128, conductor 129, safety heating resistance 130, conductor 131, thermostat switch 121 and conductor 132 to the other terminal of the secondary 123'.

When the main line switch 122 is closed a circuit is established from the main 133 through the conductor 134, lock-out mercury switch 135, conductor 135', primary winding 123, and conductor 138 to the other main 133'.

Fig. 7 shows that the secondary winding 123' of the transformer-relay 124 acts as an electro-magnetic winding for an electro-magnet having a pole 136 adjacent to which is a movable armature 136' which is pivoted to the frame of the electro-magnet and carries the motor mercury switch 137.

It will thus be seen that when the thermostat switch 121 closes the armature 136' will be attracted to the pole 136 to effect closure of the mercury switch 137. Thereupon a circuit will be established from the conductor 135' through the conductor 139, switch 137, conductors 140, 141, motor 89, and conductors 142, 138 to the main 133'.

At the same time that the motor circuit is closed a circuit will be established through the conductor 143, ignition mercury switch 144, conductor 145, and primary 146 of the ignition transformer 27, which will effect sparking between the terminals 37, 38 and 38, 40.

At the same time that the motor is started and the electric ignition mechanism is operated a circuit is established through the conductor 149, electro-magnet 46, and conductor 150, to effect opening of the valve 151 for passage of the gas through the gas supply pipe 44.

The closure of the thermostat switch 121 therefore effects starting of the motor 89, operation of the electric ignition mechanism and flow of gas from the nozzle 48 shown in Fig. 4. When the motor starts, the feeding mechanism shown in Fig. 1 operates to deliver a mixture of air and powdered coal to the preliminary combustion device 15 for burning therein preliminarily, the combustion being completed in the furnace chamber 152.

In some installations it is desirable to prolong the starting period and I have therefore mounted the auxiliary pull-in mercury switch 128 on the same carrier 153 on which the hold-in mercury switch 154 is mounted. As shown in Figs. 7 and 10 the carriers 153 and 155 are connected by spring operated frictional devices 156 and 157 on the rock shaft 158 the inner end of which is con-

nected to the stack thermostat element 120. The adjustments are such that when the combustion of the fuel begins, the heating in the flue 119 will be sufficient to cause the thermostat element 120 to move the carrier 153 against the limit stop 159 so as to effect closure of the hold-in mercury switch 154 and immediately thereafter the opening of the auxiliary pull-in mercury switch 128. The circuit established by this operation will be from the secondary 123' through the conductor 125, resistance 160, conductor 161, switch 154, conductor 162, heating resistance 130, conductor 131, thermostat switch 121, and conductor 132 to the other terminal of the secondary 123'. The resistance 160 is thus placed in series with the resistance 130 to cut down the current through the latter sufficiently to prevent the latter from effecting operation of the tripping mechanism 163, and sufficient current will flow through winding 123' to maintain switch 137 closed.

As shown in Fig. 7 an expansion device 164 is located adjacent the heating resistance 130. When sufficient current passes through the latter it will heat to cause such expansion of the device 164 as to operate the tripping device 163 and thereby permit the lock-out mercury switch 135 to tilt to opened position thereby cutting off the current from the supply mains and necessitating resetting by manually operating the knob 165.

By the arrangement of the circuits shown in Fig. 5 and the adjustments illustrated in Figs. 7, 8, and 9, I have provided a prolonged starting period in such installations as require prolonged heating of the furnace before the stack element 120 becomes sufficiently heated to rotate the shaft 158 sufficiently to move the carrier 155 against the limit stop 166. In other words, the time element for operation preliminarily of the heating element 130 to trip the switch 135 to opened position has been eliminated. When the furnace has been sufficiently heated to move the carrier 155 against the stop 166 the main pull-in switch 126 is opened and at the same time the ignition switch 144 is opened. Whereupon the electric ignition will discontinue in its operation and the valve 151 will close automatically. The motor 89 and the fan will continue in operation however until a predetermined room temperature has been reached, whereupon the thermostat switch 121 will be opened and the armature 136' will move away from the pole 136 to open the motor switch 137, whereupon the motor and fan will automatically stop and so also the fuel feeding mechanism.

The thermostatic control switch comprises two pairs of contacts 121 and 167 and when contacts 121 open in response to an increase in temperature of the space to be heated, contacts 167 will be closed and a circuit will be established from a low voltage secondary 168 through the conductors 169, 161, hold-in switch 154, conductor 162, resistance 130, conductor 131, contacts 167 and conductor 170 to the other terminal of the secondary 168. The resistance 130 may be so proportioned that it will act to operate the tripping mechanism 163 if the stack element 120 does not cool within a predetermined time to open the hold-in switch 154. During normal operation, however, within such predetermined time the hold-in switch 154 will be opened and both of the pull-in switches 126 and 128 will be closed. It should also be noted that an interval will be established before the closure of the thermostat 121 can restart the supply of fuel to the furnace because not until both of the switches

126 and 128 are closed can sufficient current be passed to operate the armature 136'. When the fuel supply has been automatically cut off by the opening of the thermostat 121 the preliminary return of the carrier 153 against the stop 171 will effect opening of the hold-in switch 154 and closure of the auxiliary pull-in switch 128, but the main pull-in switch 126 is still open and will remain open until after the shaft 158 has been rocked farther by further cooling of the stack element 120. When the carrier 155 reaches the stop 172 the main pull-in switch 126 will be closed and the ignition switch 144 will be closed in readiness for restarting when the thermostat switch 121 is again closed.

The modification shown in Fig. 6 combines the effects of the hold-in switch and auxiliary pull-in switch in one instrument designated 173.

Both in the form shown in Fig. 5 and the form shown in Fig. 6 the resistance 130 acts to open the trip switch 163 and open the lock-out switch 135 if there is no operation of the hold-in switch after a pre-determined length of time. For instance, if the stack element 120 does not rock the shaft 158 at all within a period of say 1½ minutes the circuit through the resistance 130 will cause the latter to effect the opening of the lock-out switch 135.

In Fig. 6 under normal operations the preliminary rocking of the shaft 158 will cause the mercury 174 in the device 173 to connect the contacts 154' before the switch 128' is opened. Therefore, the hold-in switch 154' will be closed before the switch 128' is opened. The movement of the carrier 153 from the stop 171 to the stop 159 will effect closure of the switch 154' and immediately afterward the opening of the switch 128'. The resistance 160 will thereby be thrown into circuit with the resistance 130 so as to prolong the starting period indefinitely or until the stack element 120 has been heated sufficiently to move the carrier 155 from the stop 172 to the stop 166. When this occurs the main pull-in switch 126 will be opened. Otherwise the operation of the system illustrated in Fig. 6 is the same as that illustrated in Fig. 5.

It should be understood that both in the system shown in Fig. 5 and the system shown in Fig. 6 the secondary 123' is relatively high voltage and of sufficient strength to cause the armature 136' to move to the pole 136. The secondary 168 is, however, of relatively low voltage and of insufficient strength to cause the armature 136' to move to the pole 136. The secondary 168 merely acts as the secondary of a transformer to obtain the safety features above pointed out.

While in some furnaces a pulverized fuel burner may be provided without having connected thereto the preliminary combustion device 15, such burner would require continued burning of gas at the gas burner nozzle 26 during the burning of the pulverized fuel so as to assure the continued burning of the latter. That is to say, in a thermostatically controlled heating system, certain furnaces may at certain times become so cooled that when started in operation the cooling effect on the flame of burning pulverized coal may be sufficient to cause the same to be extinguished if the gas flame from the nozzle 26 is not maintained. Therefore, when the preliminary combustion device 15 is omitted, I prefer to so arrange the electro-magnetic valve structure 46 as to be dependent on the motor switch 137 alone. This may be done by placing the electro-magnet of this valve structure in the

motor circuit direct—in the conductor 141 or 142 or 138 shown in Fig. 6. Then the gas will continue to burn at the nozzle 48 whenever the pulverized fuel burns at the nozzle 26 and the fuel flame will not be extinguished but will be maintained so long as the motor 89 operates the feeding mechanism and the blower.

However, it is highly desirable to reduce the consumption of the gas and I therefore prefer to include the preliminary combustion device 15 so that the gas may be cut off during the running period of the furnace. The refractory walls of the preliminary combustion chamber become sufficiently heated during the starting period to act continuously during the running period to maintain the pulverized fuel flame. For instance, such refractory walls may reach a temperature during the running period of approximately 2400° F. so that irrespective of the temperature of the walls of the main furnace chamber 152 the burning of the fuel will be maintained. Furthermore, the preliminary chamber 15 confines the mixture of the pulverized coal and air for ignition to a limited space without preventing gradual expansion from the openings 20 for further and complete combustion in the chamber 152. This arrangement also affords a more uniform distribution of the heat over the walls of the main furnace chamber 14 and eliminates any warping of the furnace walls.

Since the intense heat of the fuel flame maintains the refractory walls heated to a high temperature the pulverized coal may be burned with maximum efficiency and therefore the consumption of the fuel may be reduced to a minimum. For instance, I have found by actual test of a practical heating system such as that disclosed herein, that the feed of the pulverized coal to the fan need be no greater than one cubic foot in a period of twelve hours while burning of the pulverized coal in the furnace is being continuously sustained without the burning of any gas from the pipe 44 and the burner nozzle 48 during the running period.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I wish therefore not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention what I desire to secure by Letters Patent of the United States is:—

1. In combination with a motor operated fuel feeding and ignition means, a control system therefor comprising an ignition circuit having a switch therein, a motor circuit, a motor switch, a thermal time limit cut-out switch which opens when heated to a predetermined degree and must thereafter be manually closed, said thermal switch controlling both of said circuits, a first control circuit having means which when energized closes said motor switch, a resistance heater for said cut-out switch, first and second switches

and contacts of a main switch which close in response to a determined lowering of the temperature of the space to be heated, a second control circuit including a resistance and a third switch in parallel with said first and second switches and in series with said heater, a third control circuit including said third switch, the resistance heater and the contacts of the main control switch which close in response to a determined rise in temperature of the space to be heated, and combustion responsive switching mechanism operable upon the establishment of combustion to (1) close said third switch, (2) to open said second switch and (3) to open said first and said ignition switches and upon cessation of combustion to (1) open said third switch, (2) to close said second switch and (3) to close said first and ignition switches whereby, if said third switch fails to close the cut-out switch will operate in a time period to shut down the system.

2. In an automatic heating system, the combination with a furnace, of a fuel burning apparatus comprising a power circuit and a control circuit, a safety cut-out switch which when operated disables both of said circuits, fuel supply control means in said power circuit, a switch common to both of said means, a furnace heat responsive switch individual to said ignition means, said control circuit comprising a series circuit including a room temperature responsive switch, a relay coil, a pair of furnace heat responsive switches and a time responsive operating means for said cut-out switch, a shunt circuit bridging said pair of furnace heat responsive switches comprising a resistor and a furnace heat responsive switch, said room temperature switch being effective responsive to a predetermined minimum room temperature to close its contacts and thereby close said series circuit whereby said relay coil and said time responsive operating means are energized, means for closing said switch common to both said fuel supply control means and said fuel ignition means responsive to the energization of said relay coil, said furnace heat responsive switch in said shunt circuit operating responsive to an initial furnace heat to close said shunt circuit, one of said pair of furnace heat responsive switches in said main series circuit operating responsive to an initial furnace heat to open its contacts whereby the said series circuit includes said shunt resistor which is effective to disable the operation of said time responsive operating means to prevent operation of said cut-out switch, said furnace heat responsive switch individual to said ignition means operating responsive to advanced furnace heat to disable said ignition means, and the other of said pair of furnace heat responsive switches operating responsive to advanced furnace heat to open its contacts, said switch common to said fuel control means and said fuel ignition means remaining under the control of said room temperature responsive switch.

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