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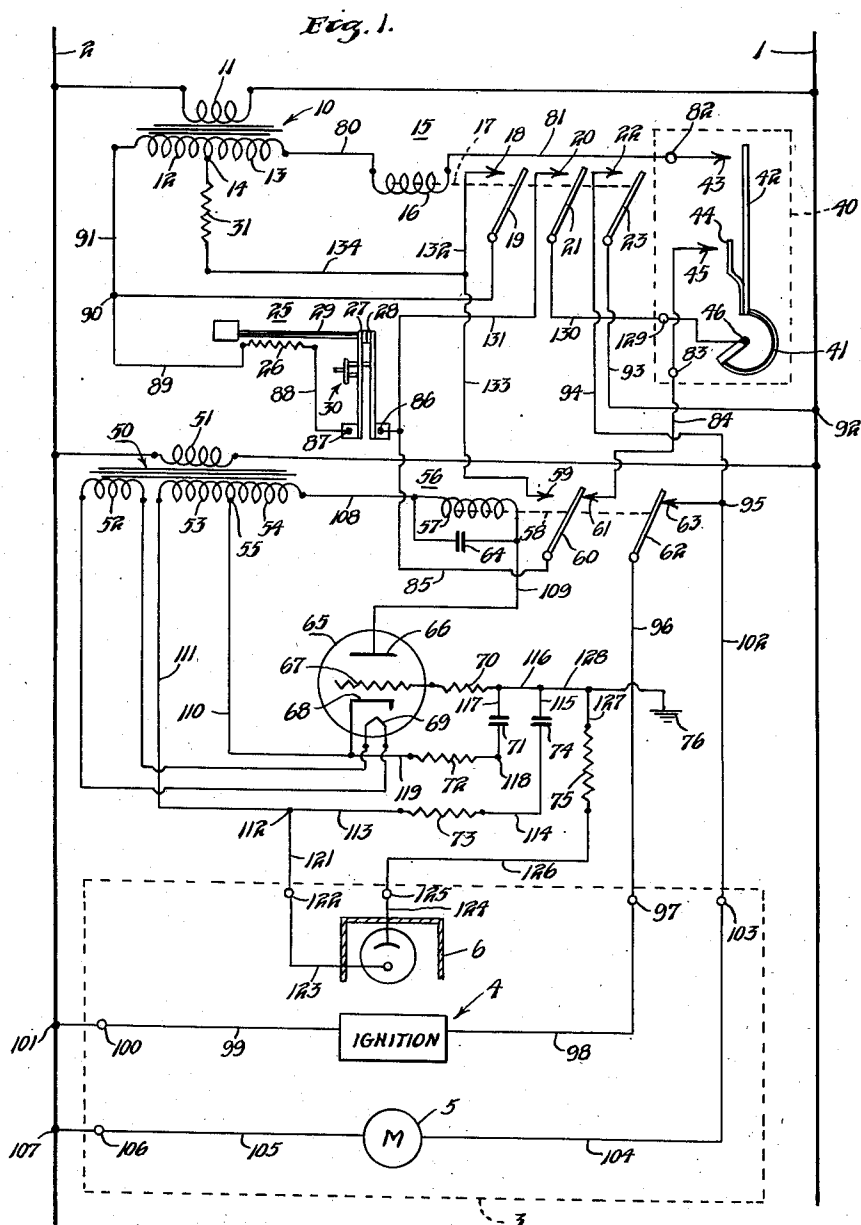
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FUEL BURNER SAFETY CONTROL SYSTEM

Filed March 3, 1947

2 Sheets-Sheet 1



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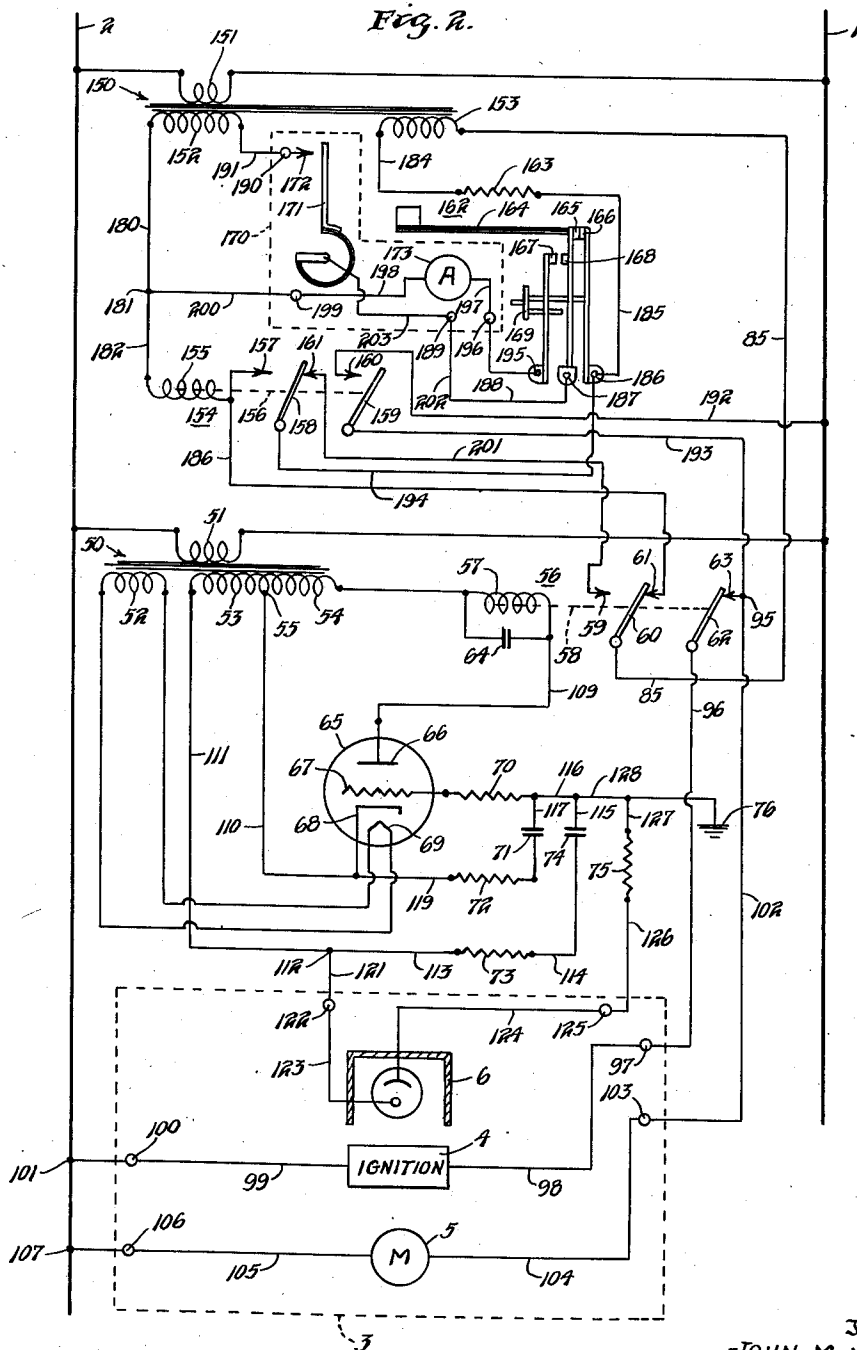
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UNITED STATES PATENT OFFICE

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FUEL BURNER SAFETY CONTROL SYSTEM

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19 Claims. (Cl. 158—28)

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This invention relates broadly to automatic control apparatus for fuel burners and is generally directed to that type of system which is put in operation by a room thermostat or other temperature sensitive element. In such a system it is necessary to provide a combustion responsive device which will give an indication of flame. As there is always a possibility of the combustion responsive device operating falsely, it is necessary to provide a safety shut-down which will prevent the system from operating when such a condition exists.

In conventional fuel burner control apparatus, it is customary to provide a timed safety switch which is energized at the time the room thermostat closes and starts the burner in operation and is deenergized upon operation of a combustion responsive device. In my improved apparatus I utilize this safety switch to prevent the system from operating when the combustion responsive device indicates combustion and the burner is not in operation. As the safety shut-down may indicate either a flame failure or equipment failure, it may, in certain cases, be advisable to distinguish between flame failure and equipment failure by making it impossible to deenergize the control apparatus until the equipment has been repaired.

Added to the safety features of my safety switch circuit and working in conjunction therewith, I provide a further safety feature that prevents the system from going back into operation in the wrong sequence upon a momentary power failure when the flame responsive device does not become deenergized either because of a sticking relay or some other fault that will hold the flame responsive device in an energized position.

It is therefore an object of the present invention to provide apparatus which will be shut down upon the failure of the combustion responsive device to correctly indicate a flame.

A further object is to utilize the control apparatus safety switch to obtain a shut down of the system upon a flame failure or failure of the combustion responsive device to operate correctly.

A still further object is to provide control apparatus with a safety shut down which when operated by a flame failure may be reenergized and when operated by a failure of the combustion responsive device may not be reenergized.

Still another object is to utilize the control apparatus safety switch to obtain a shut down of the system which when operated by a flame failure may be reenergized and when operated by a failure of a combustion responsive device may not be reenergized.

Another object is to provide electronic burner control apparatus which is adapted to be shut down upon a flame failure or a false indication of flame.

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Still another object of my invention is to provide in cooperation with the above described objects in apparatus that will prevent the apparatus from causing a fuel burner from going into operation except in the proper timing sequence should a momentary power failure occur.

Other objects of the invention will be readily apparent upon consideration of the specification, claims and drawings of which:

Figure 1 is a diagrammatic showing of one particular embodiment of my invention with the simplified type of fail-safe circuit as employed with an electronic flame detector; and

Figure 2 is a diagrammatic showing of a modification of my invention which has added fail-safe features.

In referring to Figure 1 of the drawings, the power lines 1 and 2 are connected through the control system to the housing 3 which contains an ignition device 4, burner motor 5, and a flame detecting element 6 which is shown as a photocell.

In the control system proper, a transformer 10 has a primary winding 11 connected to the input power lines 1 and 2. A secondary winding of transformer 10 has a tap 14 which divides the winding into two parts designated as 12 and 13. Numeral 15 designates a relay which has a winding 16, adapted when energized to move the relay armature 17. The relay armature 17, when energized by winding 16, will move relay switch arms 19, 21 and 23 into engagement with their respective contacts 18, 20, and 22. Switch arms 19, 21 and 23 are normally biased out of engagement with these contacts by any suitable means (not shown).

A safety switch device 25 consists of a pair of biased open switch arms 27 and 28 which are maintained in a closed position by a bimetal element 29. A heater element 26 is mounted adjacent to the bimetal element so that when it is energized it will cause the element to move in an upward direction. When the bimetal element 29 has been warped sufficiently to allow the contacts of switch arms 27 and 28 to break, the switch arm 27 will move under the bimetal element 29 due to a biasing action placed thereon, and will hold the element 29 in its warped position. A reset member 30 has been provided which when thrust toward the right will move the switch arm 27 from under the element 29 and allow the element 29 to come back into the position shown on the diagram.

A thermostat housing 40 contains a thermostat having a bimetallic element indicated at 41. Associated with the element 41 are switch blades 42 and 44 which upon a decrease in temperature are caused to move to the left by the element 41 and engage contacts 43 and 45 respectively. The switch blades and contacts are so arranged that

upon a temperature decrease the switch arm 42 engages the contact 43 at a temperature slightly above that when the switch arm 44 engages the contact 45. A bimetallic element mounting 46 also provides an electrical circuit contact.

Another transformer 50 has its primary 51 connected to the power lines 1 and 2. Secondary windings of the transformer 50 consist of a filament transformer winding 52 and a tapped secondary winding consisting of sections 53 and 54 with a center tap 55. A relay 56 has a relay winding 57 adapted when energized to move an armature 58 and cause switch arms 60 and 62 to disengage their respective contacts 61 and 63 and to cause switch arm 60 to engage contact 69. Switch arms 60 and 62 are normally biased open by any suitable means (not shown).

An evacuated electron discharge device 65 contains an anode 66, a control element in the form of a grid 67, a cathode 68, and a filament 69. A grid resistor 70 is connected to the control element 67. A condenser 71, resistor 72, resistor 73, and condenser 74, act as biasing elements in a manner to be described hereinafter. A resistor 75 acts as a current limiting resistor in an electrical circuit for the photocell 6. This last named circuit comprises an electronic flame detector of the type completely described in my copending application, Serial No. 465,476, filed November 13, 1942, now Patent No. 2,448,503, granted August 31, 1948.

Operation

The parts shown in Figure 1 occupy the position they would normally occupy when the room thermostat 40 has been satisfied. Under these conditions the burner motor 5 and the ignition device 4 will be deenergized and there will be no heat supplied to the system. As soon as the temperature in the space in which the thermostat 40 is located has decreased sufficiently to cause the blades 42 and 44 to move into engagement with their respective contacts 43 and 45, an energizing circuit for the relay 15 will have been established by way of conductor 80, relay winding 16, conductor 81, terminal 82, switch contact 43, blade 42, blade 44, switch contact 45, terminal 83, conductor 84, switch contact 61, switch arm 60, conductor 85, terminal 86, switch contacts 27 and 28, terminal 87, conductor 88, safety switch heater 26, conductor 89, junction 90, and conductor 91, back to the secondary winding of transformer 10.

With the energizing of relay 15, the switch arm 23 is moved into engagement with contact 22 and forms an energizing circuit for the ignition device 4 and the motor 5 by a circuit connection from junction 92, conductor 93, switch arm 23, switch contact 22, conductor 94, junction 95, and to the ignition device through switch contact 63, switch arm 62, conductor 96, terminal 97, conductor 98, through the ignition device 4, to conductor 99, and terminal 100 to junction 101 of line 2. The circuit for the burner motor 5 is completed from the junction 95 of the circuit already traced through the conductor 102, terminal 103, conductor 104, through the burner motor 5, to conductor 105, and terminal 106 to junction 107 of line 2.

Energization of relay 15, in addition to energizing the ignition device 4 and the burner motor 5, provides a self-holding circuit which may be traced from the secondary winding of transformer 10 through conductor 80, relay winding 16, conductor 81, terminal 82, switch contact 43, switch blade 42, terminal 46, terminal 129, conductor

130, switch arm 21, switch contact 20, conductor 131, terminal 86, switch contacts 27 and 28, terminal 87, conductor 88, energizing element 26, conductor 89, junction 90, and conductor 91 back to the secondary winding. As the closing of switch arm 19 and switch contact 18 of the relay 15 forms a short circuit across the secondary winding section 12, it is necessary to provide a current limiting resistor 31 which prevents this short circuit from causing any damage to the secondary winding.

Under normal conditions as soon as the ignition device 4 and burner motor 5 have been energized, there will be combustion which will be detected by the electronic flame detector.

Briefly, the operation of the electronic flame detector may be understood by the following description. The single electronic discharge device 65 is shown with anode 66 and cathode 68 energized by a section of the transformer winding 54 connected through conductor 108, relay winding 57, conductor 109, anode 66, cathode 68, conductor 110, and center tap 55 back to the secondary winding 54. Without any biasing voltage on the control element 67 the current flow through the electron discharge device 65 will be sufficient to energize the relay 56. A biasing voltage for the electron discharge device 65 is provided by way of a connection to the left end of the secondary winding section 53, through conductor 111, junction 112, conductor 113, resistor 73, conductor 114, condenser 74, conductor 115, conductor 116, and resistor 70, to the control element 67. With this connection to the control element 67, it can be seen that the alternating current present on the control element will be 180° displaced in phase with the voltage present on the anode 66. With this phase displacement, the control element 67 will be negative when the anode 66 is positive. With this bias voltage, the conductivity of the discharge device 65 will have been decreased sufficiently to cause the relay 56 to be deenergized and the switch arms and contacts of the relay 56 will be in the position shown on the diagram.

The biasing network for the control element 67 actually consists of a circuit that may be traced from the center tap 55, through the conductor 110, conductor 119, resistor 72, conductor 118, condenser 71, conductors 117, 116, and 115, condenser 74, conductor 114, resistor 73, and conductors 113 and 111 back to the winding 53. From this it can be seen that the magnitude of the alternating current actually applied to the control element is less than that with the bias connection through resistor 73 and condenser 74 considered alone. However, it is still sufficient in magnitude to maintain the discharge device effectively non-conductive.

In order to put the relay 56 in an energized condition it is necessary to provide additional bias for the electron discharge device. This is accomplished when flame is sensed by the photocell 6. The photocell 6 is energized by the secondary winding section 53 through conductor 111, junction 112, conductor 121, terminal 122, conductor 123, photocell 6, conductor 124, terminal 125, conductor 126, resistor 75, conductors 127, 128, 116, and 117, condenser 71, resistor 72, conductors 119 and 110 back to the center tap 55. As the photocell has unidirectional conductive properties on the presence of light, the application of alternating current to the photocell makes it act as a rectifier in a manner to charge the condenser 71 plus on the control element side and minus on the

cathode side. With this charge on condenser 71 it can be seen that the control element now has a more positive bias which will allow the discharge device 65 to be in a conductive condition and thereby energize relay 56.

Assume now that the ignition device 4 and the burner motor 5 are operating correctly and combustion has been established. Upon the establishment of combustion, the photocell 6 will put a bias on the electron discharge device 65 which will in turn energize the relay 56. When relay 56 is energized, the switch arm 62 will move out of engagement with contact 63 and break the energizing circuit to the ignition device 4.

While the initial energizing circuit for relay winding 16 was completed through the switch arm 60 and switch contact 61 of the relay 56, the above traced holding circuit completed through the switch arm 21 and switch contact 20 of the relay 15 is independent of switch arm 60 and contact 61 so that the movement of the switch arm 60 from the contact 61 will have no effect upon the energization of relay 15. This starting circuit for relay 15 is necessary to provide for the situation that might arise when a momentary power failure occurs or when the thermostat contacts are accidentally opened. Were this starting arrangement not present, it would be possible upon the recurrence of power, if the relay 56 should stick in the energized position, to have relay 15 become energized to start the burner 4 without any ignition present to ignite the fuel present. Therefore, since the ignition device 4 is energized when relay 56 is deenergized it is advisable to have the starting circuit completed through contacts that are closed when the relay 56 is deenergized.

With relay 56 energized the switch arm 60 now engages the switch contact 59 to complete a holding circuit for the relay 15 independent of the safety switch device 25. The holding circuit for the relay 15 may now be traced through from the secondary winding section 13 through conductor 80, relay winding 16, conductor 81, terminal 82, switch contact 43, switch blade 42, terminal 46, terminal 129, conductor 130, switch arm 21, switch contact 20, conductor 131, conductor 85, switch arm 60, switch contact 59, conductor 133, conductor 132, switch contact 18, switch arm 19, conductor 135, junction 90, and conductor 91 back to the secondary winding. With this last circuit remaining operative, the burner motor will be energized until such time as the heat from the burner motor has caused the thermostat 40 to move to the right and break the energizing circuit for the relay 15. Breaking of energizing circuit to relay 15 by the opening of the switch contacts of the thermostat allows the switch arms 19, 21 and 23 to move out of engagement with their respective contacts 18, 20 and 22. When the switch arm 23 moves out of engagement with contact 22 the energizing circuit to the burner motor 5 and ignition device 4 is opened and the system is shut down. As soon as the flame in the burner dies out, the photocell 6 will not maintain the discharge device 65 in a conducting condition and therefore relay 56 will be deenergized. With both relays deenergized the apparatus will now be in the position shown on the drawing and the apparatus will now be in a position to be put in operation by the closing of the switch contacts of the thermostat 40 on a call for more heat.

In the event that the energizing of the ignition device 4 and burner motor 5 does not initiate combustion, it may be seen that the appa-

ratus will be shut down to prevent any damage. This is because the energizing circuit for the relay 15 is completed through the safety switch heater 26 and the contacts of switch arms 27 and 28.

This circuit may be traced from the winding 13 through conductor 80, winding 16, conductor 81, terminal 82, contact 43, switch blade 42, element 41, terminal 46, terminal 129, conductor 130, switch arm 21, contact 20, conductor 131, terminal 86, switch arms 28 and 27, terminal 87, conductor 88, heater 26, conductor 89, junction 90 and conductor 91 back to the winding 12. If this above traced circuit is allowed to remain energized for a predetermined length of time, it may be seen that the current flow through the heater 26 will warp the bimetallic element 29 upward to allow the contacts of switch arms 27 and 28 to separate. The circuit to relay 15 will now be broken and the ignition device 4 and burner motor 5 will be deenergized thus preventing any further operation. The apparatus cannot be put back in operation until the reset member 30 is pressed to the right to allow the bimetal element to move back in a position to hold the contacts of the arms 27 and 28 in a closed position. If the contacts of the thermostat 40 are still in a closed position the relay 15 will be energized and the apparatus will again attempt to establish combustion.

Operation upon flame failure

Assume the system is operating normally with the burner motor functioning properly and relay 56 energized indicating a flame. The safety switch device 25 in this condition will be shunted out in the manner just described. Should the fuel supply to the burner motor fail, combustion will cease, thus causing the flame detector photocell to cease supplying a rectified bias signal to the discharge device 65. The resulting decrease in conductivity of the discharge device 65 will cause deenergization of the relay 56 which in turn will move the switch arms 60 and 62 to the deenergized position. Deenergization of relay 56 causes the switch arm 62 to engage the contact 63 and put the ignition device back in operation in an attempt to initiate combustion again. The movement of the switch arm 60 from the switch contact 59 removes the shunt from the safety switch device so that the safety switch heater 26 is now operative in the circuit traced above through the heater 26 to the relay winding 16. After a certain time delay the heating action of the safety switch heater 26 will warp the bimetal element 29 in an upward direction. If combustion is not reestablished in the meantime, as soon as the bimetal 29 has warped sufficiently the circuit for the relay 15 will be opened as described above when no flame occurred when the burner was put in operation. The opening of the circuit will cause the deenergization of the relay 15 which in turn will deenergize the entire system. If combustion is reestablished, relay 56 will again be energized to shunt out the safety switch heater again as described in connection with a normal starting cycle.

Operation upon a false indication of flame

If, for any reason, the relay 56 is maintained in an energized position when the thermostat 40 has been satisfied the system will be rendered inoperative by the action of the safety switch. This may readily be seen when a circuit is traced from the tap 14 of the secondary winding of transformer 10 through the resistor 31, conductor 134, con-

ductor 133, switch contact 59, switch arm 60, conductor 85, terminal 86, switch contacts 27 and 28, terminal 87, conductor 88, energizing element 26, conductor 89, junction 90, and conductor 91 back to the secondary winding. With the safety switch heater 26 of the safety switch 25 energized in this manner, the resultant opening of the contacts 27 and 28 will make it impossible to have an energizing circuit for the relay 15 should the thermostat 40 call for more heat. Manual intervention is required to put the apparatus back in operation again. This is done by pressing the reset member 30 to the right to close the contacts of the switch arms 27 and 28 as described above.

Figure 2

In the modification shown in Figure 2, an apparatus has been provided which will distinguish between a flame failure and a false indication of flame. It differs from the apparatus shown in Figure 1 in that upon a false indication of flame the safety switch heater is maintained energized continuously and manual intervention cannot put the apparatus back in operation until the trouble has been cleared from the apparatus.

The flame detection circuit and the burner apparatus are the same as shown in Figure 1. All elements common to the two figures carry the same reference numerals. A transformer 150 has a primary winding 151 connected to the power lines 1 and 2. Two secondary windings, 152 and 153 form energizing circuits for a relay 154 and a safety switch 162 in a manner to be described hereinafter. The relay 154 consists of a winding 155, armature 156, switch arms 158 and 159, and switch contacts 157, 160, and 161. The safety switch device 162, includes a safety switch heater 163 and a bimetallic element 164 which is adapted to move in an upward direction when heated sufficiently by the heating element 163. The safety switch also includes switch contacts 165 and 166 which are normally engaged in the position shown until such time as the element 164 has warped sufficiently upward to allow the arm carrying the switch contact 165, which is biased toward the left, to break the connection between the contacts 165 and 166. The safety switch 162 also comprises another pair of contacts 167 and 168 which will be closed when the arm carrying the switch contact 168 has been allowed to move toward the left to break the contacts 165 and 166. A reset member 169 has been provided to put the system back into the position shown once the bimetal has been moved into the safety position. Located in thermostat housing 170 is a thermostat having a blade 171 positioned by a bimetallic element and having an associated contact 172. Also conveniently located with the thermostat may be an alarm 173.

Operation of Figure 2

When the heating condition has been satisfied the elements are in the position shown on the diagram. Upon a call for heat in an enclosure where the thermostat housing 170 is located the blade 171 of the thermostat will move towards the left into engagement with the contact 172. The closing of this contact will complete an energizing circuit for the relay 154 which may be traced from the secondary winding 152 through the conductor 191, terminal 190, contact 172, blade 171, conductor 203, terminal 189, conductor 188, terminal 187, switch contacts 165 and 166, terminal 186, conductor 185, heating element 163, conductor 184, secondary winding 153, con-

ductor 85, switch arm 60, contact 61, conductor 183, relay winding 155, conductor 182, junction 181, and conductor 180 back to the secondary winding 152. Energizing of relay 154 causes the switch arm 159 to move into engagement with contact 160 to form a complete circuit for the ignition device 4 which may be traced from the power line 1 through conductor 192, contact 160, switch arm 159, conductor 193, junction 95, switch contact 63, switch arm 62, conductor 96, terminal 97, conductor 98, through the ignition device 4 to conductor 99, terminal 100, and junction 101 of the power line 2. As in Figure 1, the energizing circuit for the burner motor 5 may be traced from the junction 95 that is common with the ignition circuit through the conductor 102, terminal 103, conductor 104, through the burner motor to conductor 105, terminal 106, and junction 107 of line 2. Energizing of relay 154 also moves switch arm 158 into engagement with contact 157 to provide a holding circuit for relay 154 that is independent of the switch arm 60 and contact 61 of the relay 56. This circuit may be traced from the secondary winding 152 through the conductor 191, terminal 190, switch contact 172, blade 171, conductor 203, terminal 189, conductor 188, terminal 187, switch contacts 165 and 166, terminal 186, conductor 194, switch arm 158, contact 157, winding 155, conductor 182, junction 181, and conductor 180 back to the secondary winding 152. The secondary winding 153 is still energizing the safety switch heater 163 by way of conductor 85, switch arm 60, switch contact 61, conductor 183, contact 157, switch arm 158, conductor 194, terminal 186, conductor 185, safety switch heater 163, and conductor 184. As soon as flame has been established by the burner motor and the ignition device the relay 56 will be energized in a manner previously described in connection with Figure 1. Energizing of relay 56 will move the switch arm 62 out of engagement of contact 63 to thereby deenergize the ignition device 4. The energizing of relay 56 also moves the switch arm 60 out of engagement with contact 61 to thereby open the circuit to the safety switch heater to thereby prevent the safety switch heater from shutting down the system. Thereafter, as with the previous arrangement, the system will continue to operate until the thermostat becomes satisfied or until there is a combustion failure.

Operation upon a flame failure

Assume again the system is in normal operation with the burner motor functioning properly and the relay 56 energized indicating a flame. As previously explained the safety switch device 162 is not energized since the safety switch heater 163 does not have any energizing circuit. Should a flame failure occur, due to lack of fuel or faulty operation of the burner motor the relay 56 will be deenergized. When this occurs, the circuit to the ignition device 4 has been reestablished. A completed circuit is also established for the safety switch heater 163 from winding 153 through conductor 85, switch arm 60, switch contact 61, conductor 183, switch contact 157, switch arm 158, conductor 194, terminal 186, conductor 185, heater 163, and conductor 184. If a flame is not detected after a predetermined time, the bimetallic element 164 will have warped sufficiently to allow the switch contacts 165 and 166 to separate to thereby break the energizing circuit to the relay 154. The movement of the arm

carrying the switch contact 165 toward the left causes the contact 168 to engage the contact 167 and form a circuit for the alarm which may be traced from the secondary winding 152 through the conductor 191, terminal 190, contact 172, blade 171, conductor 203, terminal 189, conductor 188, terminal 187, switch contacts 168, and 167, terminal 195, conductor 202, terminal 196, conductor 197, the alarm 173, conductor 198, terminal 199, conductor 200, junction 181, and conductor 180 back to the secondary winding 152. Although this particular diagram shows the alarm circuit completed through the thermostat, it is to be understood that any suitable alarm circuit could be completed by way of contacts 167 and 168.

With relay 154 deenergized and relay 56 deenergized, it is not possible to complete an energizing circuit for the safety switch heater element 163. When it is desired to restart after such a shutdown, the reset member 169 is depressed to allow the element 164 to go back into the position shown on the diagram. The switch contacts 165 and 166 will then be in a position to allow energization of relay 154. It is therefore possible for the system to start operation again in the manner just described and should the flame not be detected the system will go out on the safety switch shut down as just described.

Operation upon a false indication of flame

Should the relay 56 remain energized when the relay 154 is deenergized due to some type of failure in the flame detecting apparatus when there actually is no flame present in the burner, a circuit is established for the safety switch heater 163. This circuit may be traced by way of conductor 85, switch arm 60, contact 59, conductor 201, contact 161, switch arm 158, conductor 194, terminal 186, conductor 185, safety switch heater 163, and conductor 184 back to the secondary winding 153. After a predetermined time delay, the safety switch heater 163 will cause the bimetal 164 to move in an upward direction and allow contacts 165 and 166 to open in the manner previously described. The opening of contacts 165 and 166 will make it impossible for the relay 154 to be energized upon the closing of the thermostat 171. In this case, the pressing of the reset button 169 will not allow a circuit for the relay 154 to be established because the safety switch heater element 163 is continuously energized by the transformer winding 153 and will not allow the bimetal to return to the position shown on the drawing.

From this it may be seen that an apparatus has been provided where the failure of the flame detecting apparatus to properly indicate flame may be distinguished from a flame failure.

It should be apparent from the preceding description that I have provided a control apparatus in which the safety switch has been utilized to provide a shut down upon a flame failure or upon the false indication of flame. Too, by a slight modification, I have provided a control apparatus which utilizes the safety switch to shut the apparatus down in case of a failure and to distinguish between a flame failure and a false indication of flame. Too, in cooperation with the above, I have ensured that the apparatus of my invention will start in the proper sequence.

I have shown my invention in connection with an electronic flame detector and while it is applied well there it is to be understood that any type of combustion responsive device could be

substituted. Too, it will be obvious to those skilled in the art that various modifications will suggest themselves and therefore I intend my invention to be limited only by the scope of the appended claims.

I claim as my invention:

1. In combination, a power source having a transformer secondary winding, first and second relay means each having a plurality of switch arms and contacts, a current limiting impedance connected to a point on said power source and one of the contacts of each of said first and second relay means, a safety switch having energizing means and switch contacts in a series connection, said contacts being opened by said means after a period of energization, means connecting one end of said safety switch to said power source and a switch arm of said first relay means, means connecting the other end of said safety switch to a further contact and a switch arm of said first and second relay means respectively, a first condition responsive device connected to complete an energizing circuit for said first relay means through said safety switch and a switch arm and contact of said second relay means, a second condition responsive device adapted to energize said second relay means and deenergize said safety switch to prevent the deenergization of said first relay means, and means including said current limiting device, said power source, and certain of the switch arms and contacts of said second relay means for energizing said safety switch independently of said first condition responsive device when said first relay means is deenergized and said second relay means is energized to thereby maintain said first relay means inoperative.

2. In a control apparatus for a fuel burner, a temperature responsive device, means actuated by said temperature responsive device to energize a fuel burner, a combustion responsive device adapted to indicate proper operation of the burner, a safety switch operable to deenergize said first named means upon failure of operation of said combustion responsive device, said safety switch comprising a pair of contacts and an actuator therefor which is effective after a period of energization to open said contacts, means connecting said combustion responsive device to said safety switch to render said safety switch inoperative and maintain said first named means operative independently of said safety switch upon proper operation of said combustion responsive device, and further means connecting said combustion responsive device in an actuating circuit independently of said temperature responsive device with said safety switch to render said safety switch operative when said combustion responsive device is falsely indicating combustion to maintain said first named means inoperative.

3. In a control apparatus for a fuel burner, a temperature responsive device, means actuated by said temperature responsive device to energize the fuel burner, a combustion responsive device adapted to indicate proper operation of the burner, a reset safety switch having a pair of switch contacts and an actuator therefor operable after a period of energization of said actuator to cause said switch to deenergize said first named means upon failure of operation of said combustion responsive device, means connecting said combustion responsive device to said safety switch to disconnect said safety switch actuator and maintain said first named means operative upon proper operation of the burner, and fur-

ther means connecting said combustion responsive device in an energizing circuit independently of said temperature responsive device with said safety switch to render said safety switch actuator operative when said combustion responsive device is falsely indicating combustion to thereby maintain said first named means inoperative.

4. In a control apparatus for heating apparatus, a power source, controlling means, first relay means adapted when energized to initiate operation of the heating apparatus, means for energizing said first relay means including said power source and said controlling means, second relay means adapted when energized to indicate operation of the heating apparatus, means including said power source for energizing said last named relay means upon operation of the heating apparatus, a safety switch device having an actuator therefor operable when energized for a predetermined time to cause said safety switch to render said first relay means inoperative, means including said power source for energizing said safety switch device through said first relay means when said first relay means is energized, means including contacts of said second relay means when energized for maintaining said first relay means operative independently of said actuator of said safety switch, and means including said source of power for energizing said safety switch device independently of said first relay means and said controlling means when said second relay means is falsely indicating operation of the heating apparatus and said first relay means is deenergized.

5. In a control apparatus for heating apparatus, a power source, first relay means adapted when energized to initiate operation of the heating apparatus, switch means indicative of the need for operation of the heating apparatus, means including said switch means and said source of power for energizing said first relay means, an electrically operable cut off device having an actuator which is operative after a predetermined time delay to cause said device to be effective, means connecting said cut off device in a series connection with said first relay means, second relay means adapted to be energized by said source of power upon operation of the heating apparatus, means connecting said second relay means in circuit with said cut off device to render said cut off device inoperative when both of said relay means are operative, and means connecting said cut off device in circuit with said second relay means independently of said switch means and said first relay means when said second relay means falsely indicates operation of the heating apparatus.

6. In a control apparatus for heating apparatus; a power source comprising a transformer having a tapped secondary winding; first and second relay means each having a plurality of switch contacts said first relay means adapted to initiate operation of the heating apparatus, and said second relay means adapted to indicate proper operation of the heating apparatus; a safety switch, said safety switch comprising a pair of contacts and an actuator therefor which when energized for a predetermined period of time will open said contacts; a condition responsive device; a series circuit comprising said first relay means, said power source, said safety switch, contacts of said second relay means, and said condition responsive device, said series circuit when completed by the actuation of said condition responsive device causing energization

of said first relay means; means adapted to energize the heating apparatus upon energization of said first relay means; means including said second relay means when energized by proper operation of the heating apparatus for maintaining said first relay energized independently of the energizing means of said safety switch; and means connecting a portion of said power source in circuit with certain switch contacts of said second relay means in such a manner that when said second relay means is energized and said first relay means is deenergized the energizing means of said safety switch will actuate said safety switch to maintain said series circuit inoperative when said condition responsive device closes to thereby maintain the heating apparatus inoperative.

7. In a control apparatus for a fuel burner; a power source; a control device; first relay means; means for energizing the fuel burner including said power source, said control device and said first relay means; a combustion responsive device adapted to indicate proper operation of the burner; second relay means energized by said combustion responsive device; a timed safety switch having energizing means and switch contacts connected in a circuit with said first relay means; a plurality of switch arms and contacts associated with said first and second relay means adapted to render said safety switch inoperative when both of said relay means are operative; and means interconnecting certain of said switch arms and contacts so that said safety switch will be energized independently of said first relay means and said control device by said power source when said second relay means is energized falsely by said combustion responsive device and said first relay is deenergized to thereby prevent operation of said first relay means and the fuel burner.

8. In a control apparatus for a fuel burner, a control device having switch contacts, a source of power, a first relay having a plurality of contacts adapted when actuated to initiate operation of the burner, means including the contacts of said control device for connecting said first relay in an energizing circuit to said source of power, a safety switch having a heater therefor, means connecting the heater of said safety switch in the energizing circuit of said first relay when said first relay is initially energized by said control device, a second relay, means for energizing said second relay upon proper operation of the burner, means including said second relay for maintaining said first relay in an energized circuit independently of the heater of said safety switch, and means connecting the heater of said safety switch in an energizing circuit independently of any actuated switch contacts of either of said control device or said first relay means when said second relay is falsely indicating proper operation of the burner.

9. A control apparatus for a fuel burner system having a control switch for indicating the need for burner operation, the combination comprising, a source of power, a first relay adapted to actuate the fuel burner when energized, a safety switch having a heater therefor, an energizing circuit for connecting said first relay to said source of power adapted to be completed by means including the control switch and the heater of said safety switch, a second relay adapted to be energized by means indicative of proper operation of the burner, means including said second relay when energized for maintain-

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ing said first relay energized independently of the heater of said safety switch, and means for connecting the heater of said safety switch in an energizing circuit when said first relay is de-energized and said second relay as falsely indicating operation of the burner.

10. A control apparatus for a fuel burner system having a temperature responsive switch for indicating the need for burner operation, the combination comprising, a source of power, a first relay having an energizing winding therefor and adapted when energized to initiate operation of the burner, a safety switch having switch contacts and an actuating heater therefor, energizing circuit means adapted to include temperature responsive switch and the heater and contacts of said safety switch for connecting said power source to said first relay in an energizing circuit, a second relay adapted to be energized by means indicative of proper burner operation, means including said first and second relay means for deenergizing the heater of said safety switch when the burner is operating properly, and means for connecting the heater of said safety switch in an energizing circuit that is independent of said temperature responsive switch and the energizing winding of said first relay to said source of power when said first relay is de-energized and said second relay is falsely indicating proper operation of the burner.

11. A control apparatus for a fuel burner system having a control switch for indicating the need for burner operation, the combination comprising, a source of power, first relay means adapted to be energized by said source upon the closing of the control switch for rendering operative the fuel burner, a safety switch for effecting burner shutdown connected in series with said first relay means, said safety switch having an actuator which is operative to cause said safety switch to deenergize said first relay means after said actuator has been energized a predetermined time, second relay means adapted to be energized by means including said power source upon the proper functioning of the fuel burner and operative to deenergize said safety switch and maintain said first relay means in an energized circuit independently of said safety switch, and means interconnecting said second relay means and said power source such that, following a predetermined time interval, deenergization of said first relay means when said second relay means is energized will cause said power source to energize the actuator of said safety switch independently of said control switch to maintain said first relay means inoperative thereby preventing further operation of the fuel burner.

12. A control apparatus for a fuel burner system having a control switch for indicating the need for burner operation, the combination comprising, a source of power, first relay means adapted to be energized by said source upon the closing of the control switch and to render operative the burner, a safety switch for effecting burner shutdown connected in series with said first relay means, said safety switch having an actuator which is operative to cause said safety switch to deenergize said first relay means after said actuator has been energized a predetermined time, a control device adapted to be rendered operative by means indicating proper operation of the burner, circuit means including said control device maintaining said first relay means in an energized circuit independently of

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said safety switch, and rendering said safety switch inoperative, and means connecting said control device in a circuit with the actuator of said safety switch independently of the control switch such that if said control device indicates combustion when said first relay means is de-energized, said safety switch will maintain said first relay means inoperative upon the closing of the control switch to prevent further operation of the fuel burner.

13. In a control apparatus for a fuel burner, a power source, a control switch, first relay means having a plurality of switch arms and contacts, means for energizing said first relay means including said power source and said control switch, means for energizing a fuel burner including at least one of the switch arms and contacts of said first relay means, second relay means having a plurality of switch arms and contacts, means for energizing said second relay means upon proper operation of the burner, a plurality of circuits controlled by certain of the switch arms and contacts of said first and second relay means, one of which is independent of said control switch and contacts of said first relay means, a safety switch having a pair of contacts and a single actuator therefor, and electrical means connecting said contacts in controlling relation to said first relay means and said actuator in an electrical circuit so that said actuator will cause said safety switch to render said first relay means inoperative when said one of said last named circuits is completed through said actuator upon continued energization of said second relay means when the burner is inoperative or to render said first relay means inoperative when another of said last named circuits is completed through said actuator upon energization of the burner with said second relay means remaining inoperative.

14. In a control apparatus for a fuel burner, a source of power, first means adapted to respond to a condition indicative of the need for burner operation to energize the burner, further means adapted to respond to a condition indicative of proper operation of the burner, and means adapted to render said first named means inoperative either upon a failure of said further means to indicate proper operation of the burner or upon continued operation of said further means with said first named means inoperative, said last named means comprising a safety cutoff device having an actuator therefor which is effective when energized for a predetermined time to actuate said safety switch, a plurality of electrical circuits controlled by said condition responsive means and said further means, means including said power source and one of said circuits for energizing said actuator of said cutoff device independently of said first named means when said further means is operative and the burner is inoperative, and means including a further of said circuits for maintaining the fuel burner operative independently of said actuator if both said condition responsive means and said further means are operative.

15. In an electronic control apparatus for a fuel burner, a power source, a temperature responsive device, energizing means for establishing combustion in the fuel burner, operable means for actuating said energizing means upon the operation of said temperature responsive device, relay means, an electron discharge device having operable circuits therefor to energize said relay means upon a condition of proper op-

eration of the fuel burner, a time delay safety switch means having an actuator connected in circuit with said operable means to render said operable means inoperative when said electron discharge device fails to operate said relay means, means including said relay means shunting said safety switch means actuator from the circuit of said operable means upon proper operation of the burner, and further means independent of said temperature responsive device interconnecting said relay means and said operable means to actuate said safety switch means actuator when said electron discharge device is operating and said operable means is deenergized to thereby maintain said operable means inoperative upon a further operation of said temperature responsive device.

16. In a control apparatus for a fuel burner, a power source, an electron discharge device having an anode, cathode and control elements, a temperature responsive device, a first relay adapted to energize the fuel burner upon the actuation of said temperature responsive device, a combustion responsive device for indicating proper operation of the burner, a second relay connected in circuit with the anode of said electron discharge device, means connecting said combustion responsive device to said electron discharge device so that upon the occurrence of combustion at the burner said second relay means will be energized, a safety switch having a pair of contacts and an actuator therefor which will open said contacts after a predetermined time delay, means connecting said safety switch in a series circuit with said first relay means independently of said second relay when the latter is energized, circuit means including said second relay for energizing said first relay means independently of said safety switch actuator, and further means for energizing said safety switch actuator by said power source independently of said temperature responsive device when said first relay means is deenergized and said second relay means is energized due to faulty operation of said combustion responsive device to thereby prevent operation of said first relay means and the burner upon a further operation of said temperature responsive device.

17. A control apparatus for a fuel burner, a power source, first electrical means adapted to respond to a condition indicative of the need for burner operation operable to energize the burner, further electrical means adapted to respond to a condition indicative of proper operation of the burner, said further means comprising a thermionic electron discharge device having a filamentary heater which is normally continuously energized, said heater having a time delay upon energization thereof, following an appreciable period of deenergization, before thermionic emission occurs which delay is greater than the time required for energization of said first electrical means, and means adapted to render said first named means inoperative either upon a failure of said further means to respond to a condition indicating proper operation of the burner or upon continued operation

of said further means when said first named means is inoperative.

18. Control apparatus for a fuel burner, comprising a source of power, first switching means adapted when actuated to a first position to initiate burner operation, second switching means for indicating proper burner operation when actuated to a first position and lack of burner operation when actuated to a second position, said second switching means being controlled by a thermionic discharge device having a filamentary heater therefor which has an appreciable time delay in heating to a degree where said device will be in a condition to conduct, means normally continuously connecting said heater to said source, a timed safety switch having a heater therefor and switch contacts connected to render the burner inoperative when said contacts are open, and means connecting said source to said last named heater when operation of the burner is not safe, said last named means comprising said first switching means when in said first position with said second switching means in said second position or said second switching means when in said first position with said first switching means not in said first position.

19. A control apparatus for a fuel burner system having a control switch for indicating the need for burner operation, the combination comprising, a source of power, first relay means adapted to be energized by said source upon the closing of the control switch for rendering operative the fuel burner, a safety switch for effecting burner shutdown, said safety switch having an actuator connected in series with said first relay means and operative to cause burner shutdown after said actuator has been energized a predetermined time, second relay means adapted to be energized by means including said power source upon the proper functioning of the fuel burner and operative to effectively deenergize said safety switch actuator and maintain said first relay means in an energized circuit independently of said safety switch actuator, and means interconnecting said second relay means and said power source such that, following a predetermined time interval, deenergization of said first relay means when said second relay means is energized will cause said power source to energize said actuator independently of said control switch to maintain said apparatus inoperative thereby preventing further operation of the fuel burner.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,075,289	Judson	Mar. 30, 1937
2,102,618	Francis	Dec. 21, 1937
2,102,691	Francis	Dec. 21, 1937
2,254,984	Tate	Sept. 2, 1941
2,274,384	Scanlan	Feb. 24, 1942