

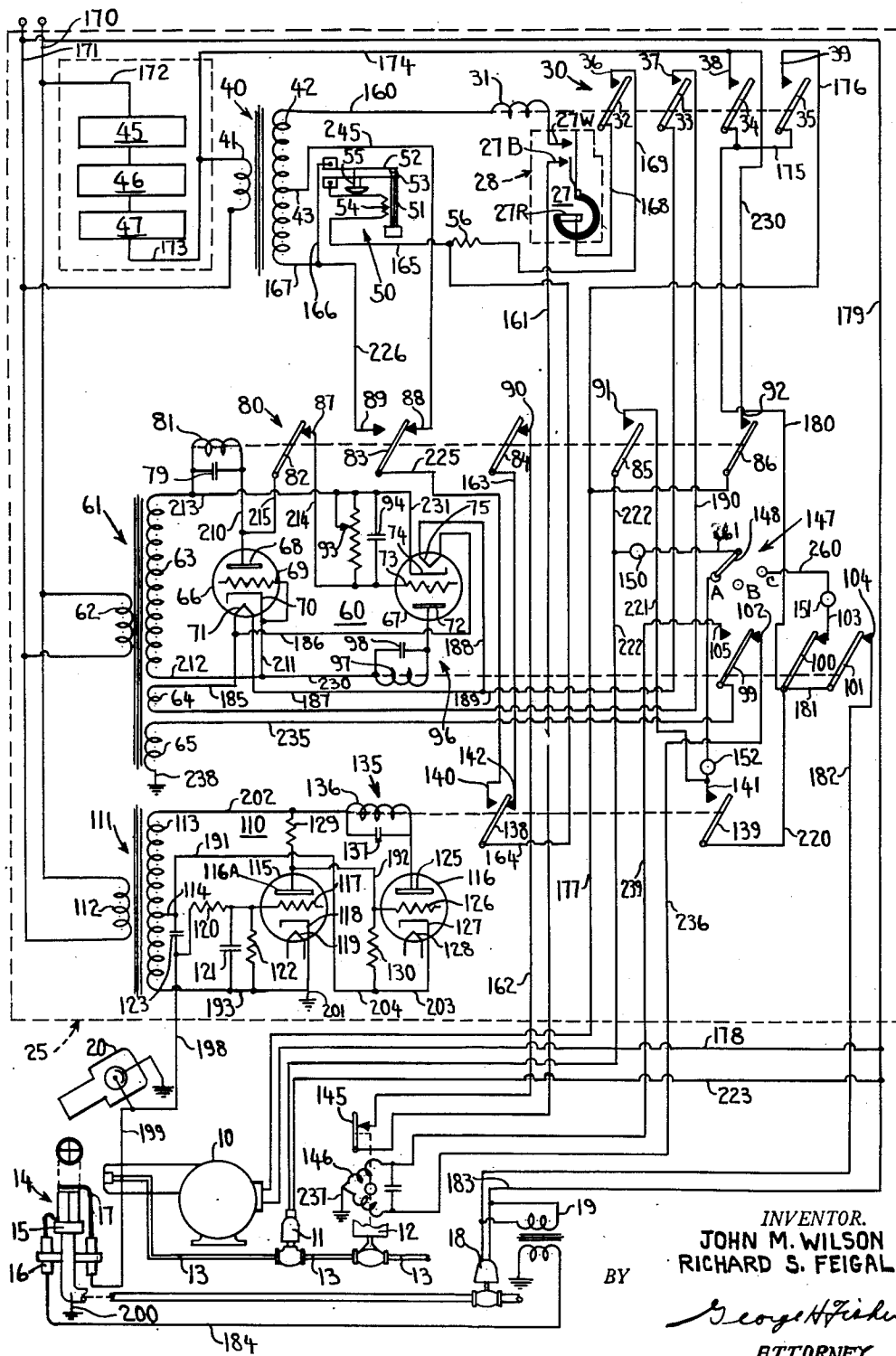
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FUEL BURNER SAFETY CONTROL APPARATUS

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FUEL BURNER SAFETY CONTROL
APPARATUS

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The present invention is concerned with an improved control apparatus for a fuel burner and more particularly an apparatus with greater flexibility to make the same readily adaptable for universal use on fuel burners, particularly those of the industrial type.

In many present day fuel burner installations, the burner is provided with an electric ignition device, a gas pilot valve, a blower motor, and a main fuel valve. To insure maximum safety with this type of burner, it is necessary to control the operation time or sequence in which the burner and its components become effective. This involves purge timing, opening the main fuel valve only after the pilot flame has been established, delaying opening of the main fuel valve until a timed period after the blower operates, and delaying the deenergization of the ignition device and pilot valve until after the main fuel valve has been opened, or any combination of the above as the specific installation may require. To obtain added safety, it is also necessary to provide shutdown upon a failure of components in the control apparatus or upon a failure of combustion at the burner.

The present invention contemplates accomplishing the above set forth type of control by a new and improved control apparatus that utilizes to best advantage electronic control devices to accomplish the desired timing and safety functions. The electronic devices are utilized in the timing circuit and in the flame detection circuits and this lends quick and positive response to the type of control desired. Three distinct timing periods are obtainable from the electronic timing device and these include delayed fuel valve opening, delayed ignition cutoff, and a blowout timing following burner operation. This is accomplished by utilizing a filament heater timing circuit and a resistance capacitance timing circuit, the former being utilized in the delayed fuel valve opening and the blowout timing while the latter is utilized for the ignition timing.

Checking pilot and burner operation is an electronic flame detector that utilizes a flame rod for pilot flame detection and a photocell for main flame detection. Circuits of the timer and the flame detector are associated with a safety cut-out device which is arranged to render the control apparatus inoperative whenever there is a flame failure, a false indication of flame when the apparatus is inoperative, or upon the electronic timer failing to operate when the apparatus comes into operation.

It is therefore an object of the present inven-

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tion to provide an improved burner control apparatus having an electronic timing device for providing delayed fuel valve opening, delayed ignition cutoff, and blowout timing following burner operation.

A further object of the present invention is to provide a burner control apparatus having an electronic timer utilizing the time delay of heating and cooling of the timer for obtaining delayed fuel valve opening and blowout timing.

A still further object of the present invention is to provide an apparatus having a safety checking circuit which will render the apparatus inoperative upon a flame failure, upon a false indication of flame, or upon the timing apparatus failing to operate upon a demand for burner operation.

Another object of the present invention is to provide an improved burner control apparatus with a limit control device associated therewith having an electronic flame detection circuit and arranged so that when the limit control apparatus is operative, the burner is rendered inoperative by interruption of the power supply to a portion of the control apparatus but not that supplied to the flame detection circuit.

These and other objects of the present invention will be understood upon a consideration of the accompanying specification, claims and drawing of which:

The single figure shows diagrammatically the control apparatus and the manner in which it is associated with a fuel burner and its associated operating components.

Referring now to the single figure, the numeral 10 represents a blower motor which may be used to supply air to the combustion chamber of the fuel burner. A solenoid valve 11 and a motor operated valve 12 control the flow of fuel through a conduit 13 which conduit may conduct the fuel to a point where it will be atomized by the air originating from the blower motor 10. A pilot assembly 14 comprises a gas pilot nozzle 15, an ignition electrode 16 and a flame electrode 17 for detecting the presence of the pilot flame. A flame stabilizer and grounding element in the form of a pair of crossed fins is mounted on the end of nozzle 15. These fins stabilize the pilot flame against cross drafts and allows the flame to make a good electrical contact therewith. A projected end view is shown above the nozzle 15. Controlling the flow of fuel to the pilot nozzle 15 is a solenoid operated valve 18. The ignition potential for the ignition electrode 16 originates at an ignition transformer 19. Detecting the

presence of the main burner flame is a photo-cell indicated by the numeral 20.

Located within a housing indicated generally by the numeral 25 are the control circuits for the various components associated with the fuel burning device. These control circuits may be brought into operation by any suitable device which is operative upon the need for burner operation. This device may be a thermostat such as has been indicated by the numeral 27 and which may be located in a separate enclosure 28. Whenever the thermostat 27 indicates a need for burner operation, the electrical circuits located within the housing 25 will be effective to energize the blower motor, energize the pilot assembly to establish a pilot flame, check the presence of the pilot flame, open the main fuel valve after the pilot flame has been checked and a predetermined time has elapsed after the blower motor has been brought into operation, and render all of the components ineffective should there be a failure of the components or of the electrical circuits located within the housing 25.

Included in the circuits located in the housing 25 is a main control relay indicated by the numeral 30. This relay includes a winding 31, switch blades 32, 33, 34 and 35 normally biased out of engagement with their associated switch contacts 36, 37, 38 and 39 respectively. Supplying power to this relay is a transformer 40 having a primary winding 41 connected to a common input source of power and a secondary winding 42 which is tapped at 43. The primary winding may be connected to the input power line through a plurality of limit control devices that may be associated with the fuel burner. These limit control devices may be a low water-cutoff 45, a high limit cutoff 46 and a fuel temperature responsive thermostat 47. Whenever any one of these limit controls is operative it is impossible to complete an energizing circuit to the primary 41 of transformer 40. Obviously, any one or all of the limit controls could be dispensed with should a particular installation not require such.

Associated with the energizing circuit for the main control relay 30 is a safety cutoff device 50 which comprises a bimetallic timing element 51, a pair of switch contacts 52 and 53, a resistance heater 54 and a reset actuator 55. When the heater 54 has been energized for a predetermined length of time, the bimetal 51 will be warped from its normal position so that the contacts 52 and 53 will break contact to open the energizing circuit and holding circuit for the main control relay 30. Depressing of the reset actuator 55 will close the contacts 52 and 53 if the bimetal 51 has returned to its normal position. A resistor 56 is associated with the safety cutoff device in the main control relay for current limiting purposes.

The numeral 60 represents the electronic timing portion of the subject control apparatus. Supplying power to this timer is an alternating current transformer 61 having a primary winding 62 and a plurality of secondary windings 63, 64 and 65. Also included in the timing apparatus are a pair of electron discharge devices 66 and 67. The discharge device 66 comprises an anode 68, a control electrode 69, and a cathode 70 which is heated indirectly to be electron emissive by a filament type heater 71. The discharge device 67 comprises an anode 72, a control electrode 73, a cathode 74, the latter being heated to be electron emissive by a filament type heater

75. In the plate circuit of the discharge device 66 is a control relay 80 having a relay winding 81, and switch blades 82, 83, 84, 85 and 86 normally biased as shown by means not shown. The switch blade 82 is normally biased into engagement with an associated switch contact 87. The switch blade 83 is normally biased into engagement with switch contact 88 and when the relay winding 81 becomes energized the switch blade 83 moves into engagement with an associated contact 89. Switch blade 84 is normally biased into engagement with switch contact 90 and, when the relay winding 81 becomes energized, the blade 84 will move out of engagement with contact 90. Switch blades 85 and 86 are associated with switch contacts 91 and 92 respectively and are normally biased out of engagement with their respective contacts when the relay winding 81 is deenergized.

Associated with the input of triode 67 are a potentiometer 93 and a timing condenser 94. Associated with the anode circuit of discharge device 67 is a further control relay 96 having a relay winding 97, which is by-passed by a suitable by-pass condenser 98, and a plurality of switch blades 99, 100 and 101. When the relay winding 97 is deenergized, the switch blades 99, 100 and 101 are normally biased into engagement with contacts 102, 103 and 104 respectively by means not shown. When the relay winding 97 becomes energized, the switch blade 99 moves into engagement with an associated switch contact 105.

The electronic flame detection portion of the apparatus is indicated by the numeral 110. This flame detection apparatus is substantially the same as the "Flame Detection Apparatus" shown in Richard S. Feigl Patent 2,556,961. For a complete understanding of the operation of the flame detection apparatus, reference should be made to this copending application. This detection apparatus includes an alternating source of power comprising a transformer 111 having a primary winding 112, connected to the common source of power, and a secondary winding 113 which is tapped at 114. Also included in the flame detection apparatus are a pair of electron discharge devices 115 and 116. The discharge device 115 comprises an anode 116A, a control electrode 117, and a cathode 118 which is heated to be electron emissive by a suitable filament type heater 119, continuously connected to a source of power, not shown. Connected to the input of this discharge device is a filter network comprising a resistor 120, a condenser 121, and a further resistor 122. Also associated with the input of this discharge device is a condenser 123 which is directly associated with the flame detecting elements of the apparatus including the photocell 20 and the flame rod 17.

The electron discharge device 116 comprises an anode 125, a control electrode 126, and a cathode 127 which is heated to be electron emissive by a suitable filament type heater 128, continuously connected to a source of power, not shown. Located on the input of triode 116 are a pair of resistors 129 and 130. Located in the output or anode circuit of the discharge device 116 is a control relay 135 having the relay winding 136, by-passed by a suitable by-pass condenser 137, and a pair of switch blades 138 and 139 which are normally biased out of engagement with their associated switch contacts 140 and 141 respectively, and when so biased switch blade 138 will be engaging a further switch contact 142.

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Associated with the energizing circuit for the main control relay 30 is a switch operated by the motorized valve 12. This switch 145 is operated by a motor 146 whenever the motor has moved the valve assembly to the low supply position. The switch is utilized to ensure that the main control relay 30 cannot be energized until the motorized valve 12 is in the low fuel supply position.

In order that various modes of operation may be obtained from the subject apparatus, a switch 147 is provided. This switch comprises a blade 148 and a plurality of contacts A, B and C certain of which are electrically connected to terminals in the control apparatus. The blade 148 connects to a terminal 150, the contact A connects to a terminal 152 and the contact C connects to a terminal 151. The switch 147 may be dispensed with if it is desired to make permanent connections between the terminal 150 and the terminals 151 or 152.

Operation

In considering the operation of the subject apparatus it will be assumed that the controls and components associated with the fuel burner are all in the deenergized position as they are shown upon the drawing except with blade 148 of switch 147 engaging contact B. When in this position, there will be no pilot flame, main flame, or blower motor operation.

Assume now that the space wherein is located the thermostat 27 begins to cool and that the contacts 27W and 27B are engaging the switch blades of the thermostat 27. The switch contact 27W closes before the contact 27B. This arrangement of the contacts is arranged so that contact 27B is used only as a start circuit. Once the circuit it is designed to complete is complete, a holding circuit is established through contact 27R independent of contact 27B. Thus any chattering tendencies of contact 27B will not affect the circuit associated with the thermostat once that it has become energized.

The energizing circuit completed by the closing of the thermostat 27 is the energizing circuit to the main control relay 30. This energizing circuit may be traced from the upper terminal of the secondary 42 through conductor 160, relay winding 31, switch contacts 27W and 27B, conductor 161, end switch contacts 145, conductor 162, switch contact 90, switch blade 84, conductor 163, switch contact 142, switch blade 138, conductors 164 and 165, heater 54, switch contacts 52 and 53, and conductors 166 and 167 to the lower terminal of the secondary 42. It will be noted that this energizing circuit for the relay 30 was completed through deenergized contacts of the timing relay 80, the flame detection relay 135 and the low position indicating end switch of the motorized valve 12. As soon as the relay 30 becomes energized, a holding circuit is completed for this relay and this holding circuit may be traced from the upper terminal of secondary 42, conductor 160, relay winding 31, switch contacts 27W, contact 27R, conductor 168, switch blade 32, switch contact 33, conductor 169, voltage dropping resistor 55, conductor 165, heater 54, contacts 52 and 53, and conductors 166 and 167 to the lower terminal of secondary 42. This will mean that the control relay 30 will now be energized independently of contact 27B of thermostat 27 and will not be subject to any chattering tendencies of the thermostat contact 27B.

When the relay 30 has become energized, an

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energizing circuit is completed to the blower motor 10 through contacts of the relay 30. This energizing circuit may be traced from the input power line 170, conductor 172, limit controls 45, 46 and 47, conductors 173 and 174, switch contacts 38, switch blade 34, conductor 175, switch blade 35, switch contact 39, conductors 176 and 177, blower motor 10, conductors 178 and 179 back to the other input power line 171. With the energization of the blower motor, the blower will come into operation and will be forcing air into the combustion chamber of the burner. This air will be available for the combustion purposes in the associated furnace.

Also energized at the same time that the blower motor 10 is energized are the pilot valves 18 and the ignition transformer 19. Inasmuch as the pilot valves 18 and the ignition transformer are effectively connected in parallel, the circuit to both of the components may be traced as follows: from input power line 170, through conductor 172, limit controls 45, 46, 47, conductors 173 and 174, switch contact 38, switch blade 34, conductors 180 and 181, switch blade 101, switch contact 104, conductor 182 to the pilot valve and ignition transformer and conductors 183 and 179 back to the other input power line 171. With the energizing circuit completed to the pilot valve 18 and ignition transformer 19, the pilot valve will become energized and will open and the ignition transformer will be conditioned so that it will be able to energize the ignition electrode 15 through conductor 184. With the ignition electrode 16 energized, there should be a sparking at the end of the electrode between the electrode and the pilot nozzle 15. If there is gas coming to the pilot nozzle 15, this gas will be ignited and a pilot flame will be established.

Also established upon the energization of relay 30 is the energizing circuit to the filaments of the electron discharge devices of timer 60. The energizing circuit for these filament heaters of the discharge devices may be traced from the upper terminal of the secondary 64 through conductor 185 to filament 71 and conductor 186 to filament 75, from filament 71 through conductor 187 and from filament 75 through conductor 188 to conductor 189 and from there to switch blade 33, switch contact 37 and conductor 190 back to the lower terminal of secondary 64. With the filaments 71 and 75 energized, the initial timing of timer 60 will be started.

In the mean time, while the cathode of the discharge devices and timer 60 are being heated, the flame detection device 110 will be operative to detect the presence of the pilot flame existing on the pilot assembly 14. In considering the operation of the flame detection device 110, reference should be made to the above-mentioned copending application of Richard S. Feigal for a complete understanding of the same. Briefly, the apparatus is one which will detect the presence or absence of a flame by using the current rectifying characteristics of a flame. The apparatus is designed to indicate a flame only when there is a flame existing across the flame electrode 17 or a flame is being viewed by the photocell 20. Under a no flame condition, the discharge device 115 will be normally conducting as the control electrode 117 is effectively biased slightly positive with respect to the cathode since the resistor 120 and the parallel combination of the condenser 121 and resistor 122 form a voltage divider across the lower half of secondary 113. With this, on the positive half cycle of the alternating power

source when the anode is positive, the control electrode 117 will be slightly positive with respect to the cathode 118. This will mean that the discharge device will be conductive and plate current will flow in a circuit that may be traced from the center tap 114 through conductor 191, resistor 130, conductor 192, anode 116A, cathode 118 and conductor 193 to the lower terminal of the secondary 113. With current flowing through the resistor 130, the discharge device 116 will be biased to be effectively non-conducting since the upper terminal of the resistor 130 will be negative with respect to the lower terminal on the conductive half cycle of the discharge device 116. With this negative bias on the discharge device 116, there will be no current flow through the device for energizing the flame detection relay 135.

When a flame is present, as when the flame electrode has a flame impinging thereon from the pilot nozzle 15, the discharge device 115 will be rendered non-conductive. This will occur since the existence of a flame between the pilot nozzle 15 and the flame electrode 17 forms a rectifying impedance which, with current flowing therethrough, may be used to charge a condenser associated with the input of discharge device 115. The condenser that is charged is condenser 123 and the charging circuit for this condenser may be traced from the center tap 114, through condenser 123, conductor 198, conductor 199, flame electrode 17, pilot nozzle 15, ground 200, ground 201, and conductor 193 back to the lower terminal of secondary 113. The charge on this condenser will be such that the lower terminal of the condenser is negative while the upper terminal is positive. Since the lower terminal of condenser 123 is directly connected to the control electrode 117 of discharge device 115 through the resistor 120, this control electrode 117 will be biased effectively negative with respect to the cathode by reason of this negative charge on the condenser 123. This will effectively stop the current flow through the discharge device 115 so that there will no longer be a current flow through the resistor 130. With no current flow through resistor 130 due to the discharge device 115, the discharge device 116 will be able to pass current and this current flow will be sufficient to energize the relay 135. The energizing circuit for the relay 135 may be traced from the upper terminal of the secondary 113 through conductor 202, relay winding 136, anode 125, cathode 127, and conductors 203 and 204 back to the center tap 114. Should a groundout condition occur, where the flame electrode 17 was touching the pilot nozzle 15, there would no longer be a rectifying impedance available to charge the condenser 123 and therefore discharge device 115 would once again become conductive. When so conductive, the current flow from this discharge device will flow through resistor 130 and will bias the discharge device 116 to be nonconductive and the relay 135 will become deenergized.

Assuming now that the flame detection apparatus 110 is operating properly and that the flame between the pilot nozzle 15 and the flame electrode 17 is acting in the normal manner described above to effect energization of relay 135. When the flame detection relay 135 becomes energized, the switch blade 138 moves into engagement with its associated switch contact 140 and switch blade 139 engages contact 141. The switch blade 139 and contact 141 are directly associated with the energizing circuit of the main fuel valve and, if

an electrical circuit cannot be completed through switch blade 139 and contact 141, it will be impossible to energize the main fuel valve. The circuit utilizing this switch arm and contact will be considered when the operation of the timer 60 has been discussed. When the switch blade 138 and contact 140 come into engagement, a first portion of a shunt circuit around the safety switch heater 54 is completed. This shunt circuit will likewise be traced after operation of the timer 60 has been considered.

As mentioned above, when the main control relay 30 becomes energized, the energizing circuit to the filament heaters 71 and 75 is completed. After a predetermined time delay, the cathodes of the discharge devices will become electron emissive. When these cathodes are emissive, electrons will begin to flow between the cathodes and anodes. The current flow will initially be rather slow before the cathodes are up to full temperature and the current that does flow may be traced from the upper terminal of the secondary 63 through relay winding 81, conductor 210, anode 68, cathode 70, and conductors 211 and 212 to the lower terminal of secondary 63. Some of the current flow for discharge device 66 may also be traced from the upper terminal of secondary 63 through conductor 213, potentiometer 93, conductor 214, switch contact 87, switch blade 82, and conductor 215 to the anode 68. In other words, the winding 81 and the potentiometer 93 are effectively connected in parallel. With the current flowing in the last traced circuits, the condenser 79, connected in parallel with winding 81, and condenser 94, connected in parallel with potentiometer 93 will become charged. When the condenser 79 has become charged sufficiently, the current flow through the relay winding 81 will be sufficient to move the relay into the energized position. When the condenser 79 is so charged, the condenser 94 will be similarly charged and the polarities of their charge will be such that the lower terminal of condenser 94 is negative and the upper terminal of the condenser is positive. Since the control electrode 73 is directly connected to the lower terminal of condenser 94, the control electrode will be biased negative with respect to the cathode which is connected to the upper terminal of condenser 94. This will prevent any current from flowing through the discharge device 67 as long as this biasing potential remains on the condenser 94.

When the relay 30 becomes energized due to sufficient current flowing through the winding 81, the switch blades will move from the position in which they are shown upon the drawing to the energized position where the switch blade 82 will move out of engagement with switch contact 87, switch blade 83 will move out of engagement with switch contact 88 and into engagement with contact 89, switch blade 84 will move out of engagement with switch contact 90 and switch blades 85 and 86 will move into engagement with their respective contacts 91 and 92. When the relay 30 becomes energized, the energizing circuit through the main fuel valve 11 is completed and this circuit may be traced from the input power line 170 through conductor 172, limit control devices 45, 46 and 47, conductor 173, conductor 174, switch contact 38, switch blade 34, conductor 180, conductor 220, switch blade 139, switch contact 141, conductor 221, switch contact 91, switch blade 85, conductor 222, valve 11, and conductors 223 and 179 back to the other input power line 171. With the main fuel valve 11 energized, a combustible

fuel such as oil will pass through the valve and conduit 13 into the fuel burner chamber where the air from blower 10 will atomize the oil and the atomized oil will be ignited by the presence of the pilot flame existing on the pilot nozzle 15.

Also completed by the energization of the relay 80 is a shunt around the heater of the safety cut-out device 50. This shunt around the heater of the safety cutout device is provided to maintain the energizing circuit for the relay 30 while rendering the safety cutout device 50 ineffective. This energizing circuit for the relay 30 may now be traced from the upper terminal of secondary 42 through conductor 160, relay winding 31, switch contact 27W, contact 27R, conductor 168, switch blade 32, switch contact 36, conductor 169, resistor 56, conductor 164, switch contact 140, conductor 225, switch blade 83, switch contact 89, conductor 226 and conductor 167 to the lower terminal of secondary 42. It will be noted that this last traced circuit included the resistor 56. The purpose of this resistor 56 is merely to keep the current flow in the last traced circuit for winding 31 below a predetermined value so that there will be no excessive heating in the winding. When timing switch blade 84 moved out of engagement with switch contact 90, the circuits through the originally traced energizing circuit for the main control relay 30 was broken. However, since the relay has its own holding circuit, the opening of switch blade from contact 90 will have no affect upon the apparatus at the moment.

Another circuit completed by the energization of the timer relay 80 is a shunt circuit for the blower motor 10 that is independent of the contacts of the main control relay. This shunt circuit may be traced from the input power line 170 through conductor 172, limit controls 45, 46 and 47, conductor 173, conductor 174, conductor 230, switch contact 92, switch blade 86, conductor 177, blower motor 10, and conductors 178 and 179 back to the other input power line 171. This last traced circuit will maintain the blower motor energized after the main control relay 30 has become deenergized in a manner that will be discussed below.

When the timing relay 88 becomes energized, a further switch contact and blade, 87 and 82, are open circuited. As traced above, the switch blade 82 and contact 87 are in a portion of the anode circuit of the discharge device 66 and allow some of the anode current to pass through the potentiometer 93 and charge condenser 94 at the same time. Obviously, when the switch blade 82 moves out of engagement with switch contact 87, the charging circuit for the condenser 94 is no longer existing and the condenser will tend to discharge. This condenser will discharge through the potentiometer 93 at a rate determined by the amount of resistance existing in the potentiometer circuit. After a predetermined length of time the condenser 94 will have discharged through the potentiometer 93 sufficiently so that the control electrode will approach the same potential as the cathode 74 at which time the current flow through the discharge device 67 will be sufficient to energize the timing relay 96 in a circuit that may be traced from the lower terminal of the secondary 63 through conductor 212, conductor 230, relay winding 97, anode 72, and conductors 231 and 213 back to the upper terminal of secondary 63. When the timing relay 96 becomes energized,

the switch blades 99, 100 and 101 move out of engagement with their respective contacts 102, 103 and 104. When switch blade 99 moves out of engagement with contact 102, it moves into engagement with switch contact 105. When switch blade 101 moves out of engagement with switch contact 104, the energizing circuit to the pilot valve 18 and the ignition transformer 19 is opened. With the opening of this energizing circuit, the pilot valve will become deenergized and will stop the flow of gas to the pilot nozzle 15. Since the pilot flame has been operating a timed period after the main fuel valve 11 was operated, the need for the pilot flame is no longer existing and therefore it is desirable to shut the pilot flame off.

With the pilot flame cut off, it is necessary that the photocell 20 detect the presence of the main burner flame if the flame detection relay 135 is to remain in the energized position. Inasmuch as a photocell is a rectifying impedance in much the same manner that a flame is a rectifying impedance, the condenser 123 on the input of discharge device 115 will remain charged with the same polarity as occurred when the pilot flame was intersecting the flame rod 17. The photocell 20 and the flame rod 17 are effectively connected in parallel and, therefore, both of the devices function in exactly the same manner as far as the electronic flame detecting circuit 110 is concerned and with the main burner flame present, the flame detection relay 135 will remain energized.

When the switch blade 99 is engaging switch contact 102, the control motor of the motorized valve 12 has been driven to an end position by an energizing circuit that may be traced from the upper terminal of secondary 65 through conductor 235, switch blade 99, switch contact 102, conductor 236, the lower winding of motor 143, ground 237 and ground 238 back to the lower terminal of secondary 65. When in this position, the motorized valve is in the low supply position and only a small amount of fuel may be sent through the valve to the combustion chamber. When the switch blade 99 moves into engagement with switch contact 105, a new energizing circuit is established to the motor 146 and this circuit may be traced from the upper terminal of secondary 65 through conductor 235, switch blade 99, switch contact 105, conductor 239, the upper winding of motor 146, ground 137, and ground 238 back to the lower terminal of secondary 65. With the motor 146 so energized, the motor will move the motorized valve assembly in an upward direction so that the valve assembly is moved to the high supply position where a large amount of fuel may pass through to the fuel burner combustion chamber.

The fuel burning control apparatus and the components associated therewith are now in the normal operating position where the valve assembly 14, the pilot valve 18, and the ignition transformer 19 are no longer effective and the blower motor 10 is supplying air to atomize the fuel now flowing at a maximum, as governed by the motorized valve 12, and the main burner flame is being detected by the photocell 20. As long as all components are operating properly, the apparatus will stay in this state of operation until such time as there is no longer a demand for such operation.

As soon as there is no longer an indication for a need of continued operation of the burner,

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the room thermostat 27 will open and the switch blades of the thermostat will move out of engagement with the contacts 27W and 27B. When the room thermostat opens, the energizing circuit to relay winding 31 is broken so that the relay will become deenergized. When this relay becomes deenergized, the switch blades 32, 33, 34 and 35 move out of engagement with their associated contacts 36, 37, 38 and 39. When the blade 32 moves out of engagement with switch contact 36, the holding circuit for the relay winding 31 is opened so that it is impossible to reenergize the winding 31 unless the circuits associated with the thermostat contact 27B are all in the deenergized position. Also deenergized by the deenergization of the main control relay 30 is a main fuel valve 11. This will occur when the switch blades 34 and 35 move out of engagement with contacts 38 and 39. When the main fuel valve 11 becomes deenergized, there will no longer be fuel flowing into the combustion chamber and the main burner flame should become extinguished. With the main burner flame no longer present, the flame detection relay 135 should become deenergized because the photocell 20 will no longer be detecting the presence of a flame.

Also deenergized upon the deenergization of the main control relay 30 is the filament circuit for the electron discharge devices of the timer 60. This occurs when the switch blade 33 moves out of engagement with switch contact 37. The opening of the filament circuit initiates another important timing period in the operation of the apparatus. Inasmuch as the cathodes of the electron discharge devices will not cool immediately, there will be current flow through the discharge devices 66 and 67 for a length of time determined by the cooling time of the respective cathodes. In other words, the main timing relay 80 will remain energized for a certain period and will maintain the blower motor 10 energized since the switch blade 36 and switch contact 92 form a shunt circuit for the blower motor to keep the blower motor in an energized circuit as long as these contacts are engaging. In other words, a blowout timing is obtained to insure that all fuel in the combustion chamber is completely burned and this is accomplished by the cooling time of the cathode 70 of discharge device 66.

While the time delay relay 96 will remain energized for a time period after the opening of the filament circuit of the discharge devices 66 and 67, the only function this relay will have will be to maintain the pilot burner assembly inoperative until after the blowout timing has taken place. When the relay 96 has become deenergized, the switch blade 99 will engage switch contact 102 and this will energize the motorized valve 12 so that the motor 146 will drive the valve mechanism to the low fuel capacity position. When switch blade 101 moves into engagement with switch contact 103, it will be possible to complete an energizing circuit to the pilot valve 13 and ignition transformer 19 upon a subsequent demand for heat or burner operation when the main control relay 30 becomes deenergized.

The apparatus is once again back in the position in which it is shown upon the drawing with all of the components deenergized. Upon a subsequent demand for further burner operation as indicated by the room thermostat 27, the apparatus will go through an operating cycle in the manner which has been described directly above.

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Operation upon flame failure

Assume for the moment that the burner control is in the full operating position with the blower motor operative, and fuel being supplied thereto at the maximum rate as dictated by the motorized valve 12 and the main valve 11. Assume now that the oil line becomes clogged momentarily so that there is no longer fuel supplied to the combustion chamber. When this occurs, the photocell 20 will no longer detect the presence of flame and will be ineffective to maintain a charge upon the condenser 123 in the flame detector 110. When this occurs, the flame detection relay 135 will move to the deenergized position so that the switch blades 138 and 139 move out of engagement with their associated switch contacts 140 and 141. When the switch blade 139 moves out of engagement with switch contact 141, the energizing circuit to the main fuel valve 11 is interrupted and when so interrupted will effect the deenergization of the main fuel valve 11 so that fuel can no longer be delivered to the combustion chamber. When the switch blade 138 moves out of engagement with switch contact 140, the shunt circuit around the heater 54 of the safety cutout device 50 is broken so that now an energizing circuit through the safety switch heater may be traced from the upper terminal of secondary 42 with the conductor 160, winding 31, switch contact 27W, contact 27R, conductor 168, switch blade 32, switch contact 36, conductor 169, resistor 56, conductor 165, heater 54, switch contacts 52 and 53, and conductors 166 and 167 to the lower terminal of secondary 42.

With the heater 54 again connected in the energizing circuit of the main control relay 30, the heater will begin to warp the bimetal 51 towards the right and, after a predetermined time, the bimetal will have moved sufficiently far that the contacts 52 and 53 will open. When these contacts open, the energizing circuit to the main control relay 30 is deenergized and the apparatus will go into the completely deenergized position in the manner described above when the room thermostat 27 no longer indicates a demand for heat.

As long as the contacts 52 and 53 are open circuited, it will be impossible to complete an energizing circuit to the main control relay 30 should there be a subsequent demand for burner operation. As soon as the reset actuator 55 is depressed, assuming the bimetal has cooled, it will be possible for the switch contacts 52 and 53 to close. As soon as the contacts 52 and 53 do close, the apparatus will start its operating cycle in the manner disclosed under operation. If, on restarting, no flame was detected at the pilot assembly 14, the flame detector 110 would not energize the flame detection relay 135 and the main oil valve 11 would not become energized. Further, the energizing circuit to the heater 54 of the safety cutout device 50 would be energized in a manner described above and, after a predetermined time, the safety cutout device would become operative to open switch contacts 52 and 53 to deenergize the main control relay 30. Obviously, the deenergization of the main control relay will deenergize the components including the pilot burner assembly 14, and the filament circuits of the timing device 60 when the relay becomes deenergized. As soon as the trouble has been cleared from the fuel line, it should be possible to depress the actuator 55 on the safety cutout device 50, close the contacts 52 and 53 and initiate normal burner operation in the manner described above.

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Operation upon false indication of flame

In order to render the control apparatus a completely safe one, it is necessary that the control apparatus fail to energize any of the key burner components when any portion of the control apparatus is not operating properly. In the event that the flame detection relay 135 should remain in the energized position after the room thermostat 27 is no longer indicating a need for heat and the main control relay 30 is deenergized, it is desired to prevent further operation of the control apparatus. When the main control relay 30 becomes energized, it will be recalled that the energizing circuits of the filament heaters of the discharge devices in timer 60 are open. When this filament heater circuit is open, the timer relay 80 will move to the deenergized position after a predetermined time. With the timer relay in the deenergized position and the flame detection relay 135 in the energized position, an energizing circuit can be traced to the heater 54 of the safety cutout device 50. This energizing circuit may be traced from the tap 43 of secondary 42 through conductor 245, switch contact 88, switch blade 83, conductor 225, contact 140, switch blade 138, conductors 164 and 165, heater 54, switch contacts 52 and 53 and conductors 166 and 167 to the lower terminal of secondary 42. With this new energizing circuit to heater 54, the bimetal 51 will again be warped toward the right and after a predetermined time the contacts 52 and 53 will open to open the energizing circuit to the main control relay 30. Upon a subsequent demand for burner operation by the room thermostat 27, it will be impossible to complete an energizing circuit for the main control relay as the contacts 52 and 53 are open. As long as the flame detection relay remains in the energized position, it will be impossible to initiate operation of the apparatus even though the safety switch contacts are subsequently depressed and the contacts 52 and 53 are closed. This is true since the energizing circuit for the main control relay 30 is completed through deenergized contacts of the flame detection relay 135, switch blade 138 and switch contact 142, before the energizing circuit for the main control relay can be completed.

Operation upon faulty operation of timer

In the event that the timer should fail to operate or should continue to operate after there is no longer a need for such operation, it is desired that the control apparatus be rendered inoperative. Assume, for example, that the timer filament circuit should open or some other fault should occur so that the relay 80 could not become energized after the control apparatus has been started up in its normal manner by a demand for burner operation by the room thermostat 27. Under this situation, the blower motor 19, the pilot valve 18 and the ignition transformer 19 will all be energized as upon a normal starting cycle. When so energized, a flame will appear at the pilot nozzle 15 and the same will be detected by the flame electrode 17 so that the flame detection relay 135 will move to the energized position. If, after a predetermined time the timer relay 80 does not become energized, the safety cutout heater 54 will have been energized for a sufficient length of time to move the bimetal 51 toward the right and open switch contacts 52 and 53. This energizing circuit may be traced from the center tap 43 through conductor 245, switch contact

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88, switch blade 83, conductor 225, switch contact 140, switch blade 138, conductors 164 and 165, heater 54, switch contacts 52 and 53, and conductors 166 and 167 to the lower terminal of the secondary 42.

The timing period for the safety cutout heater to operate the bimetal is considerably longer than the period required for the timer relay 80 to come into operation. Therefore, on the normal starting cycle, while the last traced energizing circuit is temporarily completed, the timer relay normally comes into operation to shunt out the safety cutout heater. When the timer does not come into operation, the last traced energizing circuit to the safety cutout heater 54 will be maintained and the apparatus will be shut down upon the circuit opening of the contacts 52 and 53.

Should the timing apparatus 60 remain in operation after the main control relay 30 has become deenergized, it is also desired to prevent any further operation of the apparatus which might possibly cause damage. This safety feature is accomplished by utilizing the deenergized contacts of the timer relay 80 in the starting circuit for the main control relay 30. If the timer remains in the energized position, switch blade 84 will be out of engagement with switch contact 90 so that the initial starting circuit for relay 30 cannot be completed. It will be noted that the switch contact 86 will be engaging switch contact 92 in which case the blower motor 19 will remain energized. Obviously, no damage can be done by running the blower motor when there is no fuel being supplied to the combustion chamber.

Power failure

In the event there should be an extended power failure, that is a power failure over a period of several minutes, the apparatus will of course be completely deenergized. As soon as power is returned, the apparatus will start up in its normal operating cycle, as explained above under the section entitled "Operation."

Under conditions of momentary power failure, the dangers of explosion in the combustion chamber are quite great unless some steps are taken to shut the apparatus down and start it up from its initial starting position. Assume that the apparatus is operating normally under the condition of full operation with the pilot assembly 14 deenergized and the motorized valve 12 operated to the high supply position. Should a momentary power failure occur under these conditions, the main burner control relay 30 will become deenergized and will disrupt or open its holding circuits through switch blade 32 and switch contact 36. Should the power be immediately restored, it will be impossible to reenergize the burner control relay 30 through this holding circuit and it must be energized through the starting circuit which includes switch blade 138 and switch contact 142, engaging when the flame detection relay 135 is deenergized, switch blade 84 and switch contact 90, deenergized when timer relay 80 is deenergized, and the end switch 145 on the motorized valve 12. Inasmuch as all of the above mentioned switch contacts are in the energizing circuit for the burner control relay 30, it is necessary that they all be completely in the deenergized position before it is possible to energize the burner control relay.

This will mean that the timer relay 80 must go through a timing period dependent upon the

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cooling time of cathode 70 in the discharge device 66. It further means that the flame detection relay 135 cannot be energized indicating the presence of a flame in the combustion chamber. Further, the timer relay 96 must become deenergized so that the switch blade 99 moves into engagement with switch contact 102 so that the motorized valve 12 will be driven to the low supply position at which position the end switch 145 will become closed. As soon as all these switches have been moved to the closed position, it will be possible to initiate burner operation in the normal manner with the burner control relay 30 becoming energized first, which energization completes an energizing circuit to the blower motor 10 and the components of the pilot burner assembly 14 in the manner described above under the portion entitled "Operation."

Alternative uses

Obviously the above described control apparatus is one with a great deal of flexibility and there are many ways in which the control apparatus may be adapted to various types of burner installations. For example, assume that a direct connection be made from terminal 150 to terminal 152 as shown upon the drawing by moving switch blade 148 into engagement with contact A. If such a connection were made, the timing delay of relay 80 obtained in the control apparatus as it is shown upon the drawing and as obtained by the closing of the switch blade 85 and switch contact 91 would be effectively by-passed so that there would be no delay in the opening of the fuel valve 11. The energizing circuit to the main valve 11, however, is still completed through a contact of the flame detection relay 135 so that the fuel valve is not energized until a flame is detected at the pilot assembly 14 by the flame electrode 17.

In the event that a direct connection should be made between the terminal 150 and terminal 151, by moving switch blade 148 into engagement with contact C, it would be possible to have an arrangement where there would be direct ignition of the fuel through the main valve 11 as the valve 11 will become energized immediately upon the energization of the burner control relay 30. The energizing circuit to the fuel valve may be traced from the input power line 170 through conductor 172, limit control devices 45, 46 and 47, conductors 173 and 174, switch contact 33, switch blade 34, conductor 180, switch blade 100, switch contact 103, conductor 260, switch blade 148, conductor 261, terminal 150, conductor 222, valve 11, and conductors 223 and 179 back to the other input power line 171.

While the end switch 145 is operated by the movement of a motorized valve to the low fire or low supply position, that end switch could be eliminated in certain situations where such a motorized valve is not used. Further, the end switch 145 could be operated by a similar type of motor which would be driving a damper associated with the combustion chamber and would not be effective until the damper was in the desired position.

Other modifications will readily suggest themselves to anyone skilled in the art.

Conclusion

From the foregoing it will be seen that we have provided a new burner control apparatus utilizing an electronic timer and an electronic flame detector and have provided therewith a com-

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bination of safety circuits which will prevent operation should any component fail to operate or operate falsely. Further, we have provided an apparatus which will enable the controlled burner installation to be brought into operation in the desired safest sequence. Many modifications of the above control apparatus will suggest themselves to those skilled in the art and we therefore intend to be limited solely by the scope of the appended claims.

We claim as our invention:

1. Control apparatus for a fuel burner having a fuel valve and a blower motor, comprising in combination, an electron discharge device having a heater therefor, first switch means operated upon a demand for burner operation, means including said first switch means adapted to complete an energizing electrical circuit to the blower motor and to said heater, second switch means actuated by said discharge device when said heater has been energized for a predetermined length of time, means including said second switch means adapted with said first switch means to energize the fuel valve and establish independently of said first switch means a further electrical circuit to the blower motor, said further electrical circuit remaining established for a length of time dependent on the cooling time of said heater after said first switch means is no longer operative to indicate a demand for burner operation.

2. Control apparatus for a fuel burner having a blower motor and a fuel valve comprising in combination, first relay means having a plurality of switch contacts adapted to be actuated on a demand for burner operation, means including said first relay means completing an energizing circuit to the blower motor on demand for heat, second relay means having a plurality of switch contacts, said second relay means being operated upon the presence of flame at the burner, timing means for completing an energizing circuit to the fuel valve a predetermined time after the blower motor operates, said timing means having a plurality of switch contacts, a safety cutout device which is effective when energized for a predetermined length of time to deenergize the burner, an energizing circuit for said first relay means including said safety cutout device and connections adapted to be completed by means indicative of the need for burner operation, a shunt circuit around said cutout device including a switch contact of said second relay means and a switch contact of said timing device when operated, and a further energizing circuit for said cutout device comprising said one switch of said second relay means when energized and a further switch of said timing means when deenergized.

3. Control apparatus for a fuel burner having ignition means, a blower motor and a fuel valve, comprising in combination, first relay means having a plurality of switch contacts adapted to be actuated on a demand for burner operation, means including said first relay means completing an energizing circuit to the blower motor and ignition means on demand for heat, second relay means having a plurality of switch contacts operated upon the ignition means being in condition to sustain combustion, first timing means for completing an energizing circuit to the fuel valve a predetermined time after the blower motor operates, said timing means having a plurality of switch contacts, second timing means for deenergizing the ignition means a predetermined time after said first timing means operates, a safety

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cutout device which is effective when energized for a predetermined length of time to deenergize the burner, an energizing circuit for said first relay means including said cutout device and a thermostat circuit adapted to be completed upon a demand for burner operation, a shunt circuit around said cutout device including a switch contact of said second relay means and a switch contact of said first timing means when operated, and a separate energizing circuit for said cutout device comprising said one switch of said second relay means when energized and a further switch of said first timing means when deenergized, said separate energizing circuit being effective to actuate said cutout device if maintained for a predetermined length of time.

4. A control for a fuel burner having igniting means, a fuel valve, and a blower motor, comprising in combination, first relay means adapted to be energized by means indicating a need for burner operation, means including said first relay means adapted to energize the blower motor and ignition means upon energization of said relay means, time delay relay means, flame detection relay means, a first circuit for connecting the fuel valve in an energizing circuit, said circuit comprising said first relay means when operated, a second circuit for connecting the fuel valve in an energizing circuit, said second circuit comprising said first relay means when operated and said flame detection means when indicating the presence of an igniting flame, a third circuit for connecting the fuel valve in an energizing circuit, said third circuit comprising said first relay means when operated, said time delay means when operated, and said flame detection means when indicating the presence of an igniting flame, and manually operable switching means for selecting one of said circuits.

5. A control for a fuel burner having igniting means, a fuel valve, and a blower motor, comprising in combination, first relay means adapted to be energized by means indicating a need for burner operation, means including said first relay means adapted to energize the blower motor and ignition means upon energization of said relay means, time delay relay means, flame detection relay means, a first circuit for connecting the fuel valve in an energizing circuit, said circuit comprising said first relay means when operated, a second circuit for connecting the fuel valve in an energizing circuit, said second circuit comprising said first relay means when operated, and said flame detecting means when indicating the presence of an igniting flame, a third circuit for connecting the fuel valve in an energizing circuit, said third circuit comprising said first relay means when operated, said time delay means when operated, and said flame detecting means when indicating the presence of an igniting flame, manually operable switching means for selecting one of said circuits, and means including said time delay means for rendering said igniting means inoperative a timed period following energization of said first relay means.

6. A control for a fuel burner having igniting means, a fuel valve, and a blower motor, comprising in combination, first relay means adapted to be energized by means indicating a need for burner operation, means including said first relay means adapted to energize the blower motor and igniting means upon energization of said relay means, time delay means, flame detection relay means, a first circuit for connecting the fuel valve in an energizing circuit, said circuit com-

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prising said first relay means when operated, a second circuit for connecting the fuel valve in an energizing circuit, said second circuit comprising said first relay means when operated and said flame detection means when indicating the presence of an igniting flame, a third circuit for connecting the fuel valve in an energizing circuit, said third circuit comprising said first relay means when operated, said time delay means when operated, and said flame detecting means when indicating the presence of an igniting flame, manually operable switching means for selecting one of said circuits, and means including said time delay means for maintaining only the blower motor energized for a timed period following the energization of said first relay means.

7. Control apparatus for a burner having igniting means and a fuel valve, comprising in combination, means including first switch means for energizing the igniting means upon a need for burner operation, a timing device comprising a pair of electron discharge devices, relay means in circuit with each of said discharge devices, an interconnecting circuit means including said first switch means for causing said discharge devices to operate said relays in a timed sequence following energization of said ignition means, means including one of said pair of discharge devices with its associated relay for energizing the fuel valve following a first time interval, and means including the other of said devices with its associated relay for deenergizing the igniting means a timed interval following energization of the fuel valve.

8. Control apparatus for a fuel burner having a blower motor, ignition means, and a fuel valve, comprising in combination, first switch means for energizing the blower motor and ignition means upon a need for burner operation, a first timing device, means including said first switch means for energizing said first timing device, said first timing device having a plurality of switch means, means including said first switch means and one of said plurality arranged to energize the fuel valve a timed period after the energizing of the blower motor and ignition means, and a second timing device for deenergizing the ignition means, said second timing device comprising another of said plurality of switch means operated by said first timing device and an electron discharge device, said other of said plurality of switch means controlling the energization of said discharge device, said second timing device including a further switch controlled by said discharge device, said further switch being in the ignition circuit to open the ignition circuit a predetermined time after said first timing means operates said other of said plurality of switch means.

9. Control apparatus for a fuel burner having a blower motor, ignition means, and a fuel valve, comprising in combination, means including first switch means for energizing the blower motor and ignition means upon a need for burner operation, a first timing device energized by means including said first switch means, said first timing device comprising an electron discharge device and a plurality of switches actuated thereby a timed period following energization and deenergization by said first switch means, means including one of said plurality of switches and said first switch means arranged to energize the fuel valve a timed period after energization of the blower motor, a second timing device for deenergizing the ignition means, said second

timing device comprising a control switch operated by said first timing means when energizing the fuel valve and a second electron discharge device which is energized a predetermined time after the operation of said control switch, and means including said second electron discharge device for controlling said further switch, said second electron discharge device controlling a further switch in the ignition circuit a predetermined time after said first timing means operates said control switch.

10. Burner control apparatus for a burner having an initiating sequence and a running sequence, comprising in combination, a control circuit for initiating burner operation arranged to be completed by means indicative of the need for burner operation, a safety cutout device for rendering the burner inoperative when energized for a predetermined length of time, said safety cutout device having an actuator normally energized upon completion of said control circuit, timing means for effecting a running condition of burner operation, said timing means having an energizing circuit therefor completed upon completion of said circuit control, combustion responsive means operative upon the presence of combustion at the burner, and means including switch contacts of said timing means and switch contacts of said responsive means to alter said control circuit to thereby render said device ineffective when both said timing means and said responsive means switch contacts are in an energizing position and to render said device effective upon either said timing means switch contacts or said responsive means switch contacts moving to a deenergized position while the other remains in the energized position.

11. Burner control apparatus for a burner having an initiating sequence and a running sequence, comprising in combination, a safety cutout device for rendering the burner inoperative when energized for a predetermined length of time, timing means including switch contacts for effecting a running condition of burner operation, combustion responsive means including switch contacts and operative upon the presence of combustion, means including relay means for initiating burner operation, a first energizing circuit for said cutout device, said circuit including said relay means when energized, means for shunting said cutout device comprising switch contacts of said timing means and said combustion responsive means when in an energized position, a second energizing circuit for said cutout device, said second circuit comprising switch contacts of said timing means when in a deenergized position and switch contacts of said responsive means when in the energized position.

12. Burner control apparatus having means for establishing an initiating period and a running period and having limit control switching apparatus associated therewith, comprising in combination, relay means for initiating burner operation, electronic timing means comprising a thermionic discharge device for effecting a running condition of burner operation, electronic flame detection means for ascertaining proper operation of the burner, said detection means comprising a thermionic discharge device, switching means controlled by said flame detection means and assuming a first or a second operative position depending upon the presence or absence of combustion at the burner, an initial energizing circuit for said relay including said flame detection switching means in said second operative po-

sition, a source of power for said relay means said timing means and said flame detection means comprising separate transformers, input power terminals for said apparatus, means directly connecting said transformers for said timing means and said detection means to said terminals, and circuit means for that transformer associated with said relay means adapted to be completed to said terminals through the limit control switching apparatus.

13. Burner control apparatus having limit control apparatus associated therewith, comprising in combination, first relay means for initiating burner operation, an electronic flame detector having an electron discharge device with a thermionic heater therefor, a second relay controlled by said discharge device, a source of power, a first circuit including said second relay when deenergized connecting said first relay means to said source of power and arranged to be completed by means indicative of a need for burner operation, a second circuit continuously connecting said flame detector to said source of power, and electrical terminals connected in series with said first circuit only arranged for connection to the limit control apparatus for rendering only said first relay means ineffective upon actuation of the limit control apparatus.

14. Burner control apparatus having limit control switching apparatus associated therewith, comprising in combination first relay means for initiating burner operation, said relay means having an energized and a deenergized condition, electronic flame detection means for ascertaining proper operation of the burner, said detection means comprising a thermionic discharge device having a heater therefor, second relay means controlled by said discharge device and assuming an energized or a deenergized condition dependent upon said detecting means detecting the presence or absence of combustion at the burner, safety cutout means having an actuator; transformer means comprising a first primary having a first secondary winding associated therewith and a second primary winding having a second secondary winding associated therewith, means connecting said second secondary winding to said flame detection means; input power terminals for said apparatus, means directly connecting said second primary winding to said input terminals, circuit means connecting said first primary winding to said power terminals and adapted to be completed through switch contacts of the limit control apparatus; an energizing circuit for said first relay means including said second relay means in said deenergized condition and arranged to be completed by means indicative of the need for burner operation, and a component checking energizing circuit for said safety cutout means actuator including said first relay means in said deenergized condition and said second relay means in said energized condition.

15. Burner control apparatus having limit control apparatus associated therewith, comprising in combination, first relay means for initiating burner operation when said relay means is energized, an electronic flame detector having an electron discharge device with a thermionic heater therefor, a second relay controlled by said discharge device to assume a first or a second position depending upon said detector detecting the presence or absence of combustion, terminals adapted to be connected to a source of power, a first and a second transformer each having a primary and a secondary winding, means includ-

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ing means adapted to be connected to the limit control apparatus connecting the primary of said first transformer to said terminals, a first circuit including said second relay when deenergized connecting the secondary of said first transformer to said first relay means and arranged to be completed by means indicative of a need for burner operation, a second circuit continuously connecting the primary of said second transformer to said terminals, and third circuit means connecting the secondary of said second transformer to said flame detector, said apparatus functioning to cause deenergization of the primary of said first transformer upon limit control operation and to maintain said electronic flame detector energized such that a fault within said flame detector will maintain said first circuit open circuited so long as said flame detector falsely detects flame.

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