

Sept. 16, 1952

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2,610,677

FUEL BURNER SAFETY CONTROL APPARATUS

Filed Aug. 23, 1948

2 SHEETS—SHEET 1

FIG. 1

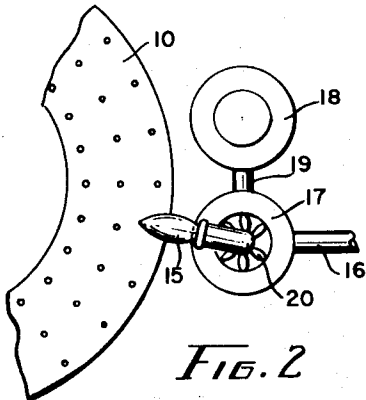
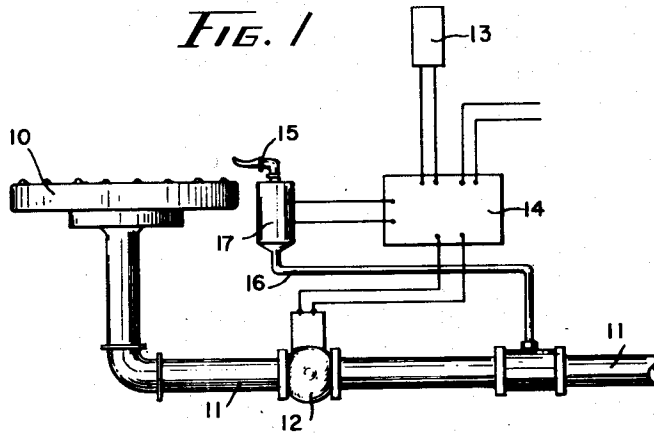


FIG. 2

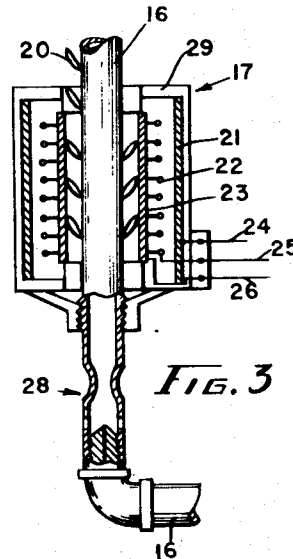


FIG. 3

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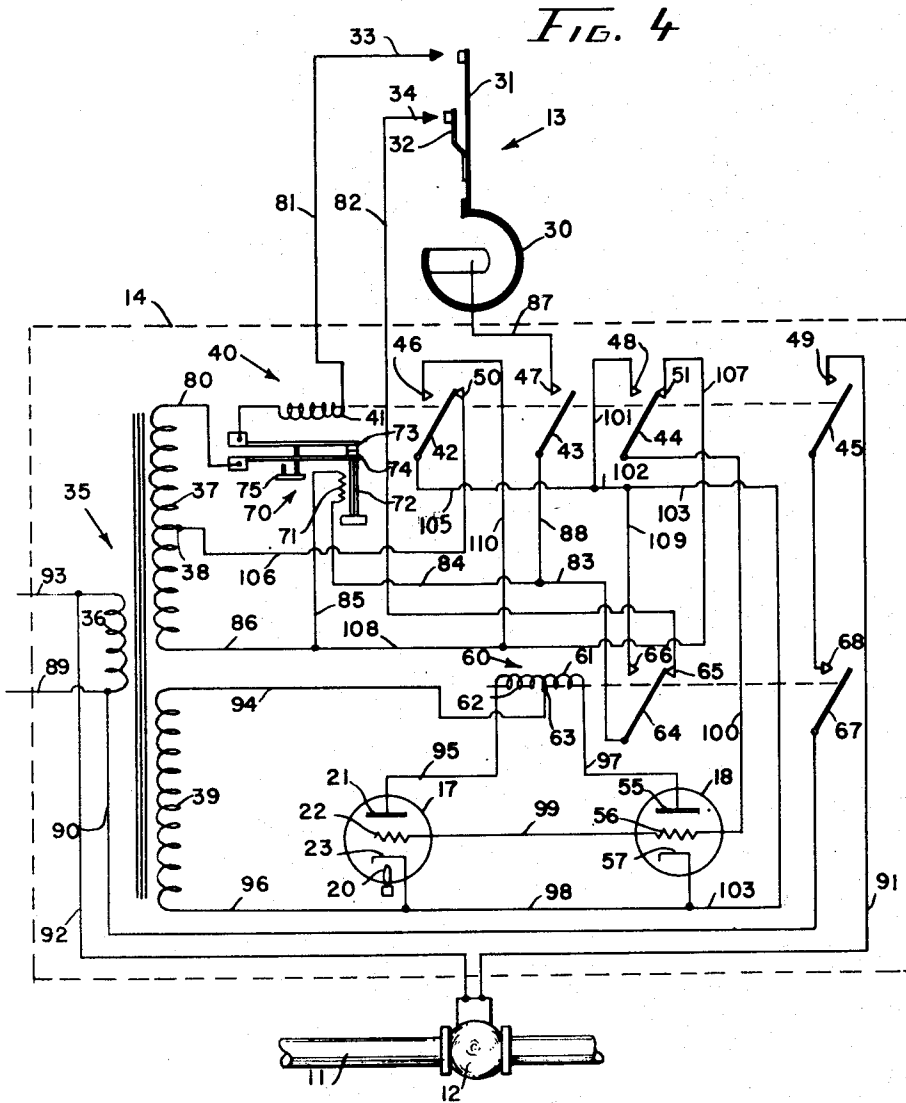
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FUEL BURNER SAFETY CONTROL APPARATUS

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2 SHEETS—SHEET 2



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UNITED STATES PATENT OFFICE

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FUEL BURNER SAFETY CONTROL
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9 Claims. (Cl. 158—123)

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The present invention is concerned with an improved type of electrical control for a fuel burner and more particularly for that type of fuel burner utilizing a gaseous fluid in its normal operation.

In present day fuel burner controls it is necessary that flame detectors be employed to detect the presence or absence of flame so that a control apparatus for a burner may be shut down in the absence of a flame to protect against the dangers of explosion that would occur if the burner continued to operate for a period after the flame has been extinguished. In the past, many of these flame detectors have been rather elaborate and expensive, particularly those of the electronic type which may require the use of a photocell or a pair of electrodes bridged by a flame to indicate the presence of a flame.

The present invention contemplates using an electron discharge device of the thermionic type as the flame detector of the subject control apparatus. The cathode of this discharge device is housed within an enclosure and is heated to be electron emissive by a flame that may be part of a main burner flame or part of a pilot flame and the cathode when so heated will allow the discharge device to conduct. This conduction may be used in any desired manner to indicate the presence of flame at the discharge device. While certain types of devices have proposed using a flame for heating a flame rod directly located in a flame to be electron emissive, these devices have not been able to stand up under long periods of operation as the heat and products of combustion cause rapid deterioration of any suitable electron emissive surface. Further, these devices when electron emissive have a current output so small as to be very difficult to detect and utilize. In the present invention the electron emissive portion of the cathode is in an enclosed housing substantially free of oxygen and at reduced pressure whereby it is possible to have long life on the cathode surface while still being able to handle a relatively large current flow from the cathode. With a discharge device of the type of the present invention, it is necessary to compensate for changes in the ambient temperature that may be in existence about the burner since the device of necessity must be located in the proximity of the burner.

It is therefore an object of the present invention to provide an improved burner control employing an enclosed electron discharge device of the type which has its cathode heated by a flame which is directly associated with the burner.

A further object of the present invention is to

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provide a burner control which employs an electron discharge device which senses the presence of flame on an electron emissive cathode and which is compensated for changes in the ambient temperature of the apparatus.

Still another object of the present invention is to provide an improved burner control apparatus which will indicate the presence or absence of flame and which will fail safe when there is a false indication of flame by the flame detection portion of the apparatus.

Another object of the present invention is to provide a burner control apparatus having an electron discharge device type of flame detector which has a control element which may be used to render the flame detector ineffective whenever there is no need for operation of the flame detector.

Another object of the present invention is to provide a burner control apparatus of the type employing an electron discharge device with a flame heated cathode and a control electrode which may be used to prevent the control apparatus from failing safe when there is no need for operation of the burner.

These and other objects of the present invention will be understood upon considering the accompanying specification, claims, and drawings of which:

Figure 1 is a diagrammatic layout of the present invention as it may be associated with a gas burner control;

Figure 2 is a showing of a plan view of the flame detection portion of the invention as it is associated with the main burner.

Figure 3 is a cross-sectional view of the flame detection portion of the invention with a pilot flame heating the cathode to be electron emissive; and

Figure 4 is the schematic layout of the complete system with which the invention is associated and which shows the manner in which the apparatus is electrically connected together in a complete system.

Referring now to Figure 1, the numeral 10 represents an appropriate gas burner. The gas for the burner is supplied through a conduit 11 in which is located an electrically operated shut-off valve. For indicating when there is a need for operation of the valve 12, a thermostatic device 13 may be used and this device is operative to control appropriate electrical controls located in a housing 14. These controls will cause opening of the valve 12 whenever there is an indication of the need for operation of the burner 10 by the thermostatic device 13. When the valve 12 is

opened, the gaseous fuel will flow to the burner where it will be ignited by a pilot flame 15, which pilot flame may be operating continuously or may be ignited by an igniter, not shown, when the valve 12 becomes operative. The supplying of gaseous fuel to the pilot flame is through a conduit 16 which, if the pilot is burning continuously, would be connected to the inlet side of the valve 12 on the conduit 11.

Detecting the presence of the pilot flame is a detection device 17, which is an electron discharge device of the thermionic type and which is concentrically mounted about the conduit 16. This flame detector is used to actuate further appropriate electrical circuits in housing 14 when the presence of a flame is detected. This operation of the flame detector may be used to shut the control apparatus down if there is no operation of the burner, or the pilot flame, in a manner that will fully be explained in the discussion that follows in conjunction with Figure 4.

In Figure 2, there is shown a plan view of the flame detection portion of the subject apparatus with a portion of the burner 10 and the pilot flame 15 emitting from the end of conduit 16. The detecting device 17 may be seen to be of a hollow cylindrical type of construction and to be concentrically mounted about the conduit 16.

A further discharge device is indicated at 18 and is attached to the device 17 by suitable connecting means 19. Both of the discharge devices 17 and 18 are of identical construction and are located equidistant from the burner 10 so that they will be exposed to the same ambient temperature. The detecting device 17 has its inner surface heated by a plurality of runner flames 20 which emit from the conduit 16 as it passes through the device 17.

Consideration of Figure 3 will give a further understanding of one manner in which the flame detecting device 17 may be constructed and associated with the pilot conduit 16. This figure shows that the device 17 includes an anode 21, which is located on or near the outer surface of the device 17 and is cylindrical in construction. Located in inner spaced relation to the anode 21 is a control electrode 22 which may be in the form of a grid and also will be cylindrical in construction. On the inner portion of the hollow cylindrical device is a cathode 23 which is adapted to be heated to be electron emissive by the runner flames that are emitting from the conduit 16 and are striking the inner surface of the cathode at a plurality of points. Each of the elements of this device 17 are insulatingly spaced within a housing 29 from each other by suitable spacing means. The housing is either evacuated or filled with a selected gas at a reduced pressure as is conventional in the art of electronic discharge tubes.

A plurality of electrical conductors 24, 25, 26 serve to electrically connect the anode, control electrode and cathode of the discharge device, respectively, to the control circuits of the subject apparatus.

Suitable supporting means for the discharge device 17 are indicated at 27 and may be threadedly engaging the conduit 16. A suitable air mixer is indicated generally at 28 on the conduit 16 and this serves to mix the proper amount of gas and air so that the combustion within the pilot flame and the runner flames on the cathode of the flame detector will be free of smoke to prevent smudging of the cathode sur-

face and slowing down its response to the presence or absence of flame.

As mentioned above, the discharge device 18 should be of the same type of construction as the device 17 so that their electrical characteristics for a given ambient temperature will be the same. This will mean that the device 18 will be of hollow cylindrical construction with its anode, control electrode and cathode disposed as are the corresponding elements in the device 17.

In Figure 4 there is shown a schematic view of how the subject apparatus may be connected to control the flow of fuel to a fuel burner. Here, it may be seen, as in Figure 1, that a thermostatic device 13 is employed to control appropriate circuits in the housing indicated by the numeral 14 and which controls in turn will be effective to energize and deenergize the electric valve 12 in accordance with the demand for burner operation indicated by the thermostatic device 13.

The thermostatic device 13 may be seen to consist of a bimetallic element 30 which is operative to move a part of switch blades 31 and 32 into and out of engagement with their associated switch contacts 33 and 34 respectively. The blades and contacts are adjusted so that there is sequential engagement of the contacts with the blade 31 engaging contact 33 at a time slightly before blade 32 engages contact 34. This switching arrangement eliminates any chattering tendencies of the control apparatus when the thermostatic device calls for operation of the burner. This will be more fully explained in considering the operation of the subject figure.

The controls located within the housing 14 have power supplied thereto by a power transformer 35 which consists of a primary winding 36, connected to any suitable source of power not shown, a secondary winding 37, which is tapped at 38, and a further secondary winding 39. Among the devices energized by this transformer is a relay 40 which consists of a relay winding 41, and switch blades 42, 43, 44 and 45 which are biased, by means not shown, out of engagement with their associated switch contacts 46, 47, 48 and 49 respectively. When the switch blades are in the biased or deenergized position, the blade 42 is engaging a switch contact 50 and the blade 44 is engaging a switch contact 51.

Also included in the housing 14 is the flame detection portion of the subject apparatus and this includes the flame detection discharge device 17, described in detail above, and the discharge device 18 which may be seen to consist of an anode 55, control electrode 56 and a cathode 57. It will be recalled that the cathode of the discharge device 18 does not have any extra heat applied thereto and is merely subjected to the ambient temperature common to both discharge devices 17 and 18.

Located in the plate circuits of the devices 17 and 18 is a relay 60 which has two relay windings, 61 and 62, which are connected in opposition and tapped at 63. When there is an equal amount of current flowing through both of the windings, a pair of switch blades 64 and 67 are biased, by means not shown, so that blade 64 is in engagement with a switch contact 65 and blade 67 is out of engagement with a contact 68. When the current flow in winding 62 is greater than that flowing in the winding 61, the blade 64 will be moved into engagement with a further

switch contact 65 and blade 67 will engage contact 68.

A safety cutout device is indicated at 70 and comprises a heater 71 which is operative when energized for a predetermined length of time to cause a bimetal 72 to warp to the right. When the bimetal 72 has warped a predetermined distance, a pair of switch contacts 73 and 74, which are supported on top of the bimetal, will separate and open an electrical circuit. The opening of this electrical circuit will prevent there being any further operation of the control apparatus or the burner until a reset actuator 75 is depressed, at which time the contacts 73 and 74 will close. This actuator 75 is so designed that the contacts 73 and 74 will not engage unless the bimetal has returned to its normal position. This will mean that if the heater 71 is still energized, it will be impossible to close the contacts 73 and 74 because the bimetal will remain in the warped position. On the other hand, if the heater is deenergized and the bimetal blade has cooled sufficiently, the bimetal will move back to its normal position and the contacts can be closed upon the subsequent depressing and releasing of the actuator 75.

Operation

In considering the operation of the subject apparatus it will be assumed that the apparatus as shown in Figure 4 is in the deenergized position with the thermostatic device 13 not calling for operation of the burner 10 or the electrically operated valve 12. If the space wherein is located the thermostatic device 13 should cool, the bimetallic element 30 will move the switch blades 31 and 32 into engagement with their associated switch contacts 33 and 34. As mentioned above, the engagement of these contacts is sequential with the switch blade 31 engaging switch contact slightly prior in time to the engaging of switch blade 32 with contact 34. With both of these contacts engaged an electrical energizing circuit for the relay 40 will be completed and this circuit may be traced from the upper terminal of the secondary 37, through a conductor 80, switch contacts 74 and 73, relay winding 41, conductor 81, switch contact 33, switch blade 31, switch blade 32, switch contact 34, conductor 82, switch contact 65, switch blade 64, conductors 83 and 84, heater 71, conductor 85, and conductor 86 to the lower terminal of the secondary 37. When this circuit is completed, the relay 40 will become energized and the switch blades 42, 43, 44 and 45 will move into engagement with their associated switch contacts 46, 47, 48 and 49. When the switch blade 43 engages switch contact 47 a holding circuit is established for the relay 40 which is independent of the switch blade 32 and switch contact 34 of the thermostatic device 13. This holding circuit prevents any chattering tendencies of the thermostatic device 13 occurring when the switch blade 32 first moves out of engagement with switch contact 34 from affecting relay 40. This holding or maintaining circuit may be traced from the upper terminal of the secondary 37 through conductor 80, switch contacts 74 and 73, relay winding 41, conductor 81, switch contact 33, switch blade 31, bimetal 30, conductor 87, switch contact 47, switch blade 43, conductor 88, conductor 84, heater 71, and conductors 85 and 86 to the lower terminal of the secondary 37.

It will be noted that the above last traced circuits for the relay 40 all included the heater 71

of the safety cutout device 70. If this heater remains energized for a predetermined length of time, the bimetal will warp to allow separation of the contacts 73 and 74. It is therefore desired that if there is proper operation of the pilot that the heater 71 be effectively deenergized and this is accomplished by the flame detection portion of the subject apparatus. If the pilot flame is present, there will be heat applied to the cathode 23 of the discharge device 17 and this cathode will be electron emissive. If it is electron emissive there will be an electron current flow between the cathode 23 and anode 21 of the discharge device 17 on alternate half cycles of the power supply secondary winding 39. The current flow circuit for this may be traced from the upper terminal of the secondary 39 through conductor 94, junction 63, winding 62, conductor 95, anode 21, cathode 23, and conductor 95 back to the lower terminal of the secondary 39. It will also be noted that the cathode 57 of the discharge device 18 may be electron emissive if the ambient temperature wherein are located the devices 17 and 18 is high enough. The current flow for this discharge device may be traced from the upper terminal of the secondary 39 through conductor 94, junction 63, winding 61, conductor 97, anode 55, cathode 57, and conductors 98 and 99 back to the lower terminal of the secondary 39. As long as the pilot flame is heating the cathode 23, this cathode will be hotter than the cathode 57 and therefore the discharge device 17 will be conducting more than the device 18.

As mentioned above, with a greater amount of current flowing through the relay winding 62 than is flowing through the winding 61, the switch blade 64 will move from engagement with switch contact 65 into engagement with contact 66 and switch blade 67 will engage switch contact 68. This current flow will exist only when there is a pilot flame on the cathode 23 and when the relay 40 is energized. When the relay 40 is in the energized position, the control electrodes of both devices 17 and 18 are connected to their respective cathodes by circuits that may be traced from the control electrode 22, and control electrode 56, which are directly tied together by a conductor 99, through a conductor 100, switch blade 44, switch contact 48, conductor 101, and conductors 102 and 103 to the respective cathodes 23 and 57. When the relay 40 is not energized, the control electrodes 22 and 56 are effectively connected to a negative point in the power source with respect to their cathodes 53 and 57. This is accomplished by phasing the secondary windings 37 and 39 so that both of their upper terminals are positive on the same half cycle and by further connecting the cathodes 23 and 57 to the tap 38 and the secondary 37 and connecting the control electrodes 22 and 56 to the lower terminal of the secondary 37. The circuits for the cathode connection may be traced from the cathodes 23 and 57 through conductor 103, conductor 102, conductor 105, switch blade 42, switch contact 50, and conductor 106 to tap 38 of secondary 37. The circuit for the control electrode connection may be traced from the control electrodes 22 and 56 through conductor 100, switch blade 44, switch contact 51, conductor 107, conductor 108, and conductor 86 to the lower terminal of the secondary 37. With this negative bias supplied to the control electrodes 22 and 56, neither of the discharge devices 17 nor 18 will be conductive and the switch blade 64 will be in the deenergized position. When the relay 40 becomes operative

upon the closing of the thermostatic device 13, this negative bias will be removed and the control electrodes will be effectively connected to the cathodes of the discharge devices. Therefore, when the pilot flame is heating the cathode 23 and the relay 40 is energized, the relay 60 will be operative to move the switch blade 64 into engagement with switch contact 66.

When the switch blade 64 engages switch contact 66, the heater 71 will be effectively short circuited from the energizing circuit of the relay 40 and this circuit may be traced from the upper terminal of the secondary 37 through conductor 80, switch contacts 74 and 73, relay winding 41, conductor 81, switch contact 33, switch blade 31, bimetal 30, conductor 87, switch contact 47, switch blade 43, conductor 88, conductor 83, switch blade 64, switch contact 66, conductor 109, conductor 102, conductor 105, switch blade 42, switch contact 46, conductor 110 and conductors 108 and 86 back to the lower terminal of the secondary 37.

When the switch blade 67 engages contact 68, with relay 40 energized, an electrical circuit will be completed to the main gas valve 12. This circuit may be traced from the input power line 89 through conductor 90, switch blade 67, switch contact 68, switch blade 45, switch contact 49, conductor 91, valve 12 and conductor 92 to the other input power line 93. With the opening of the main valve 12, the pilot flame will ignite the gas at the main burner. With this arrangement, the electrically operated valve 12 will not open until the apparatus has checked and proved the presence of a pilot flame.

The apparatus is now in its operating condition with the safety cutout device effectively deenergized and the thermostatic device 13 indicating a need for operation of the burner which operation is going on.

As soon as the burner has operated for a sufficient length of time, the thermostatic device 13 will indicate there is no further need for operation of the burner and this indication will be the opening of the electrical circuits through the thermostatic device. This will occur when the switch blade 31 moves out of engagement with switch contact 33 to open the holding circuit for the relay 40 so that this relay will now become deenergized and the switch blades 42, 43, 44 and 45 will all move out of engagement with their associated contacts 45, 47, 48 and 49. When the switch blade 45 moves out of engagement with switch contact 49 the energizing circuit to the electrically operated valve 12 will be broken and the valve will close to shut off the supply of fuel to the burner. When switch blades 42 and 44 move into engagement with their deenergized contacts 50 and 51 respectively, the control electrodes of the devices 17 and 18 are effectively negatively biased with respect to their cathodes so that the devices will be nonconducting and the relay 60 will become deenergized so that the switch blade 64 will move into engagement with switch contact 65 and blade 67 will move out of engagement with contact 68. The apparatus is now in condition for a further operating cycle upon the subsequent demand for further operation of the burner by the thermostatic device 13.

Operation on flame failure

Assume now that the apparatus as shown in Figure 4 is in the completely energized position

with the thermostatic device 13 calling for operation of the burner and with the flame detection device indicating the presence of a pilot flame. In the event that the supply of fuel in the conduit 11 should cease, or for any other reason, the burner or the pilot become inoperative, it is desired that the control apparatus be shut down so that the valve 12 will be closed to prevent this supplying of further fuel to the burner when the supply does return. With the extinguishing of the pilot flame 20 on the cathode 23, this cathode surface will no longer be electron emissive at a greater rate than that of the cathode 57 and therefore the current flow through the device 17 will be the same as the current flow through the device 18. With the current flow through both of these devices equal, the flux generated by the windings 61 and 62 of the relay 60 will be equal and opposite and therefore there will be no force from this relay winding to maintain the switch blades 64 and 67 in engagement with the contacts 66 and 68. This will mean that the switch blade 67 will open the electrical circuit to valve 12 and the same will become deenergized and the blade 64 will move into engagement with switch contact 65 and the short circuit around the heater 71 will be removed. The maintaining circuit for the relay 40 will again be traceable through the heater 71 and this circuit may be traced from the upper terminal of the secondary 37 through conductor 80, switch contacts 74 and 73, relay winding 41, conductor 81, switch contact 33, switch blade 31, bimetal 30, conductor 87, switch contact 47, switch blade 43, conductor 88, conductor 84, heater 71, and conductors 85 and 86 to the lower terminal of the secondary 37. If this energizing circuit is maintained for a sufficient length of time the bimetal 72 will warp toward the right and the contacts 73 and 74, normally supported on the top of the bimetal 72, will separate and their separation will cause the opening of the energizing circuit for the relay 40 and this relay will become deenergized. When the contacts 73 and 74 separate it also opens the energizing circuit for the heater 71 so that the bimetal 72 will cool and move back toward its normal position. Upon the subsequent depressing of the actuator 75, it will be possible to let the switch contacts 73 and 74 come back to rest on top of the bimetal 72 where they will close and will complete the electrical circuit for the control relay 40.

When the contacts 73 and 74 are again closed upon the depressing of the actuator 75 the relay 40 should be reenergized and in the event that the pilot flame is not established at the cathode 23, so that the relay 60 will move the blade 64 into contact with switch contact 66, the heater will once again warp the bimetal 72 toward the right so that the contacts 73 and 74 will separate. If flame is not established the apparatus will be again shut down.

It will be obvious that if there is no flame applied to the cathode 23, when the apparatus is brought into operation by the thermostat 13, the heater 71 will heat the bimetal 72 and cause the same to warp in the manner above described to shut the apparatus down.

As soon as the fault causing the nonappearance of flame at the burner is eliminated and the pilot flame once again appears on the cathode 23, the apparatus will operate in the manner explained above under the heading "Operation."

Operation upon false indication of flame

Assume now that the burner has been operating properly with both the control relay 40 and the flame detection relay 60 in the energized position. Upon the subsequent opening of the thermostatic device 13 and the deenergization of the relay 40, the discharge devices 17 and 18 will have their control electrodes biased negative with respect to their cathodes and there should be no further current flowing through these devices. In the event that there is some faulty operation in the flame detection device which is maintaining the relay 60 in a condition so that the switch blade 64 is engaging switch contact 65, it will be readily apparent that there is a false indication of flame or an indication of flame when there is no need for operation of the burner. With this faulty operation in existence, it is desired to shut the control apparatus down and this is accomplished by connecting the heater 71 in an energizing circuit to the secondary 27 so that it will be effective to cause the cutout device to render the apparatus inoperative. The energizing circuit for this heater, when there is a false indication of flame and when there is no need for operation of the burner, may be traced from the tap 38 of the secondary 27 through conductor 106, switch contact 50, switch blade 42, conductor 105, conductor 102, conductor 199, switch contact 65, switch blade 64, conductor 83, conductor 84, heater 71, conductor 85 and conductor 86 back to the lower terminal of the secondary 27. With the heater energized in the above traced circuit, the bimetal 72 will be warped to the right in the manner explained above so that the contacts 73 and 74 will separate. It will be noted that the separation of the contacts 73 and 74 will have no effect upon the energizing circuit for the heater 71 and this heater will be continuously energized to maintain the bimetal 72 in the warped position. This will mean that the subsequent depressing of the actuator 75 will have no effect upon the closing of the contacts 73 and 74 and it will be impossible to energize the relay 40 until the fault causing false operation of the relay 60 is removed.

As soon as the fault is removed, the relay 64 will move to the energized position where the blade 64 will engage contact 65. This will interrupt the energizing circuit to the heater 71 and the bimetal will now be allowed to cool back to its normal position where it will be possible to close the contacts 73 and 74 upon the subsequent depressing of the actuator 75.

As soon as the cutout contacts 73 and 74 are closed, it will be possible to initiate operation of the control apparatus and the burner in its normal operating cycle upon the subsequent closing or demand for operation of the thermostatic device 13.

Conclusion

From the foregoing it can be seen that I have provided a new and novel arrangement for detecting flame at a fuel burner by using a portion of the flame associated with the burner to heat a cathode of a thermionic discharge device to be electron emissive and have further provided an arrangement where this discharge device is rendered effective only when it is desired that the burner be in operation. It may also be seen that I have provided for ambient temperature compensation of the flame detection portion of the apparatus. There are many obvious modifi-

cations and changes suggested to those skilled in the art and therefore I intend to be limited solely by the scope of the appended claims in which I claim:

1. A flame detector and pilot burner assembly for use with a main burner comprising, a pilot burner normally having a flame emitting therefrom, a first electron emissive device having a thermoemissive surface and structurally related to said pilot burner so that said thermoemissive surface is normally heated by the pilot flame and at least a portion of said flame is exposed to serve as an ignition flame, a second electron emissive device having a thermoemissive surface and mechanically supported in close proximity to said first electron emissive device so that said first and said second devices are subjected to the same ambient temperature, a source of power, current responsive means for indicating the presence or absence of the pilot flame on said first of said devices, and means connecting said responsive means in circuit with said source of power and said first and second devices so that when said first of said devices does have the pilot flame applied thereto said responsive means will indicate the presence of flame and when said first of said devices does not have the pilot flame applied thereto said responsive means will not indicate the presence of the pilot flame regardless of the ambient temperature of said first and said second devices.

2. A flame detector and burner assembly comprising, a burner having a flame normally emitting therefrom when fuel is supplied thereto, a pair of electron emissive devices each of which has a thermoemissive surface and is adapted to be operative on the heating of said surface, one of said devices being mounted with respect to said burner such that its thermoemissive surface is adapted to be heated by a flame at said burner and the flame from said burner extends beyond said emissive surface, the other of said pair of electron emissive devices being mechanically supported in close proximity to said one of said devices so that the thermoemissive surface of each device is subjected to the same ambient temperature, a source of power, current responsive means for indicating the presence or absence of flame on said one of said pair, and means connecting said devices in a conductive circuit to said source through said responsive means, said conductive circuit being in current flow opposition through said responsive means so that when said devices have equal temperatures said responsive means will not indicate flame presence and when said one of said pair has a flame applied thereto said responsive means will indicate flame presence.

3. A flame detector and pilot burner assembly for use with a main fuel burner comprising, a pilot burner having a burner igniting flame normally emitting therefrom when fuel is supplied thereto, a pair of electron emissive devices each having a thermoemissive surface and each device being adapted to pass current when said emissive surface is heated, means mechanically supporting said devices in close proximity to each other so that the emissive surface of each device is subjected to the same ambient temperature, one of said devices being mounted with its thermoemissive surface in heat exchange relationship to said pilot burner so that at least a portion of said flame is exposed to serve as an igniting flame, current responsive means for indicat-

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ing the presence or absence of the pilot flame on said one of said devices, and means connecting said devices to said current responsive means in current flow opposition so that when the temperatures of said devices are equal said responsive means will not indicate flame presence and when said one of said devices is heated by said pilot flame said responsive means will indicate flame presence.

4. A flame detection and pilot burner assembly for use with a main fuel burner and a fuel burner control that will fail safe upon a failure of combustion, comprising, a source of power, a pilot burner having a burner igniting flame normally emitting therefrom when fuel is supplied thereto, a pair of discharge devices adapted to be operative on the presence of heat and each comprising an anode, cathode and control electrode, means mechanically supporting said devices in close proximity to each other so that the cathode of each device will be subjected to the same ambient temperature, one of said devices being mounted with its cathode in heat exchange relationship to said pilot burner so that said igniting flame will heat said cathode and extend beyond, means connecting the anodes and cathodes of said devices in an energizing circuit to said source of power, current responsive means in said last named connection for indicating the presence or absence of the pilot flame when the cathode of said one device is additionally heated by the pilot flame, said responsive means being adapted when the current flow therethrough is of a predetermined value due to the presence of a flame on the cathode of said one device to maintain the burner control operative whenever there is a demand for operation of the main fuel burner, and biasing means connected to the control electrodes of said devices to decrease the current flow through said devices and said responsive means below a value which is indicative of flame presence whenever there is no demand or need for operation of the main fuel burner.

5. A flame detection and burner assembly comprising, a burner adapted to normally have a flame emitting therefrom when fuel is supplied thereto, an electron emissive device, said device comprising an anode, cathode and control electrode and being adapted to pass current when said cathode is heated, means mechanically supporting said device so that its cathode is in heat exchange relationship with at least a portion of said flame of said burner and so that said flame extends beyond said cathode, a source of power, means connecting said device to said source of power in a current conductive circuit, current flow responsive means for indicating the presence or absence of said flame connected in said last named circuit to be energized in accordance with the current flow therethrough, and switching means having a first and a second position, said switching means effective when in said second position to connect said control electrode to a point on said source which is negative with respect to said cathode to thereby render the current flow through said device below a value which is indicative of the presence of flame and when in said first position connecting said control electrode to said source to thereby render the current flow through said device above said value if flame is present.

6. A flame detection and pilot burner assembly for use with a main fuel burner and a fuel burner control that will fail safe upon a failure of combustion or upon a false indication of flame and

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which includes a main control relay for energizing the main fuel burner, comprising, a pilot burner having a burner igniting flame normally emitting therefrom when fuel is supplied thereto, a pair of electron emissive devices having an anode, cathode and control electrode, each of said devices adapted to pass current when said cathode is heated, means supporting said devices in close proximity to each other so that the cathode of each device is subjected to the same ambient temperature, one of said devices being mounted with its cathode in heat conducting relationship to a portion of said igniting flame from said pilot burner with a portion of said flame exposed as an igniting flame, a source of power, means connecting said devices to said source of power in an operating circuit, current responsive means connected between said devices and said source of power for indicating the pilot flame only when the pilot flame is heating the cathode of said one of said devices more than the ambient temperature surrounding said devices is heating both of said devices, and means including switching means adapted to be controlled by said control relay for connecting said control electrodes of said devices to be biased negatively with respect to their respective cathodes when said control relay is not energizing the main fuel burner to maintain the current flow through said devices below a flame indicating value so that the continued application of the pilot flame to said cathode of said one device will not cause said responsive means to indicate flame presence.

7. Burner control apparatus comprising in combination, a fuel burner, a source of power, an electron emissive device, said device comprising an anode, a cathode and a control element, a pilot burner having a pilot flame normally emitting therefrom, said pilot burner being so positioned that said cathode is heated by said pilot flame and so that said pilot flame is exposed to ignite said fuel burner when fuel is supplied thereto, current responsive means for indicating the presence of said pilot flame when there is a demand for operation of said fuel burner, means connecting said device through said current responsive means to said source of power so that when said pilot flame is heating said cathode said responsive means will indicate the presence of said pilot flame, and circuit means connected to said control element for rendering said device ineffective whenever there is no demand for operation of said fuel burner and therefore no need for indicating the presence of the pilot flame.

8. Burner control apparatus comprising in a pilot burner having a pilot flame normally emitting therefrom to provide an igniting means for said fuel burner, a pair of electron emissive devices adapted to be operative on the presence of heat and each comprising an anode and cathode, means disposing said devices in equal heat exchange relation to said burner with the cathode of one of said devices being heated by said pilot flame, means connecting the anode and cathode of said devices in an energizing circuit to said source of power, current responsive means in said last named connection and adapted to be operative only when the current flow through said device with the pilot flame heated cathode is greater than the current flow from the other of said devices to indicate the presence of said pilot flame.

9. Burner control apparatus comprising in

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combination, a fuel burner, a pilot burner having a pilot flame normally emitting therefrom to provide an ignition means for said fuel burner, a source of power, a pair of electron emissive devices adapted to be operative on the presence of heat and each comprising an anode, cathode and control element, means locating said devices in equal heat exchange relation to said burner with the cathode of one of said devices normally being heated by said pilot flame, means connecting the anodes and cathodes of said devices in an energizing circuit to said source of power, current responsive means in said last named connection and adapted to be operative only when the current flow through said devices with the pilot flame heated cathode is greater than the current flow from the other of said devices to indicate the presence of said pilot flame, and biasing means connecting said control elements of said devices to render said devices and said responsive means operative or inoperative whenever there is need or is no need, respectively, for operation of said fuel burner.

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