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Riccardi

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[54] **ULTRAVIOLET FLAME DETECTOR**

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[52] **U.S. Cl.** ..... **340/228,** 313/94, 315/119, 315/129, 315/135, 250/83.3 UV, 431/78

[51] **Int. Cl.** **G08b 21/00**

[58] **Field of Search** ..... 340/227 R, 227 R, 340/228.1; 313/53, 94, 99; 250/83.6, 83.3 R, 83.3 UV; 431/78; 315/119, 129, 135

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[57] **ABSTRACT**

A flame detector is provided for indicating whether a flame is emitted from a burner. The detector includes an element which is sensitive to ultraviolet light and has a property of resistance falling to a relatively low value when exposed to ultraviolet light. The element is connected in series with a detector, a source of alternating current and a normally nonconducting control element which becomes conducting when a rectified direct current flows through the ultraviolet sensitive element so as to indicate that a flame is present. The flame responsive unit including the ultraviolet sensitive element and a series rectifier is interchangeable with the flame rod and burner connection of an earlier form of flame detector in which a flame rod is employed in which the flame and flame rod serve as a rectifier for causing rectified direct current to flow between the flame rod and the burner base through the flame detector circuit when a flame is present. In the event of a malfunction such as an open circuit or short circuiting of the ultraviolet sensitive element, the detector provides fail safe protection in that it guards against indicating the presence of a flame during any such malfunction.

14 Claims, 2 Drawing Figures

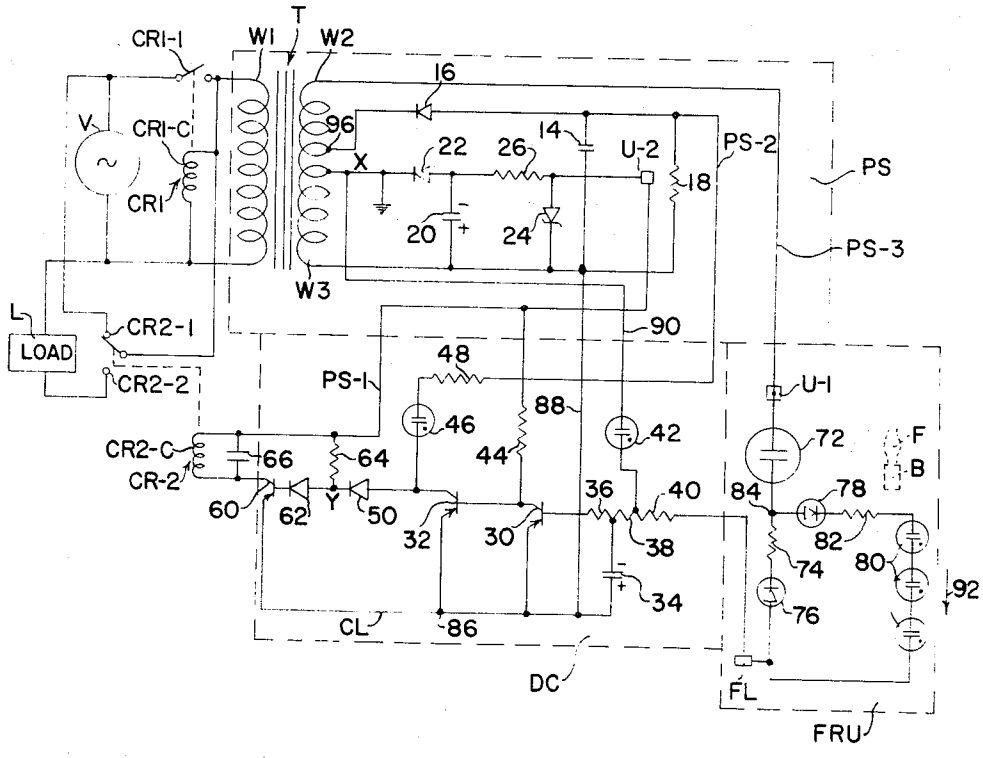
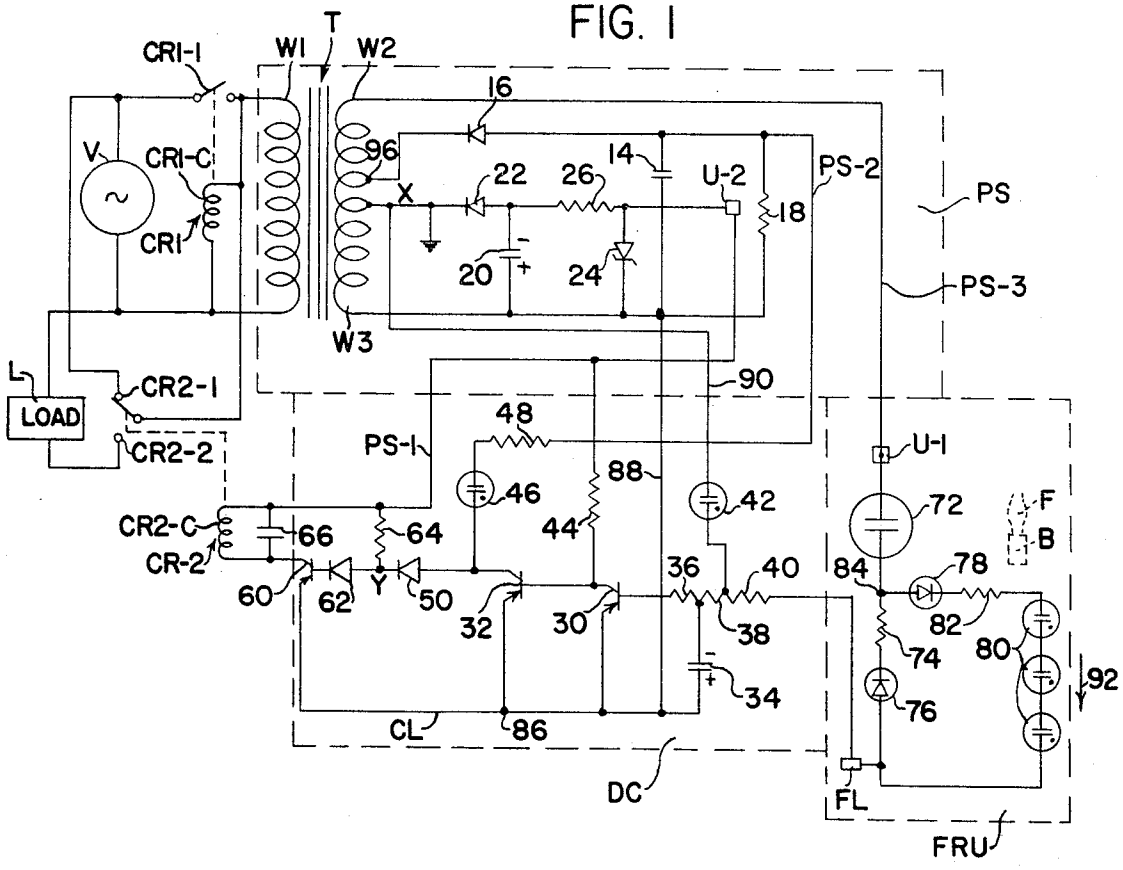


FIG. 1



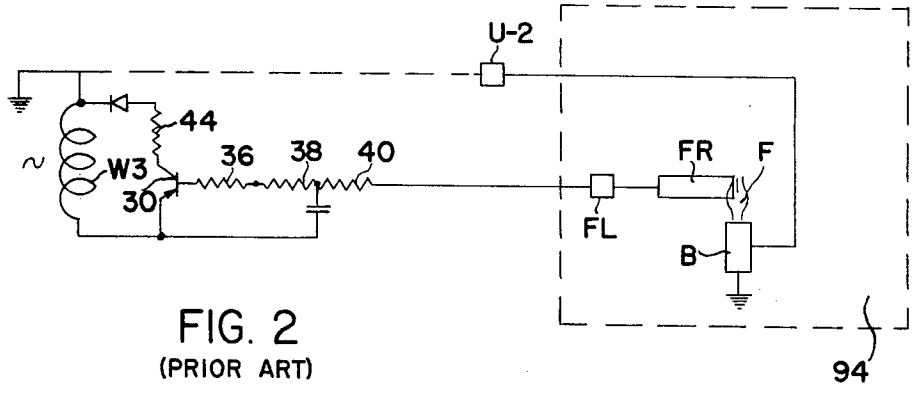


FIG. 2
(PRIOR ART)

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ULTRAVIOLET FLAME DETECTOR

This is a continuation of application Ser. No. 88,705 filed Nov. 12, 1970.

PRELIMINARY DESCRIPTION

This invention relates to the art of flame detection and more particularly to an improved flame detector which is a modification of that described in the co-pending application of John Sellors, Jr., Ser. No. 825,381, filed May 16, 1969 and assigned to the same assignee as the present application. The detector includes a flame responsive unit which is interchangeable with the flame responsive unit of said co-pending application and may utilize the same normally nonconducting electronic control means of the co-pending application which becomes conducting in the event of the presence of a flame to produce an indication thereof.

Flame detectors have heretofore been proposed to sense the flame conditions of the burner, and if a flame failure occurs to provide indication thereof. Such detectors have included a sensor, such as a photocell of a flame rod, together with an electrical detector circuit.

Flame detection by means of a flame rod is well known. Thus, in the prior art, a typical flame detector included a flame rod together with a detector circuit having two stages of electronic conductive devices. Normally, in the absence of the flame the first stage is in a conductive condition, maintaining the second stage in a nonconductive condition. The flame rod circuit includes a capacitor, a flame rod, and a metal base of a burner connected together in series across an alternating-current voltage source. Once flame is emitted from the burner, flame rectified current flows to charge the capacitor. The voltage stored by the capacitor is directed through a circuit and coupled to the input circuit of the first stage in such a manner that when the capacitor becomes charged, the stored voltage is sufficient to reverse bias as the first stage. Thus, the first stage becomes nonconductive causing the second stage to become conductive, providing an indication that flame is present.

Such prior art flame detector circuits required that the capacitor act as a blocking or series capacitor connected between the flame rod and the detector circuit. The detector circuit obtains its operating bias potential independently of the flame condition. Accordingly, in the event of a circuit nalfunction, the first stage may inadvertently become nonconductive, causing the second stage to become conductive, thereby providing a false indication of a flame condition.

It is also desirable that a flame detector have a safe start mode prior to energizing the load to determine whether a flame is present or whether a detector circuit malfunction indicates a "flame on" condition.

The present invention is directed toward a burner flame error detector which, like the detector of the aforesaid co-pending application, utilizes a series circuit in which the initial stage of an electronic control circuit is normally nonconducting but becomes conducting only when the flame is present, and which overcomes the aforementioned difficulties of previous flame failure detectors. In the present circuit, however, an ultraviolet sensitive element is employed as the flame responsive element in place of a flame rod and the flame, where it is desired to utilize a flame responsive element which does not make direct contact with the flame.

In accordance with one aspect of the present invention, a flame detector is provided for detecting whether a flame is emitted from an electrically conductive burner member and includes a flame responsive unit with unidirectional properties. The flame responsive unit corresponds to an elongated electrically conductive flame rod positioned in a flame and the flame itself so as to result in a unit with unidirectional current properties which conducts when the flame is present. However, to avoid direct contact with the flame, the flame responsive unit of the present invention comprises an ultraviolet sensitive element which is in operative relationship to the flame or exposed thereto and a rectifier in series therewith to provide unidirectional current conducting properties.

The ultraviolet sensitive element itself has the property of possessing a relatively high resistance in the absence of ultraviolet radiation such as received from a flame but falling to a relatively low resistance when the flame is present and emits ultraviolet radiation. Thus the flame responsive unit of the present invention is responsive to radiation caused by the flame, whereas the flame rod type of flame responsive unit is responsive to ionization in the flame. The flame detector includes in addition to the flame responsive unit electronic control means, such as a semiconductor, having first, second and third electrodes; circuit means for connecting the first and second electrodes, and the flame responsive unit in a series circuit across an alternating current voltage source; and an output circuit controlled by electronic control means for providing an indication as to whether a flame is present. Thereby when flame is emitted from the burner member, rectified direct current flows through the said series circuit of the first and second electrodes of the electronic control means rendering the electronic control means conducting to provide indication of flame presence.

The primary object of the present invention is to provide an improved flame detector which is relatively simple in construction and is economical to manufacture.

Another object of the present invention is to provide a flame detector package of the ultraviolet sensitive type which is interchangeable with the flame rod and burner connection of the flame rod type of flame detector described in the aforesaid co-pending application or with any device for connection to a circuit which is sensitive to a direct-current signal but unresponsive to alternating current or current in which reversed polarity components predominate.

A further object of the present invention is to provide a flame responsive unit giving a visual indication in the event of detector malfunction, in addition to guarding against producing a false indication of flame presence.

Still another object of the present invention is to provide an improved flame detector incorporating semiconductor components having long operating lifetime so as thereby to obtain a minimum power consumption and low operating costs as well as minimum maintenance expenditures.

The foregoing and other objects of the invention will become more readily apparent from the following detailed description of a preferred embodiment of the invention considered in conjunction with the accompanying drawings.

DRAWINGS

In the drawings FIG. 1 is a circuit diagram, illustrative of the invention, and FIG. 2 is a diagram of flame rod type of detector prior to that of the present inventor but illustrating the interchangeability of the flame responsive unit package of the present invention with the flame rod and the burner connection of the prior arrangement illustrated in FIG. 2.

Like reference characters are utilized throughout the drawings to designate like parts.

DETAILED DESCRIPTION

Referring now to the drawings wherein the showings are for the purposes of illustrating the referred embodiment of the invention only, and not for purposes of limiting the same, FIG. 1 illustrates a single burner application of the present invention. However, the arrangement illustrated is adapted to multiple burner applications in the same manner as the flame rod detector described in the aforesaid co-pending application. The embodiment illustrated comprises an assembly of a flame responsive unit package FRU, an electronic control package PS/DC incorporating a power supply PS and detector circuits DC, an alternating-current voltage source V, coupled to the electronic circuits PS/DC by means of a transformer T, and a common output relay CR2 for coupling a load L across the voltage source V.

The flame responsive unit FRU comprises an ultraviolet sensitive element **72**, a resistor **74**, and a rectifier **76** connected in series between a flame terminal FL and an alternating-current supply terminal U-1. In addition there is a parallel circuit connected in shunt with the pair of elements **74** and **76** and comprising a rectifier **78** and voltage responsive discharge means, becoming conductive at a predetermined voltage, consisting preferably of a plurality of neon tubes **80** connected in series with a resistor **82** and the rectifier **78** between the flame terminal FL and a terminal **84** at the junction of the ultraviolet sensitive element **72** and the resistor **74**. As shown, three neon tubes **80** are utilized. The flame responsive unit FRU may be mounted as a separate package in an ultraviolet scanner housing.

The ultraviolet sensitive element **72** may take the form of elements sold by Ampex, Sylvania and other manufacturers, for example, such as the type P574, Sylvania tube.

The alternating voltage source V may take the form of line voltage, on the order of 120 volts, 60 cycles per second. The voltage source V is coupled across the primary winding W1 of transformer T through normally open relay contacts CR1-1 of a relay CR1. The relay CR1 also includes a relay coil CR1-C connected in parallel with primary winding W1. A pair of normally closed contacts CR2-1 are connected across normally open contacts CR1-1. Normally open contacts CR2-2 serve to connect a load L across voltage source V when relay coil CR2-C of relay CR2 becomes energized. Transformer T has two secondary winding portions W2 and W3 separated by a tap X. The tap X is shown as electrically grounded.

Briefly, when power is applied to the circuit, the relay CR1 becomes energized through normally closed contacts CR2-1. This causes contacts CR1-1 to become closed to provide a holding circuit. As will be explained in greater detail hereinafter, alternating-current voltage of approximately 300 volts is applied in the circuit of the flame responsive unit U between the terminals U-1 and the emitter terminal **86** of the detector circuit DC. So long as a flame F is emitted from the burner B, ultraviolet radiation falls upon the ultraviolet sensitive element **72**, and relay coil CR2-C is energized to close contacts CR2-2, to energize load L, which, for example, may take the form of a gas safety shut-off valve.

POWER SUPPLY

As shown in FIG. 1, power supply PS includes a capacitor **14** connected to winding portions W2 and W3 by means of a diode rectifier **16**, poled as shown, and a tap **96**. A resistor **18** is connected in parallel with capacitor **14**. A capacitor **20** is connected in parallel with winding portion W3 by means of a diode rectifier **22**, poled as shown. A zener diode **24**, poled as shown, is connected in parallel with capacitor **20** by means of a resistor **26**. The junction of zener diode **24** and resistor **18** is connected to the emitter terminal **86** through a line **88**. The junction of resistor **26** and zener diode **24** is connected to a terminal U-2 and to a transistor power supply line PS-1, which provides a direct-current voltage level of the order of minus **22** volts. Similarly, the junction of diode **16** and resistor **18** is connected to a power supply line PS-2, which provides a direct current voltage level of the order of minus **100** volts. The line PS-3 connected to the end of the winding W2 supplies alternating current at 300 volts.

DETECTOR CIRCUIT

As shown in FIG. 1, the detector circuit DC includes a two-stage circuit incorporating PNP transistors **30** and **32**. These two transistors have their emitters connected together and thence to the emitter terminal **86** and the line **88**. A filter capacitor **34** is connected between the emitter terminal **86** and the base of transistor **30** through a resistor **36**. The junction of capacitor **34** and resistor **36** is connected through series connected resistors **38** and **40** to the flame terminal FL of the flame responsive unit FRU. The junction of resistors **38** and **40** is connected through a neon lamp **42** and thence to tap X on transformer T through a line **90**. The collector of transistor **30** is connected to the base of transistor **32** and is also connected through a resistor **44** to terminal U-2 power supply line PS-1. The collector of transistor **32** is connected through a neon lamp **46** and thence through a resistor **48** to the power supply line PS-2. The collector of transistor **32** is also connected through a diode **50**, poled as shown, to an output circuit point Y. However, the invention is not limited to use of the particular detector circuit described. The flame detector may be employed with any detector circuit which is sensitive to direct-current signals but is unaffected by alternating current or by signals of reversed polarity or alternating currents with negative polarity waves predominating so as to produce a net signal of opposite polarity.

OUTPUT CIRCUIT

The output circuit includes a relay CR2 and a gating device in the form of a PNP transistor **60** which, when forward biased, energizes the relay. It is to be appreciated that other gating means may be used, such as, for example, a Triac. Also, whereas relay CR2 is shown in conjunction with direct current voltage supply means, it may be used with an alternating current voltage sup-

ply means, preferably so if a Triac is substituted for transistor **60**. As shown, however, transistor **60** has its emitter connected to the emitter terminal **86** and its base connected through a diode **62**, poled as shown, to point Y. Point Y is also connected through a resistor **64** to the power supply line **PS-1**. The power supply line **PS-1** is also connected through relay coil **CR2-C** to the collector of transistor **60**. A capacitor **66** is connected in parallel with coil **CR2-C**.

Although the description thus far has been made with reference to discrete electronic components, it is to be appreciated that the invention is not limited thereto. Thus, for example, the various illustrated electronic components may be incorporated, at least in part, in integrated circuits.

OPERATION

After power is applied to the circuit, and prior to flame being emitted from the burners, the current will flow from source V through normally closed relay contacts **CR2-1** to energize the relay coil **CR1-C**. This causes relay contacts **CR1-1** to close and provide a holding circuit for energizing the power supply circuit PS. Since there is no flame, there will be essentially an open circuit to the base of each transistor **30** in the detector circuit DC. Accordingly, the transistor **30** is reverse biased and nonconductive. Transistor **32** in the detector circuit DC will be forward biased through a resistor **44** to power supply line **PS-1**. This transistor will conduct, and, assuming transistor saturation, diode **50** will be forward biased, clamping point Y to essentially saturation potential existing on the collector of transistor **32**. The forward voltage drop of diode **50** is on the order of 0.6 volts and, hence, point Y is essentially at 0.8 volts positive. Thus potential is insufficient to forward bias PNP transistor **60**.

If a flame is emitted from the burner B, then ultraviolet radiation falls on the ultraviolet sensitive element **72** and its resistance falls to a relatively low value causing rectified direct current to flow through the circuit of element **72**, resistor **74** and diode **76** and thence through resistors **40** and **38** to apply rectified direct current to filter capacitor **34** which commences to charge in accordance with the polarity indication shown, so as to forward bias the transistor **30** into conduction. Thereafter, rectified current will flow from line **88**, through the emitter to base electrodes of transistor **30**, and thence through resistors **36, 38** and **40**, flame terminal FL, diode **76**, resistor **74** and the ultraviolet element **72** to terminal **U1**, to line **PS-3** and transformer windings **W2** and **W3** back to the line **88**. So long as this rectified current flows, transistor **30** is conductive so that its collector potential is essentially clamped to that of the emitter terminal **86**, whereupon transistor **32** becomes reverse biased. This removes the previous low positive potential at the point Y. Accordingly, transistor **60** is now forward biased through diode **62** and resistor **64** to the negative potential power supply line **PS-1**. As transistor **60** becomes conductive, current will flow through its emitter to collector circuit to energize relay coil **CR2-C**. This causes relay contact **CR2-2** to become closed, energize load L, which, as discussed before, may take the form of suitable alarms or shut-off valves or timers, as desired by the user.

If for some reason flame failure occurs at burner B, transistor **30** and detector circuit DC will become reverse biased, since essentially an open circuit is presented to its base electrode. This, then, will cause transistor **32** in that detector circuit to become forward biased and conductive, whereupon the point Y is returned to the potential of that essentially existing on the emitter terminal **86** and, as stated before this potential is insufficient to maintain transistor **60** forward biased. The terminal **86** is on a common line CL for the emitters of transistors **30, 32** and **60**. Thus, transistor **60** will become reverse biased, causing relay **CR2** to become de-energized. As transistor **32** becomes forward biased and conductive, a series circuit is completed from common line CL, the emitter terminal **86**, through emitter to collector path of transistor **32**, neon lamp **46** and resistor **48** to the power supply line **PS-3**, which, as stated before, provides a potential on the order of 300 volts. As is well known, a neon lamp, such as lamp **46**, only presents a high resistance as to current flow through until a voltage of sufficient magnitude is applied there across, whereupon the resistance of the lamp decreases. In the embodiment shown, it was found that this required voltage to fire neon lamp **46** is on the order of 85 volts. Accordingly, when the transistor **32** conducts, essentially all the voltage is applied across the neon lamp, whereupon the lamp fires. Resistor **48** has a resistance value on the order of 47 kilohms and, accordingly, after lamp **46** fires approximately 15 volts is obtained across resistor **48**, leaving 75 volts for application across neon lamp **46**.

The neon lamp **42** in the detector circuit serves as a voltage protective means to prevent damage to capacitor **34** and transistor **30** in the associated detector circuit. Thus in the event that the electrodes of the ultraviolet sensitive tube **72** should become short circuited, or for any other reason a high voltage occurs, the neon lamp **42** breaks down and, along with current limiting resistors **40** and **74** a circuit is obtained to bypass the harmful short circuit current to the grounded point X and thereby prevent burn out of capacitor **34** and transistor **30**.

Although the invention is not limited to a precise values of dimensions of electrical components and types of components satisfactory results have been obtained in utilizing circuit components such as listed below in Table I.

TABLE I

Voltage source V	120 volts, 60 cycles
Diodes 16 and 22	200 piv at 250 milliamperes
Diodes 50 and 62	40 piv at 10 milliamperes
Diode 24	Zener diode 22 volts, 1 watt
Capacitor 14	10 microfarads, 100 volts
Capacitors 20 and 66	10 microfarads, 6 volts
Capacitor 34	10 microfarads, 6 volts
Resistor 18	15 kilohms
Resistor 44	1 megohm
Resistors 36, 38 and 64	100 kilohms
Resistor 40	2.2 kilohms
Resistor 26	470 ohms
Resistor 48	47 kilohms
Resistor 82	100 kilohms, ¼ watt
Resistor 74	1 megohm, ¼ watt
Rectifiers 76, and 78	450 PIV minimum at 10 ma. minimum
Neon tubes 80	3 AG

The ultraviolet sensitive element **72** of the type designated has a high resistance when not exposed to ultraviolet radiation but breaks down at approximately 300 volts when exposed to ultraviolet radiation and thereupon the potential difference across the terminals drops to about 200 volts with a sustained application of 300 volts root-mean-square voltage. Without the appli-

cation of ultraviolet radiation the element would break down at 500 or 600 volts. The voltage remaining across the resistor **74** and the diode **76** is insufficient to cause the neon tubes **80** to break down. In the event that the element **72** should fail and form a short circuit a higher voltage would occur across the neon tubes **80**, each of which was designed for a breakdown at approximately 80 volts. However, it is found that 220 volts is not sufficient to trigger the neon tubes. In normal conditions only 220 occurs across the neon tube because the peak value of the voltage from 300 volts root-mean-square is 420 volts. The potential difference under normal conducting conditions of the element **72** is 200 leaving a difference of 220 volts for application across the three neon tubes **80**. Thus the neon trigger tubes **70** normally do not light but in the event of failure of tube **72**, causing it to short circuit, the peak value of the 300 volt alternating circuit is applied and the tubes **80** break down, become luminous and provide an indication of the failure. The current flows on the negative half cycles of the alternating current wave as represented by the arrow **92**, since normally current flows only in the reverse direction as represented by the poling of the rectifier **76**. Such a failure of the element **72** cannot cause the detector circuit DC to indicate falsely, that is to indicate flame presence when there is no flame, because the capacitor **34** with resistors **36** and **38** acts as an integrator. Successive half cycles of the alternating wave which may occur when the element **72** is defective, charge and discharge the integrating capacitor **34** alternately, so that forward biasing potential does not develop between the base and the emitter of the transistor **30** which remains reverse biased. The resistor **36** renders the transistor **30** relatively insensitive to current fluctuation and precludes the transistor **30** reaching conducting condition in the event of failure of the ultraviolet sensitive element **72**.

FIG. 2 illustrates fragmentarily the circuit which results when a flame rod type of detector is employed such as described in the aforesaid co-pending application. In that case, the flame-rectified current between the flame rod FR and the burner B wherein the flame exists, flows through the base emitter circuit of the transistor **30** as in the arrangement of FIG. **2**. The same power supply detector circuit package PS/DC may be employed by merely disconnecting the terminals FL and U-2 from the flame rod package **94** and connecting the terminals FL and U-1 of the ultraviolet sensitive flame responsive unit FRU. For this purpose the power supply package PS, preferably has two terminals in addition to the grounded terminal X and the flame terminal FL, namely, the low voltage terminal U-2 and the high voltage terminal U-1. For the flame rod a low voltage is sufficient but for the ultraviolet element **72** a 300 volt supply is required. Thus, with two outputs in the power supply package the ultraviolet sensitive package is interchangeable with the flame rod package and it is unnecessary to remove or replace the power supply-detector circuit package PS/DC when it is desired to change the type of flame responsive unit employed.

If desired, both types of units may be employed in the same installation. For example, a flame rod unit may be mounted at the pilot flame to prevent a main fuel line from being opened until a pilot light has been lighted and to close such a main fuel line in the event the pilot flame blows out; and an ultraviolet type of flame responsive unit may be utilized for detecting the presence of the main flame of a gas or oil burner.

Although the invention has been described in conjunction with preferred embodiments, it will be readily apparent to those skilled in the art that various changes in form and arrangements of parts may be made to suit various requirements without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A monitoring circuit for use in series with an alternating current power supply and a flame responsive electrical element having a normal operating impedance range, a first modified impedance range when said element is exposed to and operatively associated with a flame emitted from a burner, and a second modified impedance range when said element is defectively shorted, said modified ranges being substantially less than said normal range and said second modified range being substantially less than said first modified range, said monitoring circuit comprising:

a. a continuously active first circuit for allowing current flow through said element in a first direction;

b. a normally non-active second circuit for allowing current flow through said element in a second direction opposite to said first direction;

c. means responsive to operation of said element in said second modified range for rendering said second circuit active whereby alternating current flow is established through said element; and,

d. an output means for controlling said burner; and,

e. control means responsive to alternating current flow through said element for activating said output means.

2. A monitoring circuit as defined in claim **1** wherein said first circuit includes a first half wave rectifier means poled in said first direction and a first resistor in series with said first rectifier means.

3. A monitoring circuit as defined in claim **2** wherein said second circuit is connected in parallel with said first resistor and includes a second half wave rectifier means poled in said second direction and voltage responsive means for rendering said second circuit conductive when the voltage across said first resistor means exceeds a preselected level.

4. A monitoring circuit as defined in claim **3** wherein said voltage responsive means is a means for blocking current flow until said preselected level is exceeded.

5. A monitoring circuit as defined in claim **1** wherein said control means is a capacitor means connected in series with said element, said capacitor means having a first charged condition when charged with only first current flow in said first direction, said first current flow occuring when said element is operating in said first modified range and a second charged condition when charged with current flow in both said first and second directions, and means responsive to said second charged condition for actuating said output means.

6. A monitoring circuit as defined in claim **5** wherein said capacitor means has a third charged condition when charged with only a second current flow in said first direction, said second current flow occurring when said element is operating in said normal range, and means responsive to said third charged condition for actuating said output means.

7. A flame detector for detecting whether a flame is emitted from a burner, said detector comprising:

a. an electrical element positioned in operative relationship to any flame emitted from said burner and having a normal operating impedance range, a first modified impedance range when exposed to radiation, and a second modified impedance range when defectively shorted, with said modified ranges being lower than said normal range and said second modified range being substantially lower than said first modified range;

b. a first circuit including a capacitor, a first half wave rectifier means for allowing unidirectional current flow in a first direction, a first resistor and said element;

c. voltage supply means for applying an alternating circuit across said first series circuit whereby said capacitor is changed with a first polarity corresponding to said uni-directional current flow;

d. a second series circuit connected in parallel with said first rectifier means and said first resistor, said second series circuit comprising a second half wave rectifier means for allowing unidirectional current flow in a second direction through said second direction opposite to said first direction for changing said capacitor with a second polarity and voltage responsive means for allowing current flow through said second series circuit when voltage exceeding a preselected voltage applied across said second series circuit, said preselected value being exceeded only when said element is operating in said second modified range;

e. an output control means; and,

f. means responsive to changing of said capacitor with said second polarity for operating said output control means.

8. A flame detector as defined in claim **7** wherein said second series circuit includes a second resistor with said second resistor having substantially lesser resistance than said first resistor.

9. A flame detector as defined in claim **7** wherein said voltage responsive means includes at least one voltage responsive discharge element.

10. A flame detector for detecting whether a flame is emitted from a burner member, said detector comprising:

a. an electrically conductive element having the property of less resistance when exposed to ultraviolet radiation than when not so exposed, positioned so as to be in operative relationship to a flame emitted from said burner member;

b. a first rectifier and first resistor in series with said conductive element to form a flame responsive unit with unidirectional current properties;

c. an electronic control means having first, second and third electrodes, normally in non-conducting condition;

d. first circuit means including a second resistor for connecting said first and second electrodes and said flame responsive unit in a series circuit across an alternating current circuit of relatively high voltage;

e. second circuit means for connecting said first and third electrodes across an alternating current circuit of lower voltage whereby when flame is emitted from said burner member rectified direct current flows through said first circuit means for causing conduction of said control means;

f. a branch circuit connected in parallel with said first resistor and said first rectifier, said branch circuit comprising in electrical series a second rectifier and voltage responsive means for allowing current flow through said branch circuit when a voltage exceeding a preselected voltage is applied across said parallel branch circuit, said second rectifier being poled oppositely to said first rectifier with respect to current flow through said first circuit means, whereby in the event of a short circuit of said conductive element sufficient current flows through said first resistor to raise the voltage across said voltage responsive means to a value above said preselected value and current flows through said parallel branch circuit in a direction opposite to current flow through said first rectifier.

11. A detector as described in claim **10,** wherein a filter capacitor is provided bridging the circuit of said first and second electrodes to serve with said second resistor as an integrator, bypassing said first and second electrodes to prevent said control means from becoming conductive during, fault of said ultraviolet radiation responsive element.

12. A flame detector for detecting whether a flame is emitted from a burner, said detector comprising:

a. an electrical element positioned in operative relationship to a flame emitted from said burner and having a normal operating impedance range, a first modified impedance range when exposed to radiation, and a second modified impedance range when defectively shorted, with said modified ranges being lower than said normal range and said second modified range being substantially lower than said first modified range;

b. first and second mutually parallel circuits each connected in series with said electrical element;

c. said first parallel circuit comprising a first resistor and a first half wave rectifier means for allowing flow of current in a first direction through said first parallel circuit and said element while said element is operating in any of said impedance ranges;

d. said second parallel circuit comprising a second half wave rectifier means for allowing flow of current in a second direction through said second parallel circuit and said element, said second direction being opposite to said first direction, and voltage responsive means for allowing current flow through said second parallel circuit when a voltage exceeding a preselected voltage is applied across said parallel circuits;

e. voltage supply means for applying an alternating circuit across said elements and said parallel circuits whereby a unidirectional current above a given value and in said first direction flows through said first parallel circuit when said element is operating in either of said first and second modified ranges and unidirectional current flows in a second direction and through said second parallel branch only when said element is operating in said second modified range;

f. an output means having a first condition selected for non-existence of a flame emitted from said burner and a second condition selected for existence of such a flame;

g. control means having a first state created by unidirectional current flow in said first direction and below said given value, a second state created by

unidirectional current in said first direction and above said given value and a third state created by current flow in both of said unidirectional directions;

h. means for shifting said output means into said first condition when said control means is in said first or third state; and,

i. means for shifting said output means into said second condition when said control means is in said second state.

13. A flame detector for detecting whether a flame is emitted from a burner member and comprising:

a. an electrically conductive element having the property of less resistance when exposed to ultraviolet radiation than when not so exposed, positioned so as to be in operative relationship to a flame emitted from said burner member; but insulated therefrom;

b. a rectifier in series with said element to form a flame responsive unit with unidirectional current properties;

c. an electronic control means having first, second and third electrodes, normally in non-conducting condition;

d. circuit means including an integrator comprising:

e. a resistor for connecting said first and second electrodes and said flame responsive unit in a series circuit across an alternating-current circuit of relatively high voltage and second circuit means for connecting said first and third electrodes across an alternating-current circuit of lower voltage whereby when flame is emitted from said burner member rectified direct current flows through said series circuit for causing conduction of said control means; and,

f. a branch circuit in parallel with the unit comprising said resistor and said rectifier, said branch circuit comprising a rectifier and a discharge means in series, said second mentioned rectifier being poled oppositely to the first mentioned rectifier with respect to the first mentioned series circuit, whereby in the event of short circuit of said ultraviolet radiation responsive element sufficient current flows through said resistor to raise the voltage across said discharge means to the discharge level causing alternating current to flow through said first mentioned series circuit.

14. A detector as described in claim **13,** wherein a filter capacitor is provided bridging the circuit of said first and second electrodes to serve with said resistor as an integrator, bypassing said first and second electrodes to prevent the flow of direct current in said first-mentioned series circuit and prevent said control means from becoming conductive during fault of said ultraviolet radiation responsive element.

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