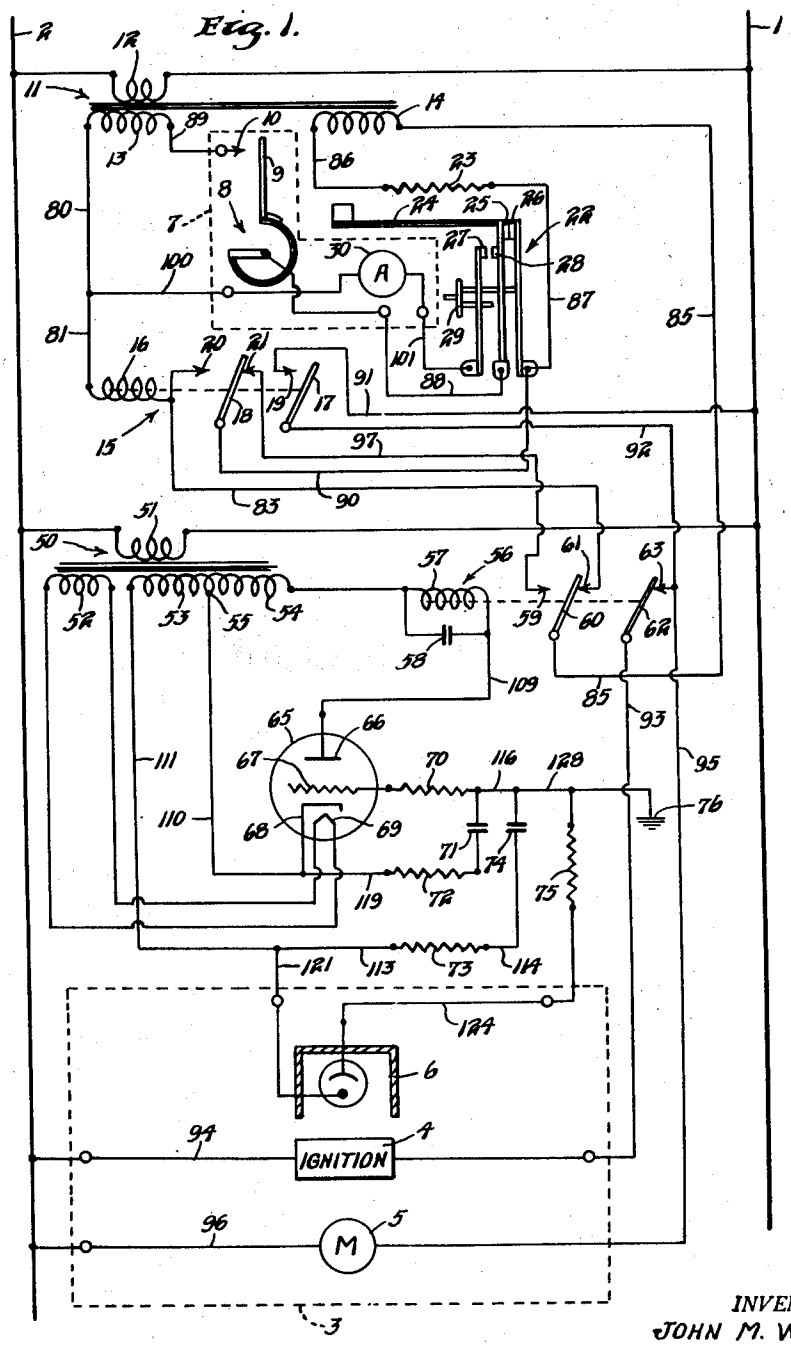
Jan. 9, 1951 J. M. WILSON 2,537,292

COMPONENT CHECKING CIRCUIT FOR BURNER CONTROL APPARATUS

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Fig. 1.



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Fig. 2.

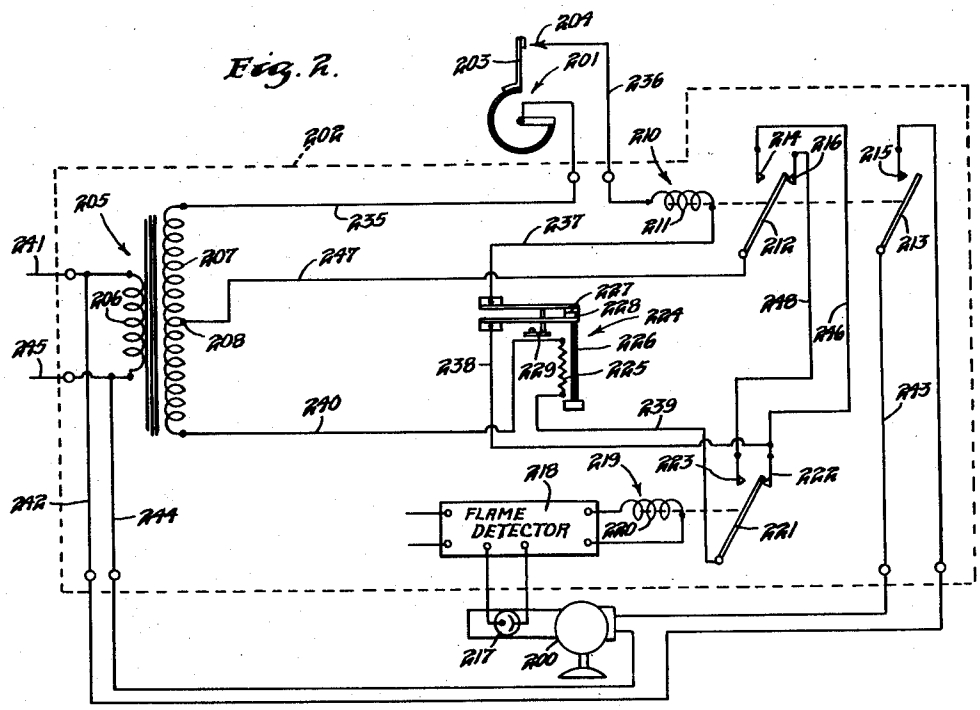
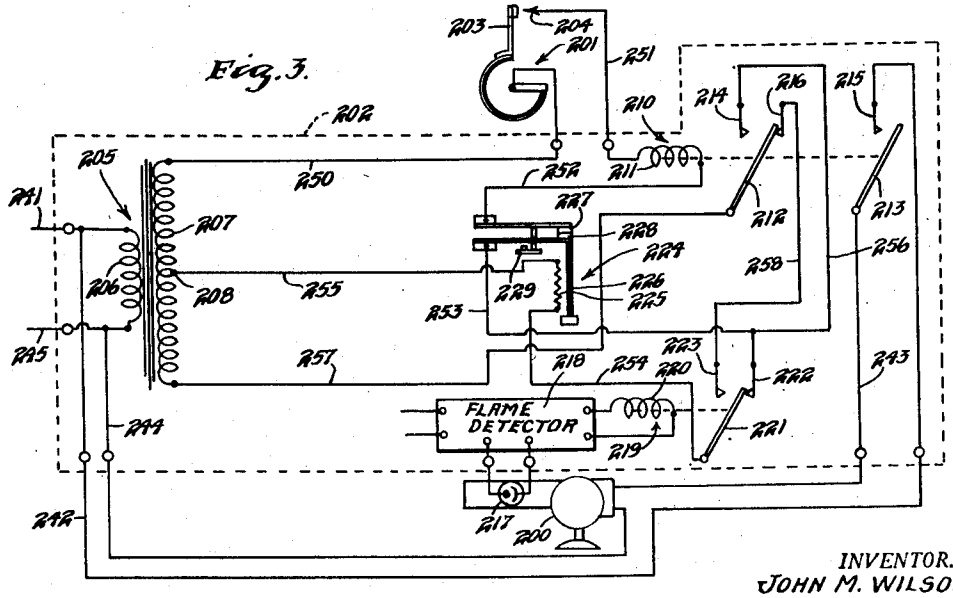


Fig. 3.



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COMPONENT CHECKING CIRCUIT FOR BURNER CONTROL APPARATUS

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Application August 9, 1948, Serial No. 43,253

13 Claims. (Cl. 158—28)

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This application is a continuation in part of my copending application, Serial Number 731,998, filed March 3, 1947, for "Fuel Burner Safety Control Apparatus."

This invention relates broadly to automatic control apparatus for fuel burners and more particularly is directed to that type of burner control apparatus that will render the burner inoperative when there has been a flame failure or when the device for indicating proper operation of the burner is operating falsely.

In present day fuel burner control apparatuses, it is customary to provide a safety cutout device for rendering inoperative the burner under certain conditions of operation and which, when it has had current flowing therethrough for a predetermined length of time, will be operative to open a pair of switch contacts that may be located in any desired position within the control apparatus, so that the burner will be shut down. In my improved apparatus, I utilize this cutout device by passing current therethrough whenever there is a condition of operation of the apparatus that indicates no flame at the burner when there should be a flame or when there is an indication of flame at the burner and the burner should not be operating. The apparatus further provides a control which distinguishes from a condition of flame failure and a condition of false indication of flame.

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

A further object of the present invention is to provide an improved burner control apparatus which will maintain the burner inoperative when there is a false indication of flame or when there has been a flame failure.

Still another object of the present invention is to provide an improved control apparatus with a safety shutdown 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. A still further object of the present invention is to provide an improved burner control apparatus employing a safety cutout device, having a heater therefor, which will cause the heater to be energized whenever there has been a flame failure or a false indication of flame and which will deenergize the heater only when the safety cutout device has operated upon a flame failure.

Still another object of the present invention

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is to provide a burner control apparatus having switching means for energizing the burner and switching means for indicating proper operation of the burner with both of the switching means having contacts which are closed when the means is operative and contacts which are closed when the means is inoperative, and having a safety cutout device which is energized only when either one of the switching means is operative and the other is inoperative.

In accomplishing these objects, I provide a circuit for the heater of a safety cutout device in which the heater is connected in an energizing circuit with a source of power whenever there is a flame failure or a false indication of flame. This will be understood upon consideration of the specification, claims and drawings of which:

Figure 1 is a diagrammatic showing of one particular embodiment of my invention associated with an electronic type of flame detector. This figure was originally a part of my above-mentioned copending application.

Figure 2 shows diagrammatically a modification of my invention using a single secondary transformer winding for a source of power for the controls; and

Figure 3 shows diagrammatically a different arrangement of the showing of Figure 2.

Referring now to Figure 1, the numerals 1 and 2 represent the input power lines to the subject control apparatus and to the controls which are operated by the apparatus. These power lines are connected through the control apparatus to the enclosure 3 which contains therein an ignition device 4 which is operative to initiate combustion of fuel emitting from a burner 5 when the burner is energized. For indicating the presence of flame at the burner a photocell 6 is provided. Located within an enclosure 7 is a thermostatic device 8 which is used to primarily control the operation of the burner 5. The thermostatic device 8 may be seen to consist of a bimetal actuated switch blade 9 which is operable to move into and out of engagement with an associated switch contact 10 in accordance with temperature changes in the space wherein is located the thermostatic device.

For supplying power to the main controls of the subject apparatus, a transformer 11 is provided and this transformer may be seen to consist of a primary winding 12, which is connected to the input power lines 1 and 2, and a pair of secondary windings 13 and 14. A main control relay is indicated by the numeral 15 and this relay may be seen to consist of a relay winding 16

which is operable when energized to move a pair of switch blades 17 and 18 into engagement with a pair of associated energized or in switch contacts 19 and 20 respectively. When the switch blade 18 is moved into engagement with contact 20, it moves out of engagement with an associated out contact 21. These switch blades are normally biased, by means not shown, into engagement with their respective out contacts.

The numeral 22 indicates a safety cutout device and this particular cutout device comprises a heater 23 which is operable, when there is a current flowing therethrough, to apply heat to an associated bimetallic element 24. This bimetallic element 24 is normally positioned so as to hold a pair of switch contacts 25 and 26 in engaged position and when the bimetal has been heated for a predetermined length of time by the heater 23 it will move in an upward direction and the contact 25 will be biased out of engagement with contact 26 by means not shown and into engagement with a further contact 27 by a contact 28. A reset actuator 29 is provided for putting the cutout device back in the operating condition after the bimetal 24 has been actuated by the heater 23 and this actuator is so constructed as to prevent closing of the contacts 25 and 26 until the bimetal is in its normal position and the actuator is released.

Providing energy for the flame detection portion of the subject control apparatus is a transformer 50 which has a primary winding, connected to the input power lines 1 and 2, and a secondary winding 52 and a further secondary winding with sections 53 and 54 with a tap 55 separating the two sections. A flame detection relay is indicated by the numeral 56 and may be seen to consist of a relay winding 57, which is bypassed by a filter condenser 58, and which is operable to move a pair of switch blades 60 and 62 from engagement with their associated deenergized or out switch contacts 61 and 63, respectively, when the winding becomes energized. These switch blades are normally biased, by means not shown, in engagement with the out contacts. When the switch blade 60 is moved into the energized position it engages an energized or in switch contact 59. Controlling the energizing current flow through the relay 56 is an electron discharge device 65 which may be seen to consist of an anode 66, a control electrode 67, and a cathode 68 which is heated to be electron emissive by a filament heater 69 connected to the secondary 52. Located on the input of the discharge device 65 is a limiting resistor 70 as well as a phase shifting control network which includes condenser 71 and resistor 72 as well as resistor 73 and condenser 74. A further resistor 75 is associated with the circuit leading to the photocell 6 and acts as a current limiting resistor. This flame detection circuit is of the type completely described in my copending application, Serial Number 465,476, filed November 13, 1942, for "Control Device," now Patent No. 2,448,503, granted August 31, 1948.

Operation of Figure 1

In considering the operation of Figure 1, it will first be assumed that the apparatus is in the condition that corresponds to the condition shown in Figure 1. Under these conditions the burner motor 5 will be deenergized and the burner control relay 15 and flame detection relay 56 will also be deenergized. Further, the thermostatic device 8 will not be indicating a need for operation of the burner.

Assume that the space wherein is located the thermostatic device 8 has cooled so that the bimetallic blade 9 will be moved into engagement with contact 10 to initiate the completion of an electrical circuit to the burner control relay 15. This energizing circuit may be traced from the left-hand terminal of the secondary winding 13 through conductors 80 and 81, relay winding 16, conductor 83, switch contact 61, switch blade 60, conductor 85, secondary 14, conductor 86, heater 23, conductor 87, switch contacts 26 and 25, conductor 88, switch blade 9, switch contact 10, and conductor 89 to the right-hand terminal of the secondary 13. With current flowing through the burner control relay winding 16 the switch blades 17 and 18 will be moved into engagement with their associated contacts 19 and 20 respectively. When the switch blade 18 engages contact 20 a holding circuit is established for the relay 15 which is independent of the secondary 14 and the heater 23. This holding or maintaining circuit may be traced from the left-hand terminal of the secondary 13 through conductor 80, conductor 81, winding 16, switch contact 20, switch blade 18, conductor 90, switch contacts 26 and 25, conductor 88, switch blade 9, switch contact 10 and conductor 89 to the right-hand terminal of the secondary 13.

While the relay 15 is maintained energized by circuit independent of the secondary 14 and the heater 23, the heater 23 is maintained in an energizing circuit that may be traced from the left-hand terminal of the secondary 14 through conductor 86, heater 23, conductors 87, and 90, switch blade 18, switch contact 20, conductor 83, switch contact 61, switch blade 60, and conductor 85 back to the right-hand terminal of the secondary 14.

The movement of the switch blade 17 into engagement with switch contact 19 on the burner control relay 15 results in the energization of the ignition device 4 and the burner 5. This energizing circuit may be traced from the input power line 1 through conductor 91, switch contact 19, switch blade 17, conductor 92, switch contact 63, switch blade 62, conductor 93, ignition device 4, and conductor 94 to the other input power line 2. The energizing circuit for the burner motor may be traced from the input power line 1 through the conductor 91, switch contacts 19, switch blade 17, conductor 92, conductor 95, burner 5, and conductor 96 to the other input power line 2. With the ignition device 4 energized and the burner motor 5 energized flame or combustion should be initiated at the burner and this flame will be detected by the photocell 6.

In considering the operation of the flame detection circuit of the subject control reference should be made to my copending application, Serial Number 465,476, for "Control Device," mentioned above, for a full understanding of the operation of this circuit. Briefly, when there is no flame detected by the photocell 6 it is desired that the control relay 56 be in the deenergized position as it is shown on the drawing. This will mean that the electron discharge device 65 will not pass sufficient current to energize the relay 56. To maintain the discharge device 65 effectively non-conducting, a phase shifting or biasing network has been provided for maintaining the control electrode 67 negative with respect to the cathode 68 during the conducting half-cycle of the power supply. This biasing network or phase

shifting network includes a circuit that may be traced from the tap 55 of the secondary winding through a conductor 110 to the cathode 68 and from the cathode 68 through a conductor 119, resistor 72, condenser 71, conductor 116, condenser 74, conductor 114, resistor 73, and conductors 113 and 111 back to the left-hand terminal of the secondary section 53. It will be noted that the control electrode 67 is connected to the conductor 116 which joins condensers 71 and 74 by a current limiting resistor 70. With the control electrode 67 and cathode 68 connected into the last traced circuit and by properly selecting the values of the resistors 72 and 73 and condensers 71 and 74 it is possible to have the control electrode 67 biased negatively with respect to the cathode 68 during the conductive half-cycle of the power supply. This negative bias on the control electrode 67 will maintain the current flow in the discharge device 65 below that value necessary to cause energization of the relay 56.

As soon as flame is detected by the photocell 6, the rectifying action of the photocell will be effective to place a charge upon the condenser 71 so that it will cause the control electrode 67 to be biased less negative than it is normally biased when the photocell is inoperative. The biasing circuit and rectifying circuit for the photocell may be traced from the left-hand terminal of the secondary section 53 through conductor 111, conductor 121, photocell 6, conductor 124, resistor 75, conductor 128, conductor 116, condenser 71, resistor 72, conductor 119 and conductor 110 to the tap 55 on the secondary winding. With the control electrode 67 biased less negative than before the current flow through the discharge device 65 will be sufficient to energize the flame detection relay 56 and this energizing circuit may be traced from the right hand terminal of the secondary section 54 through the relay winding 57, conductor 109, anode 66, cathode 68, and conductor 110 to the tap of the secondary winding.

When the flame detection relay 56 becomes energized, the winding 57 will move the switch blades 60 and 62 into the energized position. When the switch blade 62 moves out of engagement with switch contact 63, the energizing circuit to the ignition device 4 is interrupted and the ignition device will remain inoperative until such time as the switch arm and contacts are again in engagement. When the switch blade 60 moves out of engagement with switch contact 61, the circuit through the heater 23 of the safety cutout device 22 is interrupted and no current will flow through the heater. This will mean that if the operation of the flame detection relay 56 occurs within a predetermined time the heat from the heater 23 will be insufficient to cause the bimetal to be warped from its normal position to allow opening of the switch contacts 25 and 26.

The apparatus is now in the operating condition with both the burner control relay 15 and the flame detection relay 56 in the energized position. Further, the safety cutout device 22 is completely deenergized with no current flow passing through the heater 23 of this cutout device.

As soon as the heat from the burner 5 has satisfied the temperature condition for which the thermostatic device 8 is set to operate, the bimetal switch blade 9 will be moved out of engagement with the associated contact 10. The movement from the contact 10 by the blade 9 results in opening of an electrical circuit through the burner control relay 15 and this relay will become deenergized. When the relay becomes deenergized, the switch blade 17 will move out of engagement with the associated switch contact 19 to open the energizing circuit for the burner motor 5 so that the burner will become deenergized. When the burner becomes deenergized, the flame will be extinguished and the flame detection relay will become deenergized with the rectifying action of the photocell 6 no longer affecting the biasing of the control electrode 67 of the discharge device 65. With both the flame detection relay 56 and the burner control relay 15 in the deenergized position, the apparatus will be back in the position that is shown in the drawing. The apparatus is now in condition for another operating cycle upon the subsequent closing or call for burner operation by the thermostatic device 8.

Operation upon flame failure

Assume now that the apparatus has been operating normally with both the burner control relay 15 and the flame detection relay 56 in the energized positions with combustion occurring at the burner motor 5. Assume next that combustion suddenly ceases due to some faulty operation in the fuel line or the burner. With the stopping of the combustion, the photocell 6 will not detect the presence of combustion and the rectifying action of the photocell will no longer be effective to bias the control electrode 67 less negative with respect to the cathode so that the current flow through the discharge device 65 will be insufficient to maintain the flame detection relay 56 in the energized position. With the deenergization of the relay 56, the switch blade 62 will move into engagement with switch contact 63 to complete the energizing circuit to the ignition device 4 so that the apparatus will attempt to reestablish combustion. The switch blade 60 will be moved into engagement with switch contact 61 and this movement will result in the completion of an electrical circuit through the safety cutout heater 23 and this circuit may be traced from the left-hand terminal of the secondary 14 through conductor 86, heater 23, conductor 87, switch contacts 26 and 25, conductor 87, conductor 90, switch blade 18, switch contact 20, conductor 83, switch contact 61, switch blade 60, and conductor 85 back to the right-hand terminal of the secondary 14. This circuit will remain energized until such time as the ignition device 4 reestablishes combustion or until the bimetal 24 is warped to such a position as to allow separation of the switch contacts 25 and 26.

If the combustion is not reestablished and the switch contacts 25 and 26 separate, the switch contacts 28 will move into engagement with switch contact 27 so that a circuit may be traced through the indicating lamp 30. This circuit may be traced from the left-hand terminal of the secondary 13 through conductor 80, conductor 100, indicator 30, conductor 101, switch contacts 27 and 28, conductor 88, switch blade 9, switch contact 10, and conductor 89 to the right-hand terminal of the secondary 13. The circuit through the indicator 30 will give notice of the fact that the safety cutout device is in the deenergized position. When the switch contacts 25 and 26 separated, the holding circuit for the burner control relay 15 was broken and the switch blades 17 and 18 moved to the deenergized position. When the switch blade 18 moved

out of engagement with the switch contact 20, the electrical circuit that was last traced through the safety cutout heater 23 is also broken so that the heater 23 will no longer be supplying heat to the bimetal 24. As long as there is no heat applied to the bimetal 24, it will tend to move back to its normal position as it cools so that subsequent depressing of the actuator 29 will result in the bimetal moving back to the position shown on the drawing so that release of the actuator will cause the end of the bimetal to force the contact 25 into engagement with contact 26.

Depressing of the actuator 29 will recomplete the energizing circuit for the burner control relay 15 and the relay will become energized to once again attempt the establishment of combustion by the burner 5. If combustion is not established, the continued flow of current through the safety heater 23 will result in the subsequent warping of the bimetal 24 and the shutdown of the current when the flame failure occurred.

Obviously in the event that there is a failure of the apparatus to initiate combustion upon the closing of the thermostatic device 8 the apparatus will be shut down in the same manner as when the apparatus is brought into operation by resetting of the safety cutout device upon a flame failure. It will further be noted that as long as there is a flame failure or combustion failure, it is possible to initiate operation of the burner motor 5 by depressing of the actuator or reset 29 as the heater 23 is deenergized when the contacts 25 and 26 open.

Operation upon false indication of flame

Assume for the moment that the burner control apparatus has been operating properly and there has been combustion at the burner 5. Assume further that the thermostatic device 8 is no longer calling for operation of the burner and the blade 9 moves out of engagement with switch contact 10 to open the energizing circuit for the burner control relay 15. With the energizing circuit for the relay 15 open, the switch blades 18 and 17 will move out of engagement with their associated contacts so that the burner 5 will be shut down. Should there be any faulty operation in the flame detection circuit which would maintain an energizing current flowing through the flame detection relay 56, the relay will remain in the energized position so that the switch blade 60 is engaging switch contact 59 even though the burner 5 is not operative. This is now a condition where the flame detection relay is indicating proper operation of the burner while the burner, in fact, is not in operation.

My apparatus provides for a shutdown of the control apparatus by completing an energizing circuit to the safety cutout device heater 23; this energizing circuit may be traced from the left-hand terminal of the secondary 14 through conductor 86, heater 23, conductor 87, conductor 90, switch blade 18, switch contact 21, conductor 97, switch contact 59, switch blade 60, conductor 85 back to the right-hand terminal of the secondary 14. After a predetermined length of time, the heater 23 will cause the bimetal 24 to be warped from its normal position so that the bimetal can no longer maintain the contacts 25 and 26 in the energized position. When the contacts 25 and 26 separate it is impossible to initiate operation or energization of the burner control relay 15 upon the subsequent closing of the thermostatic device 8. It will be noted that once again the contacts 27 and 28 will be in engagement and the circuit to the indicator 30 will be completed so that there will be an indication of faulty operation of the system.

With a shutdown upon a false indication of flame, it will be impossible to reset the safety cutout device 22 by the actuator 29 until such time as the fault causing false operation of the burner controlled section of the flame detection relay 56 is removed. The reason it will be impossible to reset the cutout device will be obvious when it is noted that the heater 23 is continuously energized by the secondary 14 and a subsequent opening of the contacts 25 and 26 does not disturb this energized circuit.

As soon as the fault causing the false operation of the flame detection relay 56 is removed, the switch blades 60 and 62 will be moved to the deenergized position so that the energizing circuit for the heater 23 will be interrupted and the same will no longer be maintaining the blade 24 in the warped position. As soon as the bimetal 24 is cooled sufficiently, it will be possible to reset the cutout device 22 in the normal manner and the apparatus will be brought into operation upon the subsequent closing of the thermostatic device 8.

Figure 2

The apparatus shown in Figure 2 is a modification of the basic circuit disclosed in Figure 1 and utilizes a single transformer secondary winding as a source of power for accomplishing the type of control accomplished by Figure 1. The apparatus disclosed in this figure has eliminated reference to the use of an ignition device and an alarm or indicator as it is believed obvious as to how these would be incorporated in the subject figure. In Figure 2 the numeral 200 represents a burner of any desired type and this burner is rendered operative or inoperative in accordance with the operation of a thermostatic switching device 201 which may be located in any desired position to indicate the need for operation of the burner 200. The operation of the thermostatic device 201 is effective to cause the controls within the enclosure 202 to initiate operation of the burner 200.

The thermostatic device 201 may be seen to consist of a bimetallically operated switch blade 203 which is operative upon the cooling of the device to move into engagement with a switch contact 204.

Applying energy to the controls located in the housing 202 is a transformer 205 which has a primary winding 206 which may be connected to any suitable source of power and a secondary winding 207 which is tapped at 208. The burner control relay for the subject apparatus is indicated by the numeral 210 and may be seen to consist of a relay winding 211 and a pair of switch blades 212 and 213 which are moved into engagement with in switch contacts 214 and 215 respectively when the winding 211 becomes energized. When the winding 211 is deenergized, the switch blade is normally biased into engagement with an associated out contact 216 by means not shown.

A photocell 217 is provided for viewing the combustion at the burner 200 and is operative through appropriate circuits located in the block indicated at 218 to energize a flame detection relay 219. The electrical flame detection circuits indicated by the block 218 may well be of the type disclosed in Figure 1. The flame detection relay

219 may be seen to consist of a relay winding 220 which is operative to move a switch blade 221 from engagement with a deenergized or out contact 222, where it is biased by means not shown, and into engagement with an energized or in contact 223 upon the energization of the winding 220.

A safety cutout device is indicated at 224 and may be seen to consist of a safety cutout heater 225 which is operative to warp a bimetal 226 from its normal position, shown on the drawing, wherein it maintains contacts 227 and 228 in engagement, toward the right so that the contacts 227 and 228 will separate. An actuator 229 is provided for resetting the safety cutout device when the contacts 227 and 228 have been opened and this actuator is of the type that will not permit closing of the contacts 227 and 228 unless the bimetal 226 is back in its normal position.

Operation of Figure 2

The apparatus, as shown in Figure 2 of the drawing, is in the deenergized position with the burner 200 inoperative and the thermostatic device 201 not indicating the need for operation of the burner. In the event that the space where the thermostatic device 201 should cool, the bimetallic switch blade 203 will be moved into engagement with its associated contact 204 and an electrical circuit will be completed to the burner control relay 210. This energizing circuit may be traced from the upper terminal of the secondary 207 through conductor 235, switch blade 203, switch contact 204, conductor 236, relay winding 211, conductor 237, switch contacts 227 and 228, conductor 238, switch contact 222, switch blade 221, conductor 239, heater 225, and conductor 240 back to the lower terminal of the secondary 207. With the energization of the burner control 210, the switch blade 213 will move into engagement with the switch contact 215 so that an electrical circuit will be completed to the burner 200 and this circuit may be traced from the input power line 241 through conductor 242, switch contact 215, switch blade 213, conductor 243, burner 200 and conductor 244 back to the other input power line 245.

When the switch blade 212 moves into engagement with switch contact 214, a holding circuit is established for the relay 210 and this holding circuit is independent of the heater 225 of the safety cutout device. The holding circuit may be traced from the upper terminal of the secondary 207 through conductor 235, switch blade 203, switch contact 204, conductor 236, relay winding 211, conductor 237, switch contacts 227 and 228, conductor 238, conductor 246, switch contact 214, switch blade 212, and conductor 247 back to the tap 208 of the secondary 207.

A separate energizing circuit is provided for the safety cut out heater 225 and this circuit may be traced from the lower terminal of the secondary 207 through conductor 240, heater 225, conductor 239, switch blade 221, switch contact 222, conductor 246, switch contact 214, switch blade 212, and conductor 247 to the tap 208 on the secondary winding. This last traced circuit will remain in existence until such time as photocell indicates combustion at the burner 200, at which time the flame detection relay 219 will become energized so that the switch blade 221 will move out of engagement with contacts 222 to open the energizing circuit for the heater 225 traced above.

The apparatus is now in the operation position with both the burner control relay 210 and the flame detection relay 219 in the energized position and the thermostatic device 201 indicating a continued need for operation of the burner.

As soon as the thermostatic device 201 no longer indicates a need for operation of the burner, the blade 203 will move out of engagement with contact 204 and the burner control relay will become deenergized to open the energizing circuit to the burner 200. With the burner 200 no longer energized, there will not be a flame at the burner and the photocell 217 will cause the flame detection relay 219 to become deenergized so that the entire control apparatus will be in the position that it is shown on the drawing and will be ready for another operating cycle upon the closing of the thermostatic device 201.

Operation of Figure 2 upon flame failure

Assume for the moment that the apparatus is in the energized position with both the burner control relay 210 energized and the flame detection relay 219 energized indicating proper operation of the burner. In the event that combustion should fail at the burner 200, the photocell 217 will cause the flame detection relay 219 to become deenergized so that the switch blade 221 engages contact 222. When this occurs an energizing circuit is completed through the safety cutout heater 225 and this circuit may be traced from the lower terminal of the secondary 207 through conductor 204, heater 225, conductor 239, switch blade 221, switch contact 222, conductor 246, switch contact 214, switch blade 212, and conductor 247 to the tap 208 on the secondary winding. If combustion is not established within a predetermined length of time, the heater 225 will cause the bimetal 226 to be warped toward the right so that the contacts 227 and 228 will separate. The separation of the contacts 227 and 228 will result in the deenergization of the burner control relay 210 and the burner 200 will be shut down. Also deenergized by the deenergization of the relay 210 is the energizing circuit for the heater 225; with heater 225 deenergized it will be possible for the bimetallic element 226 to cool and move back toward its normal position so that the subsequent depressing of the reset actuator 229 will allow the bimetal to come back to its normal position and the contacts 227 and 228 will close so that the relay 210 will once again become energized and attempt to establish combustion at the burner 200. In the event that combustion is not established, the safety cutout heater 225 will again cause the bimetallic element to be warped to the right and the opening of the contacts 227 and 228 will result in the deenergization of the burner control relay 210.

Obviously this type of shutdown would occur if the flame detection relay failed to indicate combustion whether the control relay 210 were energized by the depressing of the actuator 229 or by the operation of the thermostatic device 201.

Operation of Figure 2 upon false indication of flame

Assume now that the burner control relay 211 and the flame detection relay 219 have been operating properly with the burner energized and the thermostatic device 201 indicating a need for burner operation. Upon the subsequent satisfaction of the thermostatic device 201, the burner control relay 210 will become deenergized

so as to interrupt the energizing circuit for the burner 200 which in turn will become deenergized and there will be no combustion in existence at the burner. Should there be a fault in the flame detection circuit which will result in the flame detection relay 219 being maintained in the energized position, a new energizing circuit will be established to the safety cutout heater and this circuit may be traced from the lower terminal of the secondary 207 through the conductor 240, heater 225, conductor 239, switch blade 221, switch contact 223, conductor 248, switch contact 216, switch blade 212, and conductor 247 to the tap 208 on the secondary 207. This circuit will remain energized until such time as the fault causing operation of the flame detection relay 219 is removed, for the same reason that the maintaining energizing circuit for the heater of Figure 1 was maintained energized as long as the flame detector was operating falsely. This will mean that the heater 225 will move the bimetal 226 toward the right so that the contacts 227 and 228 will separate and it will be impossible for the burner control relay 210 to be energized upon the subsequent closing of the thermostatic device 201. As long as the bimetal 226 is in the warped position, it will be impossible to reset or close the contacts 227 and 228.

As soon as the fault from the relay 219 has been removed, so that the switch blade 221 engages switch contact 222, the energizing circuit for the heater 225 will be broken and the bimetal 226 will cool so that it will move back toward its normal position as it is shown on the drawing and a subsequent depressing actuator 229 will result in the closing of the contacts 227 and 228 as they come to rest on the top of the bimetal 226. The apparatus is now in a condition for normal operation so that the subsequent closing of the thermostat 201 will result in the energization of the burner in the manner discussed above.

Figure 3

The apparatus shown in Figure 3 includes the identical components provided in the showing of Figure 2 and these components all carry the same reference numerals in both of the drawings. In Figure 3 the components are associated with the secondary winding 207 in a manner slightly different than that of Figure 2 in a manner that will be understood from the following discussion.

Operation of Figure 3

When the thermostatic device 201 indicates the need for operation of the burner, the blade 203 will move into engagement with contact 204 and this will result in an energizing circuit for the burner control relay 210 that may be traced from the upper terminal of the secondary 207 through conductor 250, blade 203, switch contact 204, conductor 251, relay winding 211, conductor 252, switch contacts 227 and 228, conductor 253, switch contact 222, switch blade 221, conductor 254, heater 225, and conductor 255 back to the tap 208 of the secondary 207. Upon the energization of the burner control relay 210, the switch blade 213 will move into engagement with switch contact 215 to complete the energizing circuit to the burner 200 in the same manner as occurred in Figure 2. The movement of the switch blade 212 into engagement with switch contact 214 results in the establishment of a holding circuit for the burner control relay 210 and this may be traced from the upper terminal of the secondary 207 through conductor 250, switch blade 203, switch contact 204, conductor 251, relay winding 211, conductor 252, switch contacts 227 and 228, conductor 253, conductor 256, switch contact 214, switch blade 212, and conductor 257 back to the lower terminal of the secondary 207. It will be noted that in the subject circuit, the burner control relay is energized from a portion only of the secondary 207 and is maintained energized by the entire secondary voltage while the reverse was true with the circuit of Figure 2.

The heater of the cutout device 224 will be maintained in an energizing circuit until such time as the flame detection relay 219 becomes operative to indicate proper burner operation and this energizing circuit may be traced from the lower terminal of the secondary 207 through conductor 251, switch blade 212, switch contact 214, conductor 256, switch contact 222, switch blade 221, conductor 254, heater 225, and conductor 255 to the tap 208 and the secondary 207. As soon as the flame detection relay 219 becomes operative, the switch blade 221 moves out of engagement with contact 222 to open the last traced circuit and deenergize the circuits through the heater 225. Obviously, if this circuit is not interrupted within a predetermined time, the bimetal 225 will be warped toward the right so that the contacts 227 and 228 will separate to open the energizing circuit for the relay 210 and this circuit will remain interrupted until such time as the reset actuator 229 is depressed and the contacts 227 and 228 are once again in engagement. This will occur upon either a flame failure occurring during normal operation or upon a failure of combustion to be initiated when the apparatus starts its operating cycle.

The operation, because of a false indication of flame by the flame detection relay 219, is practically identical to that of Figure 2, when there is a false indication of flame by the flame detection relay and there is no call for operation of the burner, so that the burner control relay 210 is in the deenergized position. When this occurs a circuit may be traced to the heater 225 from the lower terminal of the secondary 207 through conductor 257, switch blade 212, switch contact 216, conductor 258, switch contact 223, switch blade 221, conductor 254, heater 225, and conductor 255 to the tap 208 on secondary 207. This circuit will remain energized until such time as the fault causing the false operation of the flame detection relay 219 is removed. This will prevent the closing of the safety cutoff contacts 227 and 228, as the heater 225 will maintain the bimetal 226 warped toward the right so that the contacts cannot come to rest on the top of the bimetal. As soon as the fault is removed the heater 225 will allow the bimetal 226 to cool so that it will be possible to reset the contacts 227 and 228. The apparatus is now in a condition for a normal operating cycle upon the subsequent closing of the thermostatic device 201.

Conclusion

From the foregoing it may be seen that I have provided a burner control apparatus which will be rendered inoperative in the event of a flame failure or upon a false indication of flame and that I further have provided therewith facilities for determining whether the apparatus is shut down because of flame failure or shut down because of a false indication of flame. While I have disclosed certain embodiments of my invention it will be obvious to those skilled in the art that various modifications are readily sug-

gested upon a consideration of the foregoing specification and therefore I intend my invention to be limited solely by the scope of the appended claims in which I claim:

1. Control apparatus for a fuel burner, comprising in combination, a source of power, a first relay having switch contacts adapted when actuated to complete an energizing circuit to the burner, a second relay having switch contacts adapted to be actuated by means indicative of proper burner operation, a safety cutout device having an electrical actuator which when energized for a predetermined length of time will open an associated switch, a first circuit for energizing said first relay, said first circuit including said source of power and said cutout device actuator and switch, a second circuit for maintaining said first relay energized, said second circuit including switch contacts of said first relay and said cutout device switch, a third circuit for maintaining said cutout device actuator energized, said third circuit including said source of power and contacts of said first relay when energized and said second relay when deenergized and operative to cause said cutout device actuator to open said cutout device switch to deenergize said first relay and open said third circuit unless said second relay first becomes operative to deenergize said cutout device actuator, and a fourth circuit for continuously energizing said cutout device actuator independently of said cutout device switch when said first relay is deenergized and said second relay is in energized position falsely indicating burner operation so that said cutout device will maintain the burner inoperative until the fault causing operation of said second relay is removed.

2. Control apparatus for a fuel burner comprising in combination, a source of power, a first relay adapted when energized to complete an energizing circuit to the burner, said relay comprising switch contacts normally closed when the relay is deenergized and switch contacts normally closed when the relay is energized, a second relay adapted to be energized by means indicating proper operation of the burner, said second relay comprising switch contacts normally closed when the relay is deenergized and switch contacts normally closed when the relay is energized, a safety cutout device having an electrical actuator and an associated switch adapted when energized for a predetermined length of time to render said apparatus inoperative, a first circuit for connecting said first relay in energizing relation to said source of power adapted to be completed by means indicating a need for operation of the burner, said first circuit including said cutout device actuator and switch, and the closed switch contacts of said second relay when deenergized, a second circuit for maintaining said first relay energized, said second circuit including said source of power and closed switch contacts of said first relay when energized, a third circuit for maintaining said cutout device actuator energized, said third circuit including said source of power, closed contacts of said first relay when energized and closed contacts of said second relay when deenergized and maintained operative until said cutout device actuator operates on said cutout device switch or said second relay indicates proper operation of the burner and said actuator is deenergized, and a fourth circuit for maintaining said cutout device actuator energized when said second relay is in operating position and falsely indicating proper burner operation, said fourth circuit including said source of power, closed switch contacts of said second relay when in energized position and closed switch contacts of said first relay when deenergized.

3. In a burner control apparatus, the combination comprising, a source of power comprising a transformer winding having a tap thereon and at least two end terminals, a main control relay adapted when energized to complete an energizing circuit to the burner, said relay comprising a switch blade and in and out switch contacts, a flame detection relay adapted to be energized upon proper burner operation, said detection relay comprising a switch blade and in and out switch contacts, a safety cutout device having an actuator and an associated switch for rendering inoperative the burner when said actuator has had current flowing therethrough for a predetermined length of time, an energizing circuit for said control relay adapted to be completed by means indicative of the need for burner operation, said circuit including said cutout device actuator and switch, the switch blade and out contact of said detection relay and the end terminals of said source of power, a maintaining circuit for said control relay independent of said cutout device actuator, said maintaining circuit including the switch blade and in contact of said control relay and one end terminal and the tap of said source of power, and a circuit for maintaining current flow through said cutout device actuator independently of said control relay whenever the burner fails to operate or said detection relay operates falsely and indicates proper burner operation, said circuit including the tap and the other end terminal of said source of power and either the switch blade and in contact of said control relay and the switch blade and out contact of said flame detection relay or the switch blade and out contact of said control relay and the switch blade and in contact of said flame detection relay.

4. In a burner control apparatus, the combination comprising, a source of power comprising a transformer winding having a tap thereon and at least two end terminals, a main control relay adapted when energized to complete an energizing circuit to the burner, said relay comprising a switch blade and in and out switch contacts, a flame detection relay adapted to be energized upon proper burner operation, said detection relay comprising a switch blade and in and out switch contacts, a safety cutout device having an actuator and an associated switch for rendering inoperative the burner when said actuator has had current flowing therethrough for a predetermined length of time, an energizing circuit for said control relay adapted to be completed by means indicative of the need for burner operation, said circuit including said cutout device actuator, and switch, the switch blade and out contact of said detection relay and the tap and one end terminal of said source of power, a maintaining circuit for said control relay independent of said cutout device actuator, said maintaining circuit including the switch blade and in contact of said control relay and the end terminals of said source of power, and a circuit for maintaining current flow through said cutout device actuator independently of said control relay whenever the burner fails to operate or said detection relay is in operating position and falsely indicating proper burner operation, said circuit including the tap and one end terminal of said source of power and either the switch blade and in contact of said control relay

and the switch blade and out contact of said flame detection relay or the switch blade and out contact of said control relay and the switch blade and in contact of said flame detection relay.

5. In a condition control apparatus; a power source comprising a transformer having a plurality of secondary windings; a safety switch device having an electrical actuator and switch contacts; first and second relay means each having a plurality of switch contacts; condition sensing means operable upon a need for a change in a condition to connect said first relay means in an energizing circuit with said power source through said safety switch device actuator and switch contacts and certain of the contacts of said first and second relay means; means for holding said first relay means in an energized circuit including one winding of said power source, said condition sensing means, switch contacts of said first relay means, and switch contacts of said safety switch device; means for continuing the energization of the actuator of said safety switch device including a further winding of said power source and certain of the switch contacts of said first and second relay means; control means for a condition changing means made operative upon energization of said first relay means; means responsive to the proper operation of said last named means to cause energization of said second relay means; means for deenergizing said safety switch actuator upon energization of both said first and second relay means, means including said safety switch device and certain of the switch contacts of said first and second relay means for deenergizing said first relay means and the actuator of said safety switch when said second relay means fails to be energized, and further means including certain of said switch contacts of said first and second relay means for rendering inoperative only said first relay means when said second relay means is falsely indicating proper operation of said condition changing means.

6. In combination, a source of power having at least a pair of secondary transformer windings, a first relay means having "in" and "out" contacts, second relay means having "in" and "out" contacts, an electrically operable cutoff device having an electrical time delayed actuator and switch contacts, means including said cutoff device and an "out" contact of said second relay means for connecting said first relay means in an energizing circuit to both of said secondary windings of said power source connected in series, means including an "in" contact of said first relay means and the switch contacts of said device connecting said first relay means in a holding circuit with one of said windings of said source of power, means including an "in" contact of said first relay means and an "out" contact of said second relay means serially connected for maintaining an electrically conducting circuit through said cutoff device actuator with the other winding of said source of power so that after a predetermined time delay said cutoff device actuator will render said switch contacts of said device inoperative, means for energizing said second relay by said power source to render said last named circuit inoperative by the opening of said "out" contact by said second relay means, and further means including an "in" contact of said second relay means and an "out" contact of said first relay means serially connected for rendering said cutoff device actuator continuously energized when said first relay means is deenergized and said second relay means is energized to maintain said switch contacts of said device open and said first relay means inoperative.

7. Burner control apparatus, comprising in combination, first electrically operated switch means for initiating operation of the burner, second electrically operated switch means for indicating proper operation of the burner, a safety cutout device comprising normally closed switch contacts and an electrical actuator therefor which is operative when energized for a predetermined length of time to open said contacts and render the apparatus inoperative, means including said contacts when closed, said first switching means when energized and said second switching means when deenergized for connecting said actuator in a first energizing circuit which when operative for a predetermined length of time will become deenergized upon the separation of said contacts, and means including said first switching means when deenergized and said second switching means when energized for connecting said actuator in a second energizing circuit independent of said contacts which will remain energized after actuation of said contacts of said cutout device.

8. Burner control apparatus, comprising in combination, temperature responsive means for completing an electrical circuit and initiating operation of the burner, electrically operated switch means for indicating proper operation of the burner, a safety cutout device having switch contacts and an actuator therefor which is operative when energized for a predetermined length of time to open said contacts and render said apparatus inoperative, a first energizing circuit for said actuator, said circuit including said cutout device contacts, said responsive means when completing an electrical circuit to the burner and said switch means when deenergized and adapted to be rendered inoperative upon separation of said cutout device switch contacts or upon the energization of said switch means, and a second energizing circuit for said actuator independent of said cutout device contacts, said second circuit including said responsive means when not completing said circuit to the burner and said switch means when energized and operative to maintain said actuator continuously energized until said switch means is deenergized.

9. In a control apparatus for a fuel burner, the combination comprising, first electrically operated switch means for initiating operation of the burner, second electrically operated switch means for indicating proper operation of the burner, both of said switch means having contacts closed when energized and further contacts closed when deenergized, a safety cutout device having an electrical heater therefor which when energized for a predetermined length of time will open a pair of switch contacts and cause said cutout device to render said apparatus inoperative, electrical circuit means including said first switch means when energized, said pair of switch contacts, and said second switch means when deenergized for energizing said heater, means for deenergizing said heater including said first and second switch means when energized, and further electrical circuit means for continuously energizing said heater independently of said pair of switch contacts when said second switch means is falsely indicating proper burner operation, said means including said first switch means when deenergized and said second switch means when energized with said further means maintaining said heater energized until said second switch means is deenergized.

10. In a control apparatus for a fuel burner, a temperature responsive device, a safety switch device having a switch and an electrical actuator with a time delay and reset means therefor which can put said switch in operative position only when said actuator is inoperative, a power source comprising a transformer with a plurality of secondary windings; first and second relay means each having a plurality of switch contacts; means including said temperature responsive device, at least two of the secondary windings of said power source, said safety switch device actuator, and certain of the switch contacts of said first and second relay means for serially connecting said first relay means in an energizing circuit; burner control means adapted upon the energization of said first relay means to render the burner operative, combustion responsive means associated with said second relay means and adapted to cause energization thereof upon proper operation of the burner, means including certain of the switch contacts of said first and second relay means for rendering said safety switch device actuator inoperative when said first and second relays are energized, circuit means rendering said actuator inoperative upon energization thereof for a predetermined length of time when said first relay has been operating and said second relay has failed to operate so that said reset means when actuated can put said switch of said device in operative condition, said last named circuit means including said switch of said safety switch device, and further circuit means independent of said safety switch device switch maintaining said actuator continuously energized including switch contacts of said first relay when deenergized and said second relay when in energized position so that said reset means will not be effective to put said switch of said device in operative condition.

11. In combination, a source of power having at least a pair of secondary transformer windings, a first relay having switch contacts, a cutoff device having an electrical time delayed actuator and switch contacts, a second relay means having switch contacts, means connecting said first relay and said actuator in a series circuit to said secondary windings so that said first relay will be energized only when said actuator and both of said windings are intact, means including switch contacts of said first relay means when energized and said cutoff device switch contacts for maintaining said first relay connected in a maintaining circuit to one of said secondary windings, means including switch contacts of said first relay when energized and switch contacts of said second relay when deenergized for maintaining said actuator in an energizing circuit with said other winding until said second relay becomes energized or said actuator is effective to open the switch contacts of said device and deenergize said first relay, and means for continuously maintaining said actuator energized including switch contacts of said first relay when deenergized, switch contacts of said second relay when in energized position and said other secondary winding until said second relay is moved to deenergized position.

12. In a burner control apparatus, the combination comprising, a main control relay having switch contacts which when actuated are

adapted to complete an energizing circuit to the burner, a source of power, energizing and holding circuits for said relay having a common portion which includes said source of power and means for indicating a need for burner operation, a manually reset safety cutoff device having an electrical actuator therefor which when energized a predetermined length of time will actuate a pair of cutoff contacts to prevent operation of said main relay, a flame detection relay having switch contacts for indicating proper operation of the burner, first circuit means for energizing said cutoff device actuator until said cutout contacts render said first relay inoperative, said first circuit means including said source of power, switch contacts of said flame detection relay when deenergized, and said cutout contacts, and a second circuit means independent of said cutout contacts but including said source of power and contacts of said flame detection relay for continuously energizing said cutout device actuator when said main control relay is deenergized and said flame detection relay is in energized position and falsely indicating burner operation, said second circuit means remaining energized after actuation of said cutout device and preventing burner operation until the fault causing operation of said flame detection relay is removed.

13. In a control apparatus for a fuel burner, a temperature responsive device, means actuated by said temperature responsive device for completing an energizing circuit to the fuel burner, a combustion responsive device having a first pair of switch contacts which are actuated upon the occurrence of combustion at the burner and a second pair which are actuated when no combustion is present, a reset safety switch having an actuator therefor with cutout contacts connected in series circuit with said first named means and which when actuated are operable to deenergize said first named means upon failure of operation of said combustion responsive device, means connecting the second pair of said combustion responsive device switch contacts in a series energizing circuit with said safety switch actuator to disconnect said safety switch actuator and maintain said first named means operative upon proper operation of the burner, and further means connecting said safety switch actuator in an energizing circuit independently of said temperature responsive device and said cutout contacts to render said safety switch actuator operative when said combustion responsive device is falsely indicating combustion to thereby maintain said first named means inoperative, said last named means comprising the first pair of said combustion responsive device switch contacts.

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