

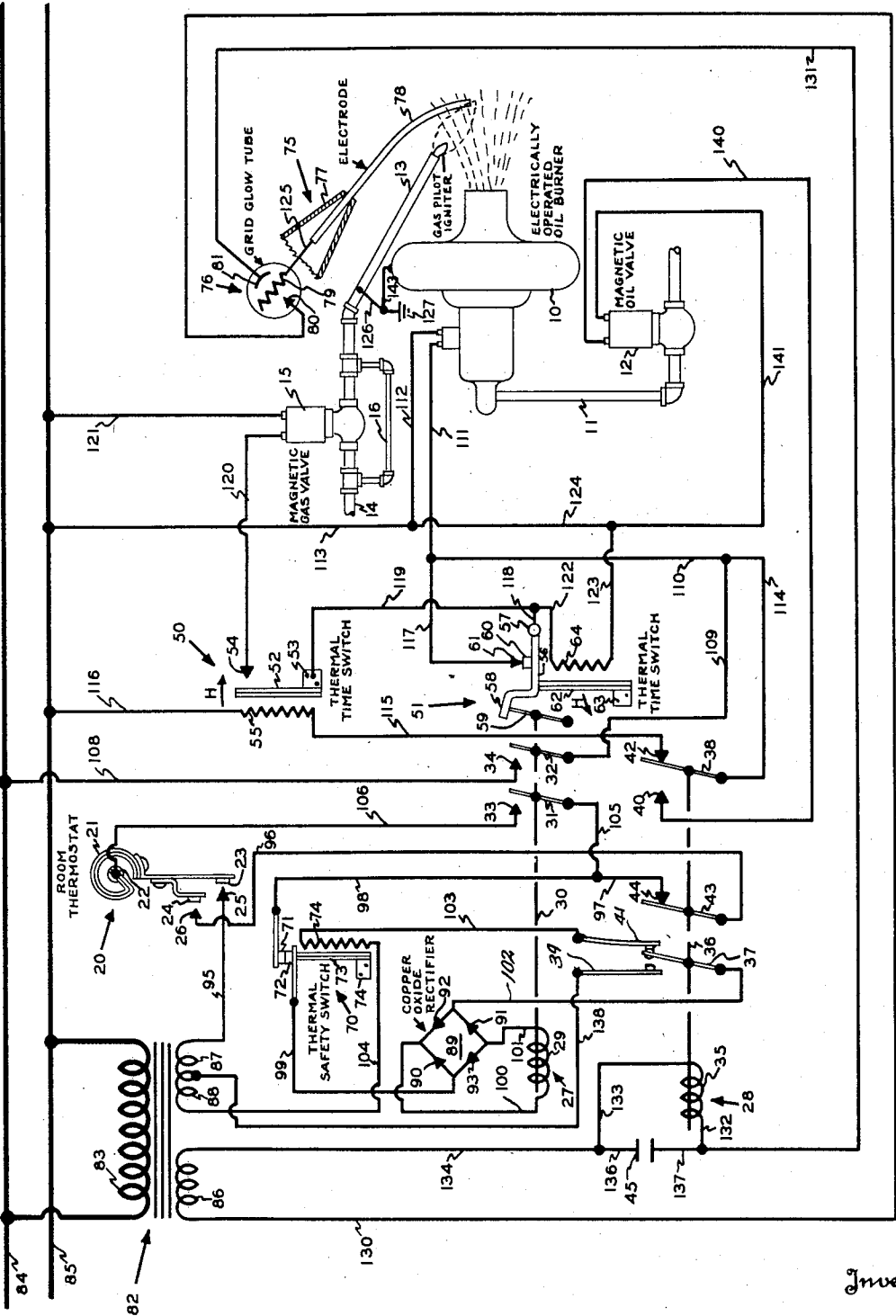
May 18, 1937.

L. L. KUEMPEL

2,081,091

BURNER CONTROL SYSTEM

Filed Sept. 8, 1934



Inventor

Leon L. Kuempel

By George H. Fisher

Attorney

UNITED STATES PATENT OFFICE

2,081,091

BURNER CONTROL SYSTEM

Leon L. Kuempel, Minneapolis, Minn., assignor
to Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Delaware

Application September 8, 1934, Serial No. 743,261

11 Claims. (Cl. 158—28)

The present invention relates to an improved burner control system by means of which the flow of fuel to a burner is prevented or discontinued if the ignition means is not operating properly or if there is a failure to establish combustion.

One of the objects of the invention is the provision of a burner control system in which fuel is initially supplied to the burner only in the event the ignition means is operating properly and wherein the supply of fuel to the burner is maintained only in the event that combustion is established and properly continues.

It is a further object of the invention to provide a burner control system in which a single device or mechanism responds both to the condition of the ignition means and to the presence or absence of flame at the burner to prevent the initial supplying of fuel to the burner if the ignition means is not operating properly and to prevent the continued supplying of fuel to the burner if the ignition means operates properly but combustion is not successfully established or maintained. The single device preferably takes the form of a mechanism which utilizes the electrical conductivity of the ignition means and the burner flame, and the ignition means is preferably of the flame producing type.

Another object of the invention is the provision of an improved burner control system in which the burner motor, ignition means, and a fuel valve are all controlled in a new and novel sequence.

Other objects of the invention will become apparent from the detailed description, the appended claims, and the drawing.

For a more complete understanding of the invention reference may be had to the following description and accompanying single drawing which is a diagrammatic illustration of one form of my novel burner control system.

Referring to the single figure in the drawing, the control system of the present invention is shown applied to an oil burner 10 of the horizontal rotary type. Oil is supplied to the oil burner 10 by an oil supply pipe 11 which is controlled by an electromagnetic oil valve 12 of any of the well-known constructions. The oil issuing from the oil burner 10 is adapted to be ignited by a gas pilot, igniter 13 which is supplied with gas by a gas supply pipe 14 that is controlled by an electromagnetic gas valve 15. The pilot 13 may be ignited in any desired manner, and is herein shown as being ignited by always maintaining a small sup-

ply of gas thereto by means of a by-pass pipe 16 which by-passes the electromagnetic valve 15.

The control system is controlled by a main control switch 20 that is preferably of the type which automatically responds to changes in some desired condition and is herein shown as a room thermostat comprising a bimetallic actuating element 21 which has one of its ends secured as at 22. The other end of bimetallic actuating element 21 controls a pair of contacts 23 and 24 which, upon a fall in room temperature, sequentially engage contacts 25 and 26 in the order named. Upon a rise in the room temperature, the contact 24 first disengages contact 26 and thereafter, upon further room temperature rise, the contact 23 disengages contact 25.

The main control switch 20 controls a pair of relays generally indicated at 27 and 28, both of these relays being operated by direct current as will hereinafter become apparent. The relay 27 includes a relay coil 29 and a cooperating armature 30. Upon energization of relay coil 29, armature 30 is attracted and in turn moves a pair of switch arms 31 and 32 into engagement with a pair of cooperating contacts 33 and 34. The relay 28 includes a relay coil 35 and a cooperating armature 36 which is attracted upon energization of relay coil 35 and moves switch arms 27 and 38 into engagement with respective contacts 39 and 40. Such movement of armature 36 also moves switch arms 37 and 38 from engagement with contacts 41 and 42 and further moves a switch arm 43 from engagement with a contact 44. The arrangement is such that switch arm 37 engages contact 39 before it disengages contact 41 upon energization of relay coil 35. Associated with relay 28 is a condenser 45, the utility of which will be hereinafter explained.

Magnetic gas valve 15 is directly controlled by a pair of thermal time switches generally indicated at 50 and 51. The thermal time switch 50 includes a bimetallic actuating element 52 which is secured at one end as indicated at 53, the other end thereof normally being disengaged from a contact 54. An electrical heating element 55 is operatively associated with thermal element 52 for heating the same. The arrangement is such that energization of electric heating element 55 for a period of about thirty (30) seconds causes movement of the free end of thermal element 52 into engagement with contact 54. The thermal time switch 51 includes a member 56 which is pivoted as indicated at 57 and includes an extension 58 that cooperates with an actuator 59. 55

Operation of the system

The actuator 59 is operated by the armature 30 of relay 27. This member 56 carries a contact 60 which is normally latched into engagement with a cooperating contact 61 by means of a bimetallic element 62 having one of its ends secured as indicated at 63. An electrical heating element 64 is operatively associated with the bimetallic element 62 for heating the same. When the electrical heating element 64 has been energized for a predetermined length of time, say sixty (60) seconds, the free end of bimetallic element 62 moves from engagement with member 56, thereby allowing contact 60 to move from engagement with contact 61, it being noted that the actuator 59 will be moved out of the path of the extended end 58 of member 56 by energization of relay 27 under these conditions, as will hereinafter appear. Upon subsequent cooling of the bimetallic element 62 by reason of deenergization of the electrical heating element 64, the contacts 60 and 61 will remain separated until such time as relay 27 is deenergized, whereupon actuator 59 will engage the extended end 58 of member 56, raising the same to the position shown in the drawing, whereupon the free end of bimetallic element 62 can move under the member 56, as shown in the drawing, to latch contacts 60 and 61 into engagement.

Operation of the complete system is dominated by a thermal time switch or safety switch 70 of well-known construction. This thermal safety switch 70 comprises a pair of contacts 71 and 72 which are normally held latched in engagement by means of a bimetallic element 73 having one of its ends secured as indicated at 74. Associated with the bimetallic element 73 is an electric heating element 74, commonly known as a safety switch heater, which upon energization for a predetermined length of time, say two minutes causes the free end of bimetallic element 73 to unlatch contacts 71 and 72, whereupon they separate. The contacts 71 and 72 thereupon remain separated until they are manually reclosed, whereupon they are thereafter maintained closed by the bimetallic element 73, provided the same has cooled sufficiently in the meantime.

The flow of current to safety switch heater 74 is controlled in part by a combustion responsive mechanism which includes a flame responsive device 75 and a thermionic tube 76, herein shown as comprising a grid glow tube. The flame responsive device 75 includes a suitable support 77 which supports an electrode 78 that is adapted to be impinged by the expanded or enlarged pilot ignition flame upon energization of the magnetic gas valve 15 and by the oil burner flame upon the establishment of combustion. The grid glow tube 76 includes a grid 79, an anode 80, and a cathode 81.

Power is supplied to the system by means of a combination step-up and step-down transformer 82 that includes a high voltage primary 83 which is connected to line wires 84 and 85 that are in turn connected to a suitable source of 110 volt alternating current. The transformer 82 includes a high voltage secondary 86 which delivers approximately 440 volts and a center tap low voltage secondary which is in effect two secondaries 87 and 88, each of which delivers substantially 10 volts. Certain of the alternating current circuits are rectified by a copper oxide rectifier 89 of usual construction which is provided with current paths 90, 91, 92, and 93.

With the parts in the position shown, the room temperature is at or above the desired value, and both relay coils 29 and 35 are deenergized. A small flame (shown in full lines) is issuing from the pilot 13 by reason of the by-pass 16, but this small pilot flame does not impinge upon electrode 78. Now as the room temperature falls, contact 23 will first engage contact 25, but no circuits are completed by such engagement. Upon a further fall in room temperature, contact 24 engages contact 26, whereupon an energizing circuit for relay coil 29 and safety switch heating element 74, in series, is established during one-half of each cycle of the alternating current as follows: secondary 88, secondary 87, wire 95, contact 25, contacts 23 and 24, contact 26, wire 96, switch arm 43, contact 44, wire 97, wire 98, safety switch contacts 71 and 72, wire 99, current path 90 of rectifier 89, wire 100, relay coil 29, wire 101, current path 91 of rectifier 89, wire 102, switch arm 37, contact 41, wire 103, safety switch heater 74, and wire 104 to secondary 88. During the other half of each cycle of the alternating current supplied by secondaries 87 and 88, the series circuit for relay coil 29 and safety switch heater 74 is as follows: secondary 87, secondary 88, wire 104, safety switch heater 74, wire 103, contact 41, switch arm 37, wire 102, current path 92 of rectifier 89, wire 100, relay coil 29, wire 101, current path 93 of rectifier 89, wire 99, safety switch contacts 72 and 71, wire 98, wire 97, contact 44, switch arm 43, wire 96, contact 26, contacts 24 and 23, contact 25, and wire 95 to the other side of secondary 87. In this manner, upon engagement of both contacts 23 and 24 with their respective contacts 25 and 26, the relay coil 29 is continuously energized by current flowing in only one direction through the medium of the rectifier 89, it being noted that these energizing circuits can be established only in the event the relay coil 35 is deenergized so that the various switches controlled thereby are in the position shown in the drawing.

Energization of relay coil 29 attracts armature 30 to move switch arms 31 and 32 into engagement with contacts 33 and 34 and also moves actuator 59 out of the path of movement of extension 58 of member 56. Engagement of switch arm 31 with contact 33 establishes holding circuits for the relay coil 29 and safety switch heater 74 which are independent of the contact 24 and contact 26 of the room thermostat 20, it being noted that wires 105 and 106, switch arm 31, contact 33, and bimetallic element 21 parallel or shunt the wire 96, contact 26, contact 24, switch arm 43, contact 44, and wire 97.

Movement of switch arm 32 into engagement with contact 34 energizes burner motor 10, the electrical heating element 64 of thermal time switch 51; and the electrical heating element 55 of thermal time switch 50. The energizing circuit for burner motor 10 is as follows: line wire 84, wire 108, contact 34, switch arm 32, wire 109, wire 110, wire 111, burner motor 10, wire 112, and wire 113 to line wire 85. The energizing circuit for electric heating element 64 is as follows: line wire 84, wire 108, contact 34, switch arm 32, wire 109, wire 110, wire 117, contact 61, contact 60, wire 118, wire 122, heating element 64, wire 123, wire 124, and wire 113 to line wire 85. The energizing circuit for electric heating element 55 is as follows: line wire 84, wire 108, contact 34, switch arm 32, wire 109, wire 114, switch arm 75

38, contact 42, wire 115, heating element 55, and wire 116 to line wire 85. After approximately thirty (30) seconds the free end of bimetallic element 52 moves into engagement with contact 54, whereupon magnetic gas valve 15 is energized as follows: line wire 84, wire 108, contact 34, switch arm 32, wire 109, wire 110, wire 117, contact 61, contact 60, wire 118, wire 119, bimetallic element 52, contact 54, wire 120, magnetic gas valve 15, and wire 121 to line wire 85. Energization of magnetic gas valve 15 causes the same to open, whereupon the pilot flame expands, as indicated in dotted lines, and impinges against electrodes 78. While the ignition means has herein been shown as comprising an expanding pilot wherein the large flow of gas is ignited by the small constant flow, it will be appreciated that other ignition means as well as other means of igniting the gas pilot igniter shown could also be utilized. Impingement of the expanded pilot flame upon the electrode 78 connects the grid 79 of grid glow tube 76 to ground as follows: grid 79, wire 125, electrode 78, the expanded ignition flame, pilot pipe 13, and wire 126 to ground 127. Such grounding of grid 79 allows the charge thereon to be dissipated, whereupon current is permitted to flow from the anode 80 to the cathode 81 of the grid glow tube 76 in a well-known manner. Relay coil 35 is thereupon energized as follows: high voltage secondary 86, wire 130, anode 80, cathode 81, wire 131, wire 132, relay coil 35, wire 133, and wire 134 to the other side of secondary 86. It will be noted that the condenser 45 is connected across or in parallel with the relay coil 35 by means of wires 136 and 137. This condenser serves to smooth out the pulsating direct current which results from the elimination of one-half of each cycle of alternating current delivered by the secondary 86 to the grid glow tube 76.

During the time that the bimetallic element 73 has been heating up, the burner motor 10 has been operated by the previously described circuit and is operating at top speed by the time relay coil 35 is energized. Energization of relay coil 35 establishes maintaining circuits for relay coil 29 which are independent of the safety switch heater 74 and utilize only the one low voltage secondary 87. During one-half of each cycle of the alternating current delivered by secondary 87, the maintaining circuit for relay coil 29 is as follows: secondary 87, wire 95, contact 25, contact 23, bimetallic element 21, wire 106, contact 33, switch arm 31, wire 105, wire 98, safety switch contacts 71 and 72, wire 99, current path 90, wire 100, relay coil 29, wire 101, current path 91, wire 102, switch arm 37, contact 39, and wire 138 to the other side of secondary 87. During the other half of each cycle of the alternating current produced by secondary 87, this maintaining circuit for relay coil 29 is as follows: secondary 87, wire 138, contact 39, switch arm 37, wire 102, current path 92, wire 100, relay coil 29, wire 101, current path 93, wire 99, safety switch contacts 72 and 71, wire 98, wire 105, switch arm 31, contact 33, wire 106, bimetallic element 21, contact 23, contact 25, and wire 95 to the other side of secondary 87. In this manner, if the ignition flame is properly produced so that it impinges upon electrode 78, the safety switch heater 74 is operatively deenergized to prevent the system from being locked up. It is obvious that if the proper ignition flame were not established so that relay coil 35 remained deenergized, the safety switch contacts 71 and 72 would be

opened after a time period so as to render the system inoperative until manual intervention.

Energization of relay coil 35 also moves switch arm 38 from engagement with contact 42 and into engagement with contact 40. Movement of switch arm 38 from engagement with contact 42 interrupts the energizing circuit for heating element 55. The rate of heat input to the bimetallic element 52 and its mass is such, however, that it does not cool sufficiently to cause movement of the free end of bimetallic element 52 from the contact 54 for a considerable period which is greater than the operating time of thermal time switch 51. Engagement of switch arm 38 with contact 40 completes an energizing circuit for magnetic oil valve as follows: line wire 84, wire 108, contact 34, switch arm 32, wire 109, wire 114, switch arm 38, contact 40, wire 140, magnetic oil valve 12, wire 141, wire 124, and wire 113 to line wire 85. Energization of magnetic oil valve 12 causes the same to open, whereupon fuel is delivered to the burner 10 and should be ignited by the ignition flame. Approximately 30 seconds after the energization of magnetic gas valve 15 or 60 seconds after energization of the electrical heating element 64, the free end of bimetallic element 62 moves from engagement with member 56 and allows the same to drop, whereupon contact 60 disengages contact 61 and interrupts the circuit to the magnetic gas valve 15 and to the electrical heating element 64. The ignition flame is therefore reduced to a size depending upon the amount of gas going through the bypass pipe 16 and no longer impinges upon electrode 78. If combustion was not successfully established during this trial ignition period, electrode 78 will no longer be connected to ground, whereupon a charge will build up on the grid 79 which in turn prevents the flow of current between the anode 80 and the cathode 81, whereupon relay coil 35 is deenergized and returns the various switches controlled thereby to the positions shown in the drawing. Such deenergization of relay coil 35 reenergizes safety switch heater 74 so that the safety switch contacts 71 and 72 will open after a time period and render the system inoperative until manual intervention. If, on the other hand, combustion is successfully established, the main burner flame will impinge upon electrode 78 so that the electrode 78 will continue to be connected to ground 127 by way of the main burner flame, the oil burner 10, and a wire 143. Under these conditions, the grid glow tube 76 continues to permit the passage of current through the relay coil 35 so that the system remains in operation. After the contacts 60 and 61 have been separated, the bimetallic element 52 will have cooled sufficiently to move from engagement with contact 54.

The system is now in normal operation, and if the burner continues to operate properly so as to maintain a flame issuing therefrom which impinges the electrode 78, the system will remain in operation until opening of the main switch or room thermostat 20. When the room temperature rises, contact 24 will first disengage contact 26, but this will not in any manner interrupt the operation of the system by reason of the maintaining circuit which traverses switch arm 31 and contact 33. Upon continued rise in room temperature resulting in separation of contact 23 from contact 25, all energizing circuits for both relay coils 35 and 29 are interrupted. Deenergization of relay coil 29 allows armature 30 to return to the position shown in the drawing 75

wherein actuator 59 engages the extended end 58 of member 56 and returns the member 56 to the position shown in the drawing wherein contacts 60 and 61 are engaged. At this time, the free end of bimetallic element 62 can again move to the position shown whereby to latch the contacts 60 and 61 in engagement. The system cannot now again be operated until such time as the room temperature lowers sufficiently to cause both contacts 23 and 24 to engage their respective contacts 25 and 25.

In the event the burner flame should fail for any reason while the system is operating normally, the ground connection for electrode 78 will be removed, whereupon relay coil 35 will be deenergized resulting in reenergization of safety switch heater 74 so that the system will be rendered inoperative the same as though combustion had never been established. In the event of a failure of electrical power during normal operation of the system, both relay coils 29 and 35 will be deenergized and the parts will return to the position shown in the drawing provided the power failure did not occur too soon after deenergization of the heating element 64. In such case, if the power returns before the bimetallic element 62 has cooled sufficiently to relatch contacts 60 and 61 in engagement with one another, the ignition valve 15 cannot be energized, and the system will go to its safety shut-down condition. This possibility is rather remote, however, and in most cases the contacts 60 and 61 will be properly relatched by the bimetallic element 62 so that the system will completely recycle upon the return of electrical power in an effort to re-establish combustion, and if this is not successful the system will lock up as previously explained.

It will be evident that many changes and rearrangements may be made in the system of the present invention without departing from the spirit thereof. For example, the particular means by which the operation of the ignition valve 15 is terminated is not important, and any of the well-known ignition terminating arrangements could be utilized without affecting the general operation of the system. It will be evident that many other minor changes could be made in the system, and I therefore intend to be limited only by the scope of the appended claims.

I claim:

1. In a burner control system, the combination with a burner and a supply of fuel therefor, of electrical means in control of the supplying of said fuel to the burner, electrically controlled ignition means of the type which produces an igniting flame only so long as the same is energized, electrical timing means operative to energize said ignition means for a time period and then deenergize the same, means to energize said timing means upon a demand for heat, and means utilizing the conductivity of the igniting flame operative to energize said fuel supply controlling means, said last-named means also utilizing the conductivity of the burner flame to maintain the fuel supply controlling means energized after said ignition means is deenergized by said timing means.

2. In a fuel burning control system, the combination with a burner and a supply of fuel therefor, of electrical means in control of the supplying of fuel to the burner, an electrically controlled ignition flame producing means operative to produce an ignition flame only so long

as the same is energized, means responsive to a demand for heat operative to energize said ignition means, means utilizing the conductivity of flame responsive to the production of an ignition flame operative to energize said fuel supply controlling means, said last-named means also utilizing the conductivity of the burner flame to maintain said fuel supply controlling means energized, and means to deenergize said ignition means a timed period after the energization of said fuel supply controlling means.

3. In a burner and ignition control system, the combination with a supply of fuel, a burner, and an associated electrical burner motor for impelling the fuel, of a fuel valve in control of said supply of fuel, electrical ignition means to ignite the fuel, an electrical timer, a burner motor circuit, a timer circuit, a main control switch operative to complete said circuits, a timer switch closed by said timer after the same has been energized for a time period, a circuit for said ignition means controlled by said timer switch, timing means to deenergize said ignition means after a time period, and means to maintain said fuel valve closed for a period after energization of said burner motor whereby said burner motor will be operating at full speed before the fuel valve opens.

4. In a burner control system, the combination with a burner and a supply of fuel therefor, of electrical means in control of the supplying of fuel to the burner, electrically controlled ignition means operative to ignite the fuel supplied to the burner only so long as said ignition means is energized, a normally open power switch, means to close said switch upon a demand for heat, a normally open fuel supply controlling means switch, a time operated ignition switch, a circuit in control of said ignition means controlled by the power switch and time operated ignition switch, a circuit in control of the fuel supply controlling means controlled by the power switch and fuel supply controlling means switch in series, means independently responsive both to the proper operation of the ignition means and the establishment of combustion operative to close said fuel supply controlling means switch whereby said fuel controlling means can only be energized in the event the ignition means is operating properly, and means to open said time operated switch after closure of the fuel control means switch whereby the fuel control means can only be maintained energized if combustion is successfully established.

5. In a fuel burning system, the combination with a burner and a supply of fuel for the burner, of electrical means in control of the flow of fuel to the burner, electrically controlled ignition means operative to ignite such fuel only so long as the same is energized, a normally closed switch, a normally open switch, a circuit in control of the ignition means controlled by said two switches in series, a second normally open switch, a circuit in control of the fuel flow controlling means controlled by said two normally open switches in series, means operative to close said first normally open switch upon a demand for heat, means independently responsive both to the proper operation of the ignition means and the establishment of combustion open to close said second normally operative switch and open said normally closed switch, means to render the entire system inoperative after a time period rendered inoperative by said last-named means, and means to prevent reenergization of the ignition means upon a

failure of flame during normal operation whereby the system is shut down without attempting to reestablish combustion, said means operating to maintain the ignition means energized for a period after opening of said normally closed switch.

6. In a fuel burning system, the combination with a burner and a supply of fuel for the burner, of electrical means in control of the flow of fuel to the burner, electrically controlled ignition means operative to ignite such fuel only so long as the same is energized, a normally closed switch, a normally open switch, a circuit in control of the ignition means controlled by said two switches in series, a second normally open switch, a circuit in control of the fuel flow controlling means controlled by said two normally open switches in series, means responsive to a demand for heat to close said first normally open switch, an electromagnetic coil operative to close said second normally open switch and open said normally closed switch when energized, means independently responsive both to the proper operation of the ignition means and the establishment of combustion in control of the energization of said electromagnetic coil whereby the same is initially energized upon proper operation of the ignition means and is thereafter maintained energized independently of the ignition means if combustion is established, means to render the entire system inoperative after a time period rendered inoperative upon energization of said electromagnetic coil, and means to maintain energization of the ignition means for a period after opening of said normally closed switch and to prevent reenergization of the ignition means upon deenergization of said electromagnetic coil as a result of a failure of flame during normal operation whereby the system is shut down without attempting to reestablish combustion.

7. In a fuel burning system, the combination with a burner and a supply of fuel for the burner, of electrical means in control of the flow of fuel to the burner, electrically controlled ignition means operative to ignite such fuel only so long as the same is energized, a normally closed switch, a normally open switch, a circuit in control of the ignition means controlled by said two switches in series, a second normally open switch, a circuit in control of the fuel flow controlling means controlled by said two normally open switches in series, an electromagnetic coil operative to close said first normally open switch when energized, a main switch in control of said electromagnetic coil, a second electromagnetic coil operative to close said second normally open switch and open said normally closed switch when energized, means independently responsive both to the proper operation of the ignition means and the establishment of combustion in control of the energization of said second electromagnetic coil whereby the same is initially energized upon proper operation of the ignition means and is thereafter maintained energized independently of the ignition means if combustion is established, means to render the entire system inoperative after a time period rendered inoperative upon energization of said second electromagnetic coil, and means to prevent reenergization of the ignition means upon deenergization of said second electromagnetic coil as a result of a failure of flame during normal operation whereby the system is shut down without attempting to reestablish combustion, and means to maintain said

ignition means energized for a period after opening of said normally closed switch.

8. In a fuel burning control system, the combination with a burner, an electrical burner motor for impelling fuel and a supply of fuel associated therewith, of an electrical fuel valve in control of the supply of fuel, ignition means of the expanding pilot type for igniting said fuel and including an electrical device operative to cause expansion of said pilot only while energized, a normally open switch and a normally closed switch, a series circuit in control of said ignition means including said normally open switch and said normally closed switch, a burner motor circuit controlled by said normally open switch, an electromagnetic coil in control of said normally open switch operative to close the same when energized, a thermal safety switch in control of the system and arranged to render the same inoperative when opened, an electrical heating element associated with the safety switch operative to open the same when energized for a time period, a main control switch operative to energize said heating element and said electromagnetic coil upon a demand for heat, a member arranged to be impinged by said pilot flame when expanded, circuit connections controlled by said member, a second electromagnetic coil in control of said normally closed switch for opening the same controlled by said circuit connections, and switching means controlled by said second electromagnetic coil when energized to operatively deenergize said electrical heating element and to energize said fuel valve, the flame thus produced impinging said member to maintain energization of said second electromagnetic coil after said pilot flame contracts, and means to maintain energization of said ignition means for a period after opening of said normally closed switch.

9. In a fuel burning control system, the combination with a burner, an electrical burner motor for impelling fuel and a supply of fuel associated therewith, of an electrical fuel valve in control of the supply of fuel, ignition means of the expanding pilot type for igniting said fuel including an electrical device operative to cause expansion of said pilot only while energized, a thermal time switch in control of said ignition means, an electrical heating element arranged to heat said thermal time switch and cause closure thereof when energized for a time period, a normally open switch and a normally closed switch, a series circuit for said heating element including said normally open switch and said normally closed switch, a burner motor circuit controlled by said normally open switch, an electromagnetic coil in control of said normally open switch operative to close the same when energized, a thermal safety switch in control of the system and arranged to render the same inoperative when opened, an electrical heating element associated with the safety switch operative to open the same when energized for a time period, a main control switch operative to energize said last-named heating element and said electromagnetic coil upon a demand for heat, a second electromagnetic coil in control of said normally closed switch for opening the same, a circuit therefor controlled by means responsive to the presence of an expanded pilot flame, switching means controlled by said second electromagnetic coil when energized to operatively deenergize said last-named electrical heating element and to energize said fuel valve, said flame responsive means also responding to the flame thus produced whereby to maintain en-

energization of said second electromagnetic coil after said pilot flame contracts, and means to maintain energization of said ignition means for a period after opening of said normally closed switch.

10. In a fuel burning control system, the combination with a burner, an electrical burner motor for impelling fuel and a supply of fuel associated therewith, of an electrical fuel valve in control of the supply of fuel, ignition means of the expanding pilot type for igniting said fuel and including an electrical device operative to cause expansion of said pilot only while energized, a thermal time switch in control of said ignition means, an electrical heating element arranged to heat said thermal time switch and cause closure thereof when energized for a time period, a normally open switch and a normally closed switch, a series circuit for said heating element including said normally open switch and said normally closed switch, a burner motor circuit controlled by said normally open switch, an electromagnetic coil in control of said normally open switch operative to close the same when energized, a thermal safety switch in control of the system and arranged to render the same inoperative when opened, an electrical heating element associated with the safety switch operative to open the same when energized for a time period, a main control switch operative to energize said last-named heating element and said electromagnetic coil upon a demand for heat, a space discharge tube including a cathode, an anode, and a control electrode, a member arranged to be impinged by said pilot flame when expanded, circuit connections between said member and control electrode whereby the bias on the control electrode depends upon the impingement or non-impingement of flame upon said member, a second electromagnetic coil in control of said normally closed switch for opening the same, a circuit therefor controlled by said anode and cathode and rendered operative when said member is impinged by flame, switching means controlled by said second electromagnetic coil when operatively energized to operatively deenergize said last-named electrical heating element and to energize said fuel valve, the flame thus produced being adapted to impinge said member to maintain operative energization of said second electromagnetic coil after said pilot flame contracts, and means to maintain said ignition means energized for a period after opening of said normally closed switch.

11. In a fuel burning control system, the combination with a burner, an electrical burner motor for impelling fuel and a supply of fuel associated therewith, of an electrical fuel valve in control of the supply of fuel, ignition means of the expanding pilot type for igniting said fuel and including an electrical device operative to cause expansion of said pilot only while energized, a thermal time switch in control of said ignition means, an electrical heating element arranged to heat said thermal time switch and cause closure thereof when energized for a time period, a normally open switch and a normally closed switch, a series circuit for said heating element including said normally open switch and said normally closed switch, a burner motor circuit controlled by said normally open switch, an electromagnetic coil in control of said normally open switch and operative to close the same when energized, a thermal safety switch in control of the system and arranged to render the same inoperative when opened, an electrical heating element associated with the safety switch operative to open the same when energized for a time period, a main control switch operative to energize said safety switch heating element and said electromagnetic coil upon a demand for heat, a grid-glow-tube including a cathode, an anode, and a control electrode, a member arranged to be impinged by said pilot flame when expanded, circuit connections between said member and control electrode whereby the bias on the control electrode depends upon the impingement or non-impingement of flame upon said member, a second electromagnetic coil in control of said normally closed switch for opening the same, a circuit therefor controlled by said anode and cathode and rendered operative when said member is impinged by flame, switching means controlled by said second electromagnetic coil when operatively energized to operatively deenergize said safety switch heating element and to energize said fuel valve, the flame thus produced being adapted to impinge said member to maintain operative energization of said second electromagnetic coil after said pilot flame contracts, means to maintain said ignition means energized for a period after opening of said normally closed switch, and means to prevent reenergization of said ignition means upon deenergization of said second electromagnetic coil by reason of a failure of flame during normal operation.

LEON L. KUEMPEL.

CERTIFICATE OF CORRECTION.

Patent No. 2,081,091.

May 18, 1937.

LEON L. KUEMPEL. .

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 70, claim 5, for the word "open" read operative; and line 71, same claim, for "operative" read open; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of September, A. D. 1937.

Henry Van Arsdale

(Seal)

Acting Commissioner of Patents.