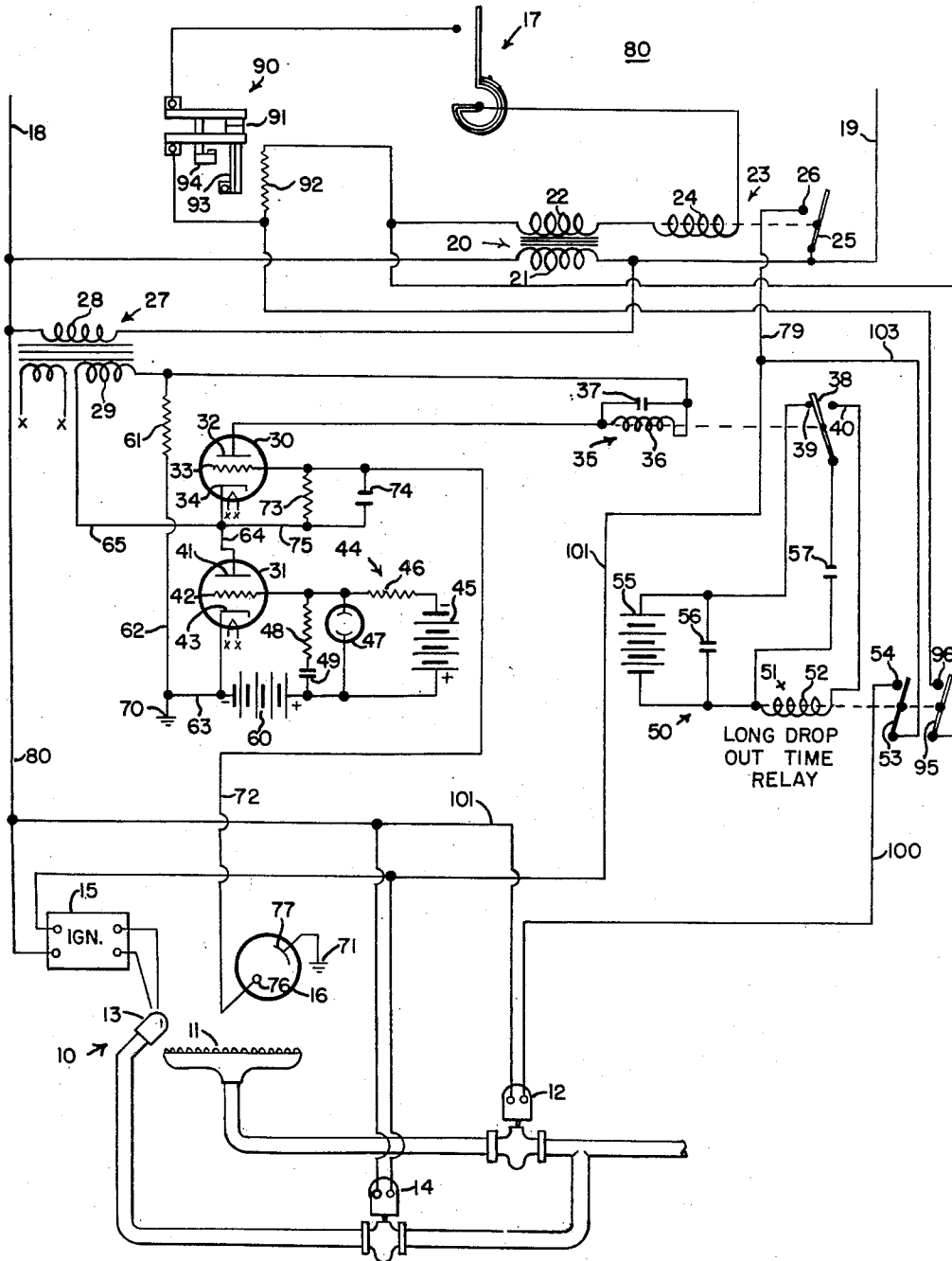


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FLAME DETECTOR

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

Electronic flame detectors have found wide acceptance and are particularly adapted for use with large fuel burners which discharge a large quantity of fuel per unit time. The electronic flame detector has the property 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 once the fire has been extinguished.

However, as with all electronic devices, the flame detector is subject to malfunction in the case of a failure of one or more of the various components of the unit. These failures can be either of a safe or an unsafe nature. A safe failure is a failure wherein the electronic flame detector fails in a condition indicative of no flame. 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 a failure wherein the flame detector continues to indicate a flame when a flame may actually have been extinguished. In this case the fuel is continuously supplied to the fire box and, if there is a flame failure, an explosion will in all probability occur. 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, during the period when a flame is not present at the burner. However, once a flame is established at the burner the flame detector continuously indicates the presence of flame and it is possible for the flame detector to have an unsafe failure. If an unsafe failure occurs at this time the flame detector cannot sense a subsequent flame failure.

It is an object of the present invention to provide an improved flame detector wherein an electronic flame detector is continuously checked during the running period of the burner and this checking is facilitated by means of an electronic oscillator which controls 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 operable flame sensor whose supply voltage is controlled in a cyclic manner by means of a relaxation oscillator to cause the flame sensor to be repetitively operative and then inoperative, and means are provided to be responsive to the sensing of flame by the flame sensor only when the voltage on the flame sensor is such as to render it operative.

It is still a further object of the present invention to provide an improved flame detector having an electrically operable flame sensor whose supply voltage is controlled by a first electron discharge device and a relaxation oscillator to cause the flame sensor to be repetitively opera-

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tive and then inoperative to sense a flame, a second electron discharge device controlled to have its conductance varied in a cyclic manner by the flame sensor, having a relay winding connected in circuit with the second discharge device, and having a capacitor and a second relay with the capacitor being cyclically charged from a voltage source and then discharged into the winding of the second relay in response to the cycling of the first relay.

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 fuel burner unit having a main burner 11, a main valve 12, a pilot burner 13, a pilot valve 14, and an ignition transformer 15 associated with the pilot burner 13. Also associated with the fuel burner unit 10 is an electrically operable flame sensor 16, which has been shown as a photoemissive type photocell having an anode 76 and a cathode 77, with the cell positioned to view a flame at the burners 11 and 13.

Operation of the burner unit 10 is controlled by a thermostat 17 which is located in the space to be heated by operation of the burner unit 10.

The present invention consists of an improved flame detector which connects to the photocell 16. Electrical power is supplied to the improved flame detector from power line conductors 18 and 19. A transformer 20 having a primary winding 21 and a secondary winding 22 is arranged with the primary winding 21 connected from power line conductor 18 to power line conductor 19.

Thermostat 17 controls the supply of voltage to a relay 23 having a winding 24, a movable switch blade 25, and a stationary contact 26. Relay 23 is shown in the de-energized position and movable switch blade 25 is biased by means not shown, to be out of engagement with stationary contact 26.

In circuit with relay winding 24 is a safety cutout device 90 having a manually closed switch 91, a bimetal actuator 93, a bimetal heater 92, and a manually operable reset button 94. The operation of the cutout device 90 is such that a predetermined time period of energization of heater 92 causes bimetal 93 to move to the right causing switch 91 to open. After bimetal 93 has cooled, button 94 can be depressed to again reset switch 91 to closed position.

A further transformer 27 having a primary winding 28 and a secondary winding 29 is arranged with the primary 28 connected between the power line conductors 18 and 19. The secondary winding 29 is connected to supply operating voltage to electron discharge devices 30 and 31, and to the photocell 16.

The electron discharge device 31 includes an anode 41, a control electrode 42, and a cathode 43. The electron discharge device 30 includes an anode 32, a control electrode 33 and a cathode 34. Anode 32 is connected to a relay 35 having a winding 36 shunted by a capacitor 37 and having a movable switch blade 38 cooperating with stationary contacts 39 and 40. The relay 35 is shown in the energized position and in this position the movable switch blade 38 engages stationary contact 39 and is disengaged from stationary contact 40.

The reference numeral 44 designates a relaxation oscillator which includes a direct current source of voltage 45, a resistor 46, a neon bulb 47, a resistor 48, and a capacitor 49. As will be described, the relaxation oscillator 44 is effective to control the conductance of the electron discharge device 31 and to thereby control the magnitude of the operating voltage applied to the photocell 16.

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The reference numeral 50 designates a control network for energizing a relay 51 having a winding 52 and movable switch blades 53 and 95 cooperating with stationary contacts 54 and 96 respectively. Relay 51 is shown in the de-energized condition and in this condition the movable switch blades 53 and 95 are biased, by means not shown to be out of engagement with stationary contacts 54 and 96 respectively. The network 50 also includes a capacitor 57 connected to switch blade 38 and a direct current source of voltage 55 shunted by a capacitor 56.

Relay 51 is of the type having a long drop-out time. This can be accomplished by a variety of means, such as, a dash pot or a slugged core for the relay.

The apparatus of the single figure is shown with electrical power applied to the power line conductors 18 and 19, and with the thermostat 17 in a condition indicative of no need for operation of the burning unit 10. In this condition, relay 23 is de-energized, relay 35 is energized and relay 51 is de-energized.

The relaxation oscillator 44 is also functioning at this time, as it does at all times since its operation is independent of the operation of other elements of the present invention. It will be assumed that the voltage applied to power line conductors 18 and 19 is 60 cycle alternating current voltage. With this supply voltage, the circuit components of oscillator 44 are selected to give a frequency of oscillation one or two cycles per second.

The relaxation oscillator 44 is connected in controlling relation to the control electrode 42 of the discharge device 31. The voltage between the cathode 43 and the control electrode 42 of device 31 consists of a source of direct current voltage 60 in series with the voltage which may be across capacitor 49 in series with resistor 48. Voltage source 60 is connected in a direction to apply a positive bias to device 31 and thereby cause the device to conduct current. The relaxation oscillator 44 functions to charge the capacitor 49. The charge on capacitor 49 tends to buck-out the voltage of source 60 and after a short time period the charge on capacitor 49 is sufficiently high to cut off, or substantially reduce, the flow of current between the anode and cathode of the discharge device 31. However, soon after the voltage on capacitor 49 has reached this value the neon tube 47 breaks down and substantially short circuits capacitor 49 through resistor 48. Therefore, in a short period of time the voltage applied to the control electrode of discharge device 31 is of a value to again render the discharge device 31 conductive. When neon bulb 47 breaks down a relatively high voltage is developed across the resistor 46 and the voltage across the neon tube 47 is thereby lowered to extinguish the tube. The capacitor 49 can then recharge to again reduce the conductivity of the discharge device 31. The above described operation occurs in reoccurring cycles at the rate of one or two cycles per second and in this manner the relaxation oscillator 44 is effective to cause the conducting state of discharge device 31 to vary in cyclic nature.

The current conducting path for the discharge device 31 can be traced from the right hand terminal of secondary 29 through resistor 61, conductor 62, conductor 63, cathode 43, anode 41, conductor 64, and conductor 65 to the left hand terminal of secondary 29. Current can flow in this circuit only when the left hand terminal of secondary 29 is positive. This current flowing through resistor 61 causes a voltage drop across resistor 61 such that the upper terminal of the resistor is negative with respect to the lower terminal of the resistor.

Resistor 61 is in the current flow circuit for photocell 16. This can be seen by tracing a circuit from the right hand terminal of secondary 29 through resistor 61, conductor 62, ground connection 70, ground connection 71, photocell 16, conductor 72, a filter network consisting of parallel connected resistor 73 and capacitor 74, conductor 75, and conductor 65 to the left hand

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terminal of secondary 29. Current can flow in this circuit only when the right hand terminal of secondary 29 is negative.

The magnitude of the voltage applied between anode 76 and cathode 77 of photo tube 16 is dependent upon the voltage drop which exists across resistor 61 and is due to conduction of electron discharge device 31. In other words, during the maximum conductance portion of the cycle of device 31 a maximum voltage will be developed across resistor 61 and a minimum voltage will be applied between the anode and cathode of the photocell 16. The circuit component values have been so selected that in this condition the voltage applied across photocell 16 is insufficient to render the photocell operative to sense the presence or absence of flame. However, during the minimum conductance portion of the cycle of device 31 a minimum voltage is developed across the resistor 61 and a maximum voltage is applied between the anode and the cathode of the photocell 16. In this condition the photocell 16 is rendered operative to sense the presence or absence of flame at the burner unit 10.

From the above, it can be seen that by means of the relaxation oscillator 44, which controls the electron discharge device 31, the photocell 16 is cyclically rendered operative or inoperative to sense the presence or absence of flame at the burner unit 10. It can also be seen that such cyclic action is independent of the operation of the other components of the improved flame detector and that such cyclic operation will continue both during the standby operation of the apparatus and during the time that the flame is established at the burner unit 10.

If it is now assumed that the thermostat 17 calls for operation of the burner unit 10, an energizing circuit is established from the secondary of transformer 20 to energize the heater 92 of cutout device 90 and to energize the winding 24 of relay 23. This causes movable switch blade 25 to move into engagement with the stationary contact 26. An energizing circuit can now be traced for the pilot valve 14 and ignition transformer 15 starting from power line conductor 19 through switch blade 25 and contact 26 of relay 23, conductor 79, conductor 101, parallel connected pilot valve 14 and ignition transformer 15, and conductor 80 to power line conductor 18. A spark now appears at the ignition electrodes of ignition transformer 15 and gas flows through the pilot valve 14 to the pilot burner 13 to be ignited.

As soon as a flame is established at the pilot burner 13 the photocell 16 senses this flame. It will be remembered that photocell 16 is first rendered operative and then inoperative in a cyclic manner and it follows that photocell 16 can detect a flame at the pilot burner 13 only during that portion of its cycle that it is operative.

The current flow circuit for the photocell 16 can be traced from the right hand terminal of secondary 29 through resistor 61, conductor 62, ground connection 70, ground connection 71, photocell 16, conductor 72, the filter network consisting of parallel connected resistor 73 and capacitor 74, conductor 75, and conductor 65 to the left hand terminal of secondary 29. This current flows only when the right hand terminal of secondary 29 is negative. This current flow charges capacitor 74 so that its upper terminal, which is connected to the control electrode 33 of discharge device 30, is negative with respect to its lower terminal. So long as flame is present at the pilot burner 13 the filter network consisting of capacitor 74 and resistor 73 is supplied with pulses of electrical current each time that the photocell 16 is rendered operative and the pulsating electrical current stops flowing when the photocell 16 is rendered inoperative.

A pulse of current is applied to the filter network from photocell 16 every half cycle that the right hand terminal of secondary 29 is negative. Since the relaxation oscillator 44 operates at a relatively low frequency, say one cycle per second, the photocell 16 is rendered operative for one-half a second and the filter network receives 30

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pulses of current. During the succeeding one-half second the relaxation oscillator 44 is effective to cause the discharge device 31 to be rendered conductive and the photocell 16 is rendered inoperative.

During this time period the photocell 16 cannot conduct even though flame may be present at the fuel burner 10 and even though the right hand terminal of secondary 29 may be negative. Therefore, no current flows to capacitor 74. The charge on capacitor 74 is then dissipated through the resistor 73 and discharge device 30 is once again rendered conductive.

So long as flame continues to exist at the burner unit 10, the discharge device 30 is cyclically rendered conductive and then non-conductive at the same frequency at which oscillator 44 is operating. This causes relay winding 36 of relay 35 to be cyclically energized and then de-energized at this frequency.

When relay 35 is in its energized condition capacitor 57 of network 50 is connected to the source of direct current voltage 55 and is charged from this voltage source. When the relay 35 is de-energized, the movable switch blade 38 moves out of engagement with contact 39 and moves into engagement with contact 40. This causes the charge on capacitor 57 to be dissipated through the winding 52 of relay 51.

From this it can be seen that so long as relay 35 cycles the capacitor 57 will be cyclically charged from the voltage source 55 and then discharged through the winding 52 of relay 51. Relay 51 is energized in response to such cyclic action to cause the movable switch blades 53 and 95 to engage stationary contacts 54 and 96. Switch blade 53 completes an energizing circuit for the main burner valve 12 which can be traced from power line conductor 19 through switch blade 25 and contact 26, conductor 79, conductor 103, switch blade 53 and contact 54, conductor 100, main valve 12, conductor 101, and conductor 80 to the power line conductor 18. This circuit causes gas to flow to the main burner 11 and this gas is ignited by the flame at the pilot burner 13.

Switch blade 95 completes a circuit which shunts heater 92 of cutout device 90. This prevents the opening of switch 91.

From the above description, it can be seen that an improved flame detector has been provided wherein an oscillator, such as relaxation oscillator 44, is provided to control the operativeness and inoperativeness of a flame sensor, such as photocell 16, and that a means, such as relay 51, has been provided to respond to a condition wherein the photocell 16 detects a flame only when it is rendered operative by the relaxation oscillator 44.

A failure of any one of the components associated with the discharge devices 30 or 31, or a failure of the discharge devices themselves, will cause the cyclic operation of relay 35 to be discontinued. This will cause the capacitor 57 to either be continuously connected across the direct current voltage 55 or continuously connected across the winding 52 of relay 51. In either case, the relay 51 will be de-energized to turn off the main burner valve 12. In other words, the possibility of an unsafe failure has been eliminated in the present improved flame detector.

Other 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. Flame detecting apparatus comprising: an electrical flame sensor, a source of operating voltage, means connecting said source of voltage in a circuit to said flame sensor, a continuously operable electronic oscillator having an output, means connecting the output of said oscillator in circuit with said flame sensor and said source of voltage to cause a cyclic voltage to be applied to said flame sensor independent of the condition to which said flame sensor is subjected so as to render said flame sensor operative to sense flame during a first portion of the cyclic

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voltage and inoperative to sense flame during a second portion of the cyclic voltage, an electron discharge device having a normal state of conduction, circuit means connecting said flame sensor in controlling relation to said discharge device to change the normal state of conduction of said discharge device when said flame sensor senses flame during said first portion of the cyclic voltage, and means controlled by said electron discharge device and responsive only to a state of conduction of said electron discharge device wherein the conduction cycles between said normal state and said changed state of conduction.

2. A flame detector comprising: an electrically operable flame sensor which is rendered conductive when subjected to a flame, a source of voltage, an impedance, means connecting said flame sensor and said impedance in a series circuit to said source of voltage, a first electron discharge device having a control electrode and having an anode and a cathode, means connecting said anode to said source of voltage and said cathode to the connection of said impedance and flame sensor so that the current flow through said first electron discharge device causes a voltage drop across said impedance, a continuously operable relaxation oscillator having an output connected to said control electrode to control the current flow between said anode and cathode in a cyclic manner, the resultant cyclic voltage drop across said impedance being effective to control the operating voltage applied to said flame sensor to render said flame sensor cyclically operative and then inoperative to sense a flame independent of the condition to which said flame sensor is subjected, a second electron discharge device having a control electrode and an anode and cathode, a first relay having a winding and switch means, circuit means connecting said relay first winding and said second discharge device anode and cathode in a series circuit to said source of voltage, means connecting said flame sensor in controlling relation to said second discharge device control electrode to control the state of energization of said first relay winding, said first relay winding thereby being cyclically energized and then de-energized when said flame sensor is subjected to a flame, a capacitor, a further source of voltage, a second relay having a winding, and means controlled by said first relay switch means for cyclically charging said capacitor from said further source of voltage and then discharging said capacitor through said second relay winding in response to the cyclic energization and de-energization of said first relay winding.

3. Condition detecting apparatus for detecting a given condition comprising: electrically operable condition sensing means, voltage supply means, means connecting said voltage supply means to said condition sensing means, a continuously operable electronic oscillator having an output, means connecting said oscillator output in circuit with said voltage supply means and said condition sensing means to cause a cyclic voltage to be applied to said condition sensing means independent of the condition to which said condition sensing means is subjected, to thereby render said condition sensing means operative to sense the given condition during a first portion of the cyclic voltage and inoperative to sense the given condition during a second portion of the cycle, and responsive means connected to be controlled by said condition sensing means and responsive to said condition sensing means sensing the given condition in a cyclic manner as said condition sensing means is cyclically rendered operative.

4. A flame detector comprising: an electrically operable flame sensor, a source of operating voltage, an impedance, means connecting said flame sensor and said impedance in a series circuit to said source of voltage, an electron discharge device having a control electrode and having a pair of main electrodes, circuit means connecting one of said main electrodes to said source of voltage and the other of said main electrodes to the connection of said flame sensor and said impedance so that the

current flow through said discharge device causes a voltage drop across said impedance, a continuously operable oscillator having an output connected to said control electrode and to one of said main electrodes and effective to cause a cyclic current to flow through said discharge device and thereby cause a cyclic voltage drop across said impedance and a resultant cyclic voltage to be impressed on said flame sensor to render said flame sensor operative and then inoperative in a cyclic manner independent of the condition to which said flame sensor is subjected, means connected to said flame sensor and controlled in a first manner when said flame sensor is operative and is subjected to a flame and controlled in a second manner when said flame sensor is inoperative, and means con-

trolled by said last named means and responsive to a cyclic control of said last named means.

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