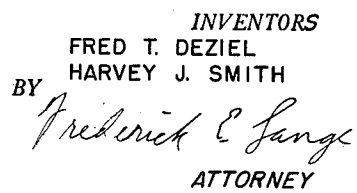


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FLAME DETECTOR

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The present invention is concerned with a flame detector and more particularly with an electronic type flame detector utilizing means for checking the proper operation of the flame detector.

Electronic flame detectors have found wide acceptance in both domestic and commercial use. They are of particular utility in the case of large commercial fuel burners which discharge a large quantity of fuel into the fire box per unit time. The electronic flame detector has the characteristic of detecting the presence or absence of flame in a very short time and therefore in the case of a flame failure the supply of fuel to the fire box is cut off before a dangerous amount of fuel is pumped into the fire box.

However, as with all electronic devices, the device is subject to malfunction in the case of a failure of one or more of the various components of the device. In the case of an electronic flame detector these failures can be either of a safe or of an unsafe nature.

A safe failure is the type of failure wherein the electronic flame detector fails in a condition to indicate that there is no flame present when in fact a flame may actually be present at the burner. This failure, while being undesirable, would have the effect of turning off the supply of fuel and therefore it is called a safe failure.

An unsafe failure is that type of failure wherein the flame detector continues to indicate a flame at the fuel burner independent of whether or not a flame exists at the burner. In this type of failure, fuel is continuously supplied to the fire box and if the flame is extinguished an explosion may occur on reignition. For this reason it is called an unsafe failure.

Prior electronic burner controls have utilized what is called a component checking arrangement wherein the ability of the electronic flame detector to operate properly is checked during the standby condition of the burner. That is, the prior electronic burner controls provided means whereby a safety switch would be actuated if at the end of a call for operation of the fuel burner the flame detector did not indicate that the flame had been extinguished at the fuel burner. However, once there is a call for heat and a flame is established at the burner the flame detector continuously indicates the presence of flame and it is possible for an unsafe failure to occur at this time. If such an unsafe failure did occur and if the flame then goes out the flame detector would be unable to sense the absence of flame and an explosion may occur on reignition.

It is an object of the present invention to provide an improved flame detector wherein the flame detector is continuously checked during the running period of the burner and this checking is facilitated by means of an electrical feedback arrangement utilizing a gaseous discharge bulb to control the voltage applied to an electrically operable flame sensor.

It is a further object of the present invention to provide an electronic flame detector utilizing an electrically

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operable flame sensor whose supply voltage is controlled in a cyclic manner once flame has been sensed by the flame sensor, with the supply voltage cycling in such a manner as to render the flame sensor alternately sensitive and then insensitive to the presence of flame, and means responsive to the condition wherein the flame sensor cyclically senses the presence of flame and then the simulated absence of flame.

It is still a further object of the present invention to provide an improved flame detector having an electrically operable flame sensor controlling the conduction of a first electron discharge device, having a second electron discharge device to control the operating voltage of the flame sensor to cause the flame sensor to be rendered insensitive to flame when the second discharge device is in a conducting state, and having an electrical feedback means including a gas tube connecting the output of the first discharge device to the input of the second discharge device to render the second discharge device conductive when flame is detected by the flame sensor.

These and other objects of the present invention will be apparent to those skilled in the art upon reference to the following specification, claims and drawings of which:

The single figure is a schematic representation of the present invention.

Referring to the single figure, the reference numeral 10 designates a burner unit having a main burner 11, a main burner valve 12, a pilot burner 13, and a pilot burner valve 14. Associated with the pilot burner 13 is an ignition transformer 15 which is arranged to ignite the gas flowing from the pilot burner 13. The pilot burner 13 is associated with the main burner 11 in a manner to ignite the gas flowing from the main burner 11.

A photocell or electrically operable flame sensor 16 is positioned relative to the burners 11 and 13 to sense the flame present at the burners. Photocell 16 has been shown as the photoemissive type having an anode 74 and a cathode 73.

The reference numeral 17 designates a thermostat which is located in the space to be heated by the burner unit 10. Thermostat 17 closes an energizing circuit for a relay 18 and a heater 90 of safety cutoff device 91 upon a need for operation of the burner unit 10.

Safety cutoff device 91 includes a heater 90, a bimetal element 92, normally closed switch 93, and manually operable reset button 94. Device 91 functions such that after a predetermined time period of energization of heater 90 the bimetal 92 warps to the right and causes switch 93 to be opened. When bimetal 92 has cooled, switch 93 can be reset by depressing button 94.

The relay 18 has a winding 19 which is energized from the secondary 20 of a transformer 21 having a primary 22 connected directly to power line conductors 23 and 24, which conductors are connected to a source of alternating current voltage, not shown.

The relay 18 also includes a switch blade 25 and a stationary contact 26. Relay 18 is shown in its deenergized position wherein the switch blade 25 is biased, by means, not shown, to disengaged contact 26. Upon energization of relay 18 the switch blade 25 moves into engagement with contact 26.

The reference numeral 27 designates a transformer having a primary winding 28, which is connected to power line conductors 23 and 24, and having a secondary winding 29 and a secondary winding 30.

Secondary 29 is connected to an electrical network including electron discharge devices 31 and 32. Discharge device 31 has an anode 33, a control electrode 34, a cathode 35, and a filament heater 36. The discharge device 32 has an anode 37, a control electrode 38, a cathode 39, and a filament heater 40. The filament heaters 36 and

40 of discharge devices 31 and 32 are connected to receive energizing voltage from the secondary 30 of transformer 27, the connections being omitted from the drawing.

Also included in the electrical network connected to secondary 29 is a relay 41 having a winding 42, which is shunted by a capacitor 43, and having a movable switch blade 44 and contacts 45 and 46. Relay 41 is shown in the energized condition wherein the switch blade 44 engages contact 45. Upon relay 41 being de-energized the switch blade 44 is biased, by means not shown, to disengage contact 45 and to move into engagement with contact 46.

The reference numeral 47 designates a neon bulb, or gas tube, which connects the anode 33 of discharge device 31 to the control electrode 38 of discharge device 32.

Switch blade 44 and contacts 45 and 46 of relay 41 are connected in a further electrical network which includes a direct current voltage source 101, a capacitor 48, a capacitor 49, and a relay 50. Relay 50 is of the type having a long dropout time and may be one of several conventional relays having this characteristic. For example, relay 50 may be of the type having a slugged core to provide for long dropout timing of the relay. The relay 50 includes a winding 51, movable switch blades 52 and 95, and stationary contacts 53 and 96. The relay 50 is shown in the de-energized condition wherein movable switch blades 52 and 95 are biased, by means not shown, to be out of engagement with contacts 53 and 96 respectively. Upon energization of relay 50 switch blades 52 and 95 move into engagement with stationary contacts 53 and 96.

The apparatus of the present invention is shown in the standby condition. That is, the primary windings 22 and 28 of transformers 21 and 27 are energized, the thermostat 17 is in the condition indicating no need for operation of the burner unit 10, the relay 41 is energized, the relay 50 is de-energized, the relay 18 is de-energized, and there is no flame present at the burners 11 or 13.

With the apparatus in the standby condition the electron discharge device 31 is in a conducting state and the electron discharge device 32 is substantially cut off. This can be seen by tracing the current flow circuit for discharge device 31 from the right-hand terminal of secondary 29 through conductor 60, winding 42, conductor 61, anode 33 and cathode 35, and conductor 62 to the left-hand terminal of secondary 29. This current flow circuit causes a voltage of the polarity indicated to exist across capacitor 43.

When the voltage across capacitor 43 reaches a given value the neon bulb 47 fires to cause a capacitor 63 to be charged to the polarity indicated. This charging circuit can be traced from the upper terminal of capacitor 43 through conductor 60, conductor 64, conductor 65, conductor 100, capacitor 63, and neon bulb 47 to the lower terminal of capacitor 43. The voltage present across capacitor 63 causes the discharge device 32 to be biased substantially to cutoff. A resistor 66 is connected across the capacitor 63 to control the discharge timing of the capacitor 63, as will be described.

The photocell 16 is an electrically operable flame sensor which is sensitive to flame when a sufficient voltage is applied thereto to render the photocell operative. The operating supply voltage for photocell 16 is derived from secondary 29 through a circuit which can be traced from the right-hand terminal of secondary 29 through conductor 64, ground connection 67, ground connection 68, photocell 16, conductor 69, resistor 70 shunted by capacitor 71, resistor 72, and conductor 62 to the left-hand terminal of secondary 29. Current flows in this above traced circuit only when the voltage of secondary 29 is in the half-cycle wherein the anode 74 is positive with respect to the cathode 73 and then only when flame is present at the burner 11 or 13. When current does flow in this circuit the capacitor 71 is charged to the polarity

indicated and substantially cuts off current flowing through the discharge device 31 to thereby cause relay 41 to be deenergized.

Upon the thermostat 17 indicating a need for operation of the burner unit 10, the energizing circuit for heater 98 and for the winding 19 of relay 18 is completed causing switch blade 25 to engage contact 26. This completes an energizing circuit for the pilot valve 14 and the ignition transformer 15. This circuit can be traced from the power line conductor 24 through switch blade 25, contact 26, conductor 30, conductor 82, pilot valve 14 connected in parallel with ignition transformer 15, and conductor 83 to the power line conductor 23.

With the energization of pilot valve 14, gas flows to the pilot burner 13 and is ignited by the ignition transformer 15. The photocell 16 has an operative voltage applied thereto at this time and is subjected to the flame present at the pilot burner 13. Therefore, a current flows through the above traced circuit charging capacitor 71. This current is a pulsating current and flows on the half cycle of the alternating current source during which the left-hand terminal of the secondary 29 is positive. After a few cycles of the alternating current source the capacitor 71 is charged to the voltage shown and causes the discharge device 31 to be substantially cut off.

With the discharge device 31 cut off the voltage which exists across capacitor 43 leaks off through the winding 42 of relay 41. After a short period of time, relay 41 is de-energized.

At the same time that the voltage across capacitor 43 is being reduced due to the current flow through the winding 42 of relay 41, the neon bulb 47 is extinguished due to the fact that the voltage on capacitor 43 is substantially reduced. The voltage on capacitor 63 can now leak off through the resistor 66.

After a short period of time the charge on capacitor 63 is substantially reduced and the discharge device 32 is rendered conductive. The conduction circuit for this discharge device can be traced from the left-hand terminal of secondary 29 through conductor 62, resistor 72, conductor 84, anode 37, cathode 39, conductor 65, and conductor 64 to the right-hand terminal of secondary 29. From this circuit it can be seen that current flows through the discharge device 32 during the same portion of the alternating current voltage cycle in which current flows through the photocell 16. Namely, when the left-hand terminal of secondary 29 is positive, the current conducted by the discharge device 32 is of a relatively high magnitude and causes substantially all of the voltage of secondary 29 to be dropped across the resistor 72. This causes an appreciable reduction in the voltage applied to the anode 74 and cathode 73 of photocell 16 and thereby renders the photocell 16 inoperative to sense the flame at the pilot burner 13.

Therefore, a current no longer flows to charge the capacitor 71 and after a short period of time the discharge device 31 is again rendered conductive to energize the winding 42 of relay 41.

The conduction of discharge device 31 again causes a voltage to appear across capacitor 43 which has the effect of again rendering the discharge device 32 nonconductive. This in turn once again causes an operative voltage to be applied to the electrodes of the photocell 16 and the photocell 16 is once again rendered operative to sense the flame at the pilot burner 13.

The above explanation has traced a single cycle of the apparatus wherein the photocell 16 senses a flame to render the discharge device 31 nonconductive, the voltage across capacitor 43 is dissipated to render the discharge device 32 conductive, the conduction of discharge device 32 through resistor 72 renders the photocell 16 insensitive to the presence of flame, the discharge device 31 is again rendered conductive to charge capacitor 43 and the discharge device 32 is again rendered nonconduc-

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tive to once again render the photocell 16 sensitive to the presence of flame.

From this it can be seen that relay winding 42 is cyclically energized and then de-energized so long as the photocell 16 continues to sense the presence of flame when an operative voltage is applied thereto and to give an indication of the absence of flame when the voltage applied thereto is of a magnitude to render the photocell 16 inoperative to sense the flame.

If any of the components associated with the discharge devices 31 or 32, or the discharge devices themselves, fail, the winding 42 of relay 41 cannot be cyclically energized and will either be continuously maintained energized or continuously maintained de-energized. For example, if a cathode-to-anode short occurs in the discharge device 31 the relay 41 will be maintained continuously energized. As a further example, if the cathode 39 of discharge device 32 loses its electron emitting properties the relay 41 will be continuously energized in the absence of flame and will be continuously de-energized in the presence of flame.

Energization of relay 50 depends upon the cyclic energization of relay 41 as will now be described. When relay 41 is in the energized condition the switch blade 44 is connected to contact 45 and capacitor 49 is charged from the direct current voltage source 101. When relay 41 is de-energized the switch blade 44 engages contact 46 and transfers the charged capacitor 49 to the winding 51 of relay 50. The capacitor 49 therefore dissipates its charge causing a current to flow through the winding 51 and causing relay 50 to be energized.

With relay 41 cycling, the capacitor 49 is alternately charged from the direct current voltage source 101 and then discharged through the winding 51. Since relay 50 has a long dropout timing the switch blades 52 and 95 remain in contact with contacts 53 and 96 during the period of time during which capacitor 49 is being charged from direct current source 101.

The explanation of the apparatus thus far has shown how a flame is established at the pilot burner 13 and how the photocell 16, in conjunction with the discharge devices 31 and 32 and the associated components, causes the relay 41 to cycle between the energized and de-energized positions and thereby causes the relay 50 to be energized to cause switch blades 52 and 95 to engage contacts 53 and 96.

When switch blade 52 engages contact 53 an energizing circuit is completed for the main burner valve 12. This circuit can be traced from power line conductor 24 through switch blade 25, stationary contact 26, conductor 80, contact 53, switch blade 52, conductor 85, main burner valve 12, conductor 86, and conductor 83 to the power line conductor 23. With energization of the main burner valve 12 the gas flows to the main burner 11 and is ignited.

When switch blade 95 engages contact 96 a circuit is completed to shunt heater 90 of cutout device 91 and thereby prevent switch 93 from opening.

So long as there is a call for operation of the burner unit 10, by the thermostat 17, the relay 41 continues to cycle in response to the cyclic manner in which the photocell 16 is first rendered operative and then inoperative to sense the presence of flame. So long as this cyclic action of relay 41 continues the relay 50 will remain energized to cause gas to be continuously supplied to the main burner 11. It can therefore be seen that the present invention provides for a continuous checking of the operativeness of the flame detector by requiring the flame detector to first sense the presence of the flame and then to sense a simulated absence of flame which is caused by applying a reduced voltage to the electrodes of the photocell 16 to render the photocell 16 inoperative.

When the thermostat 17 is satisfied the relay 18 is de-energized to turn off the valves 12 and 14 and the ignition

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transformer 15. The apparatus then returns to the standby condition shown.

From the above description, it can be seen that an improved flame detector has been provided wherein means is provided to check the operability of the flame detector.

Modifications of the present invention will be apparent to those skilled in the art and it is intended that the scope of the present invention be limited solely by the appended claims.

We claim as our invention:

1. A condition detector for detecting a given condition comprising: an electrically operable condition sensor, a source of voltage, impedance means, means connecting said condition sensor and said impedance means to said source of voltage to apply an operating voltage to said condition sensor, means controlled by said condition sensor, an electron discharge device having an anode and cathode and a control electrode, means connecting said discharge device anode and cathode in series with said impedance means to said source of voltage to cause a voltage drop to exist across said impedance means when said discharge device is conductive to thereby control the magnitude of the condition sensor operating voltage, and a gas tube connected from said means controlled by said condition sensor to said control electrode to render said discharge device nonconductive in the absence of the given condition.

2. Flame detector comprising: a source of voltage, a first electron discharge device having an anode, a cathode and a control electrode, a relay having a winding and switch means, means connecting said first discharge device anode and cathode in series with said relay winding to said source of power to energize said winding when said first discharge device is conductive, an electrically operable flame sensor connected to said source of voltage and connected in controlling relation to said first discharge device control electrode to cause said first discharge device to normally be conductive in the absence of flame and nonconductive in the presence of flame, means including a gas tube connected to said relay winding and connected to control the voltage applied to said flame sensor to render said flame sensor inoperative to sense flame when the voltage across said relay winding is insufficient to break down said gas tube to thereby cause said relay switch means to cycle when said flame sensor is subjected to a flame, and means responsive to continuous cycling of said relay switch means.

3. Flame detector comprising: a source of voltage, an electrically operable flame sensor, a voltage dropping impedance, means connecting said flame sensor and impedance in series to said source of voltage to apply an operating voltage to said flame sensor, a first controllable conducting device connected to said source of voltage, means connecting said flame sensor in controlling relationship to said first conducting device to cause said first conducting device to normally be conductive in the absence and nonconductive in the presence of flame, a further controllable conducting device, means connecting said further conducting device in series with said impedance to said source of voltage to cause substantially all of the voltage of said source of voltage to be dropped across said impedance when said further conducting device is conductive to thereby cause a low voltage to be applied to said flame sensor to render said flame sensor inoperative, circuit means connecting said first conducting device in controlling relation to said further conducting device to render said further conducting device nonconductive in the absence of flame to thereby cause a high voltage to be applied to said flame sensor to render said flame sensor operative, and means operative in response to a cyclic state of con-

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duction and nonconduction of said first conduction device.

4. A condition detector for detecting a given condition comprising: a source of voltage, an electrically operable condition sensor, voltage dropping impedance means, circuit means connecting said condition sensor in series with said impedance means to said source of voltage, a controllable current conducting device, means connecting said conducting device in series with said impedance means to said source of voltage, said conducting device when conducting causing a voltage drop across said impedance means to render said condition sensor inoperative to sense the given condition, means controlled by said condition sensor and effective to cause said conducting device to conduct current only when said condition sensor is subjected to the given condition, and means responsive to and operative upon cyclic periods of said condition sensor sensing the given condition followed by a period of said condition sensor sensing a simulated absence of the given condition due to said condition sensor being rendered inoperative.

5. A flame detector comprising: a source of alternating current voltage having a first and a second terminal, a relay having a winding and switch means, a first electron discharge device having an anode, a cathode and a control electrode, means connecting said first discharge device cathode to the first terminal of said source of voltage; means connecting said first discharge device anode through said relay winding to the second terminal of said source of voltage; an electrical flame sensor, voltage dropping impedance means, means connecting said flame sensor to said source of voltage through said impedance means, means connecting said flame sensor in controlling relation to the first discharge device control electrode to render said first discharge device nonconductive when said flame sensor both has an operative voltage applied thereto and is subjected to a flame; a second electron discharge device having an anode, a cathode and a control electrode, means connecting said second discharge device cathode to the second terminal of said source of voltage, means connecting said second discharge device anode to the first terminal of said source of voltage through said impedance means, voltage responsive means connected to said relay winding and to said second discharge device control electrode and effective to cause said second discharge device to be conductive when said first discharge device is nonconductive to thereby cause a voltage drop across said impedance means to cause an inoperative voltage to be applied to said flame sensor; and means responsive to continuous cycling of said relay switch means.

6. A flame detector comprising: a source of alternating current voltage having a first and a second terminal, a relay having a winding and switch means, a first electron discharge device having an anode, a cathode and a control electrode, means connecting said first discharge device cathode to the first terminal of said source of voltage; means connecting said first discharge device anode through said relay winding to the second terminal

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of said source of voltage; an electrical flame sensor, voltage dropping impedance means, means connecting said flame sensor to said source of voltage through said impedance means, means connecting said flame sensor in controlling relation to the first discharge device control electrode to render said first discharge device nonconductive when said flame sensor both has an operative voltage applied thereto and is subjected to a flame; a second electron discharge device having an anode, a cathode and a control electrode, means connecting said second discharge device cathode to the second terminal of said source of voltage, means connecting said second discharge device anode to the first terminal of said source of voltage through said impedance means, voltage responsive means connected to said relay winding and to said second discharge device control electrode and effective to cause said second discharge device to be conductive when said first discharge device is nonconductive to thereby cause a voltage drop across said impedance means to cause an inoperative voltage to be applied to said flame sensor; a source of direct current voltage, a capacitor, a long dropout time relay having an actuator, and circuit means controlled by said relay switch means to cyclically connect said capacitor to said source of direct current voltage and then connect said capacitor to the actuator of said long dropout time relay in response to cycling of said relay switch means.

7. A condition detector comprising: a first electron discharge device having an input and an output, an electrically operable condition sensor, means connecting said condition sensor to the input of said first discharge device in a manner to control the conduction of said first discharge device, a second electron discharge device having an input and an output, means connecting the output of said first discharge device to the input of said second discharge device to control the conduction of said second discharge device, and means including the output of said second discharge device to control the operativeness of said condition sensor to render said condition sensor cyclically operative and then inoperative upon said condition sensor being subjected to a condition to be detected.

8. A flame detector comprising: a first electron discharge device having an input and an output, an electrically operable flame sensor, means connecting said flame sensor to the input of said first discharge device in a manner to control the conduction of said first discharge device, a second electron discharge device having an input and an output, means connecting the output of said first discharge device to the input of said second discharge device to control the conduction of said second discharge device, means including the output of said second discharge device to control the operativeness of said flame sensor to render said flame sensor cyclically operative and then inoperative upon said flame sensor being subjected to a flame, and means responsive to and operative upon said flame sensor cyclically sensing flame when operative and then sensing the absence of flame when inoperative.

No references cited.