United States Patent

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Continuation-in-part of application Ser. No. 733,920, June 3, 1968, now abandoned.

[54] **FLAME DETECTOR**
23 Claims, 3 Drawing Figs.

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[51] Int. Cl. G08b 17/00
[50] Field of Search 340/227, 228, 228.1; 431/18, 26, 46, 78, 80

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ABSTRACT: A flame detector is disclosed herein for detecting whether a flame is emitted from a burner. The detector includes a sensor, such as a flame rod, and an electrical circuit for providing an indication as to whether a flame is detected. Circuitry is also disclosed for checking the detector circuitry for component malfunctions or actual flame conditions during a safe start time delay period.

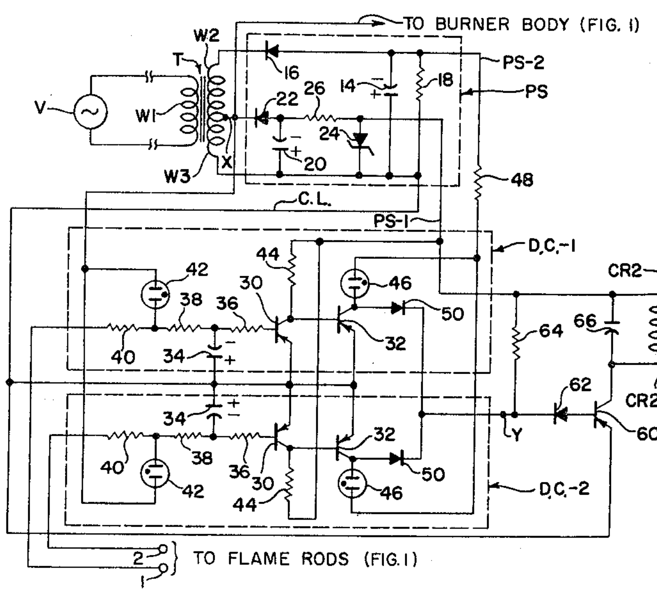
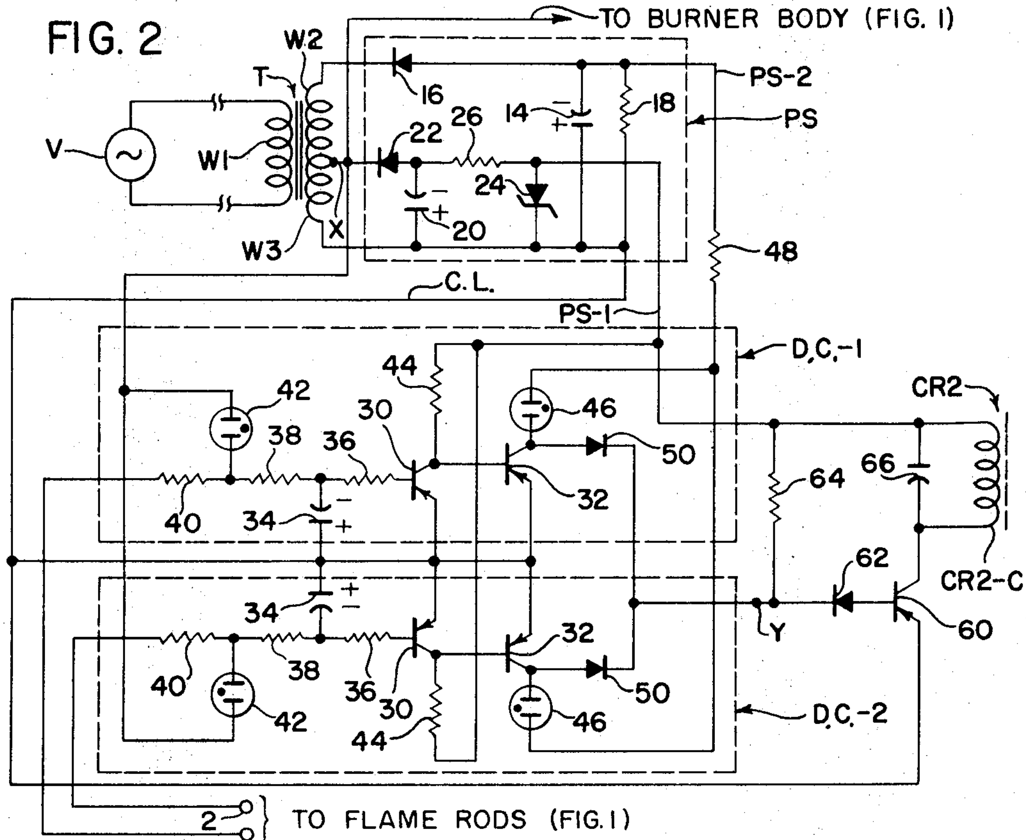


FIG. 2



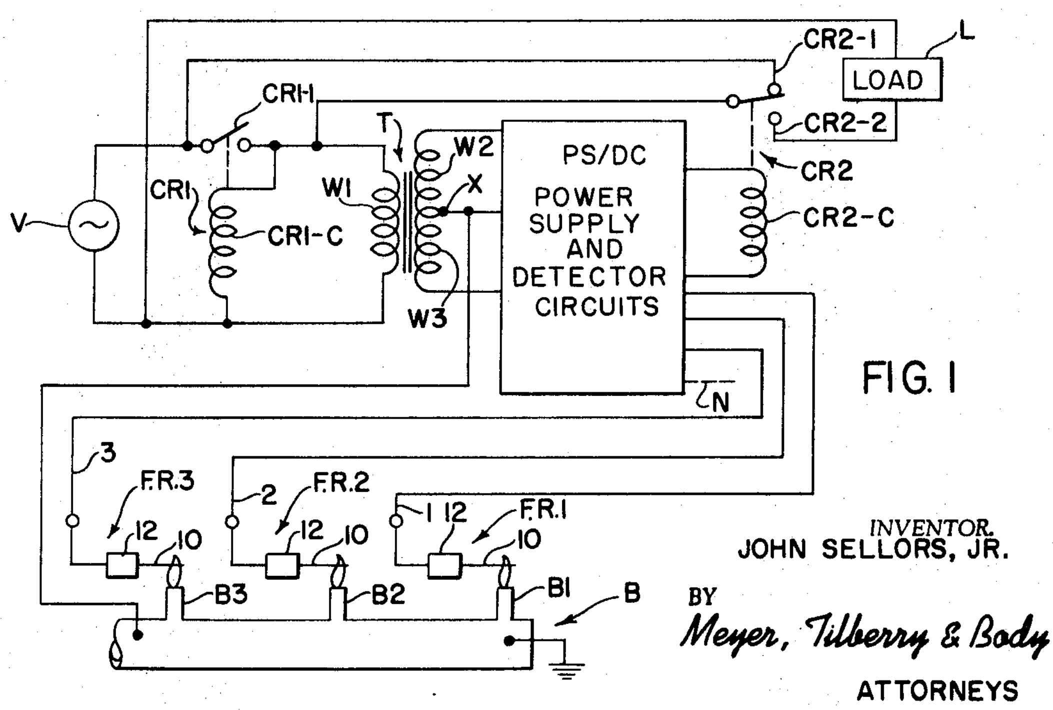


FIG. 1

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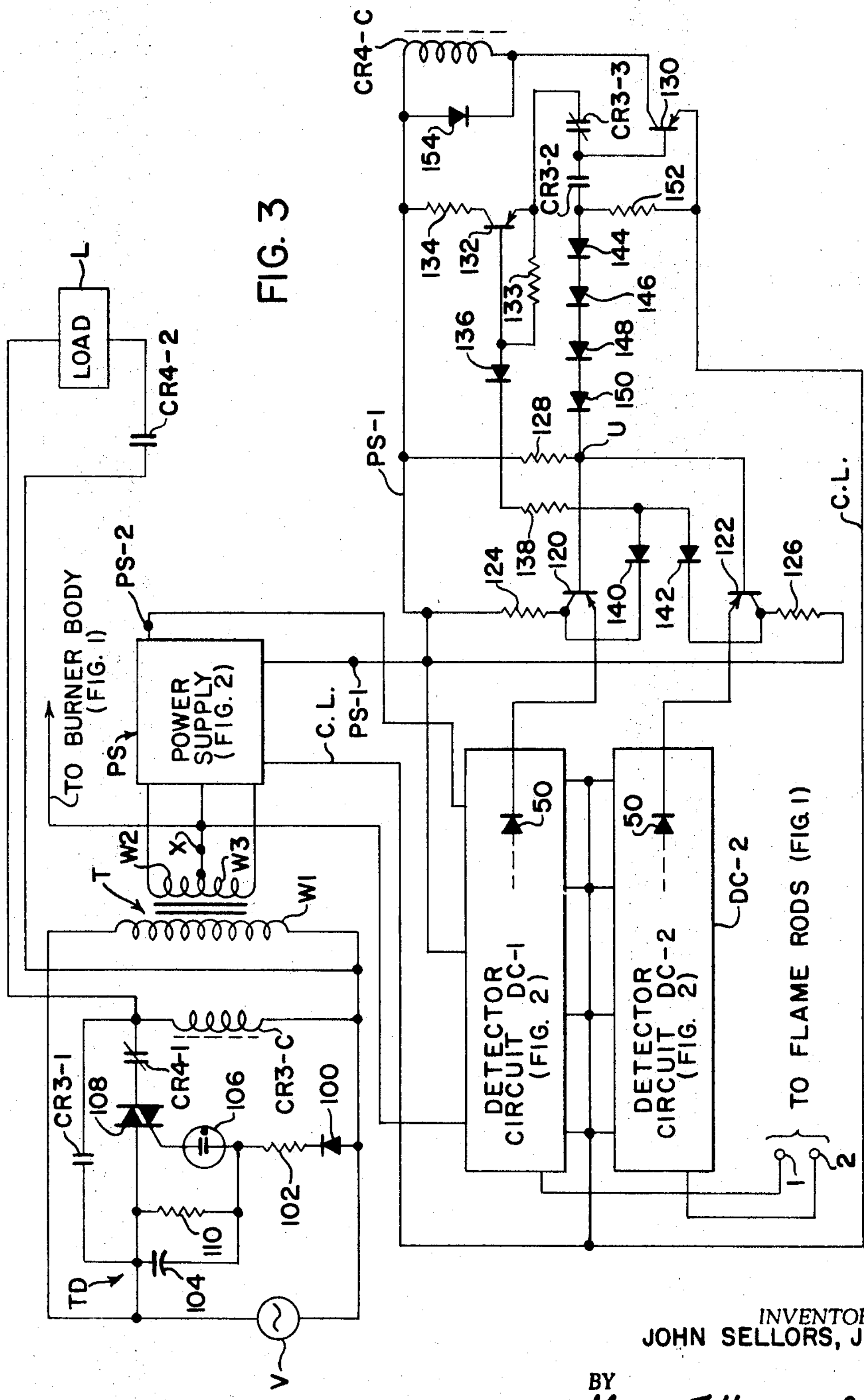

FIG. 3

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FLAME DETECTOR

This is a continuation-in-part of my copending application, Ser. No. 733,920, filed on June 3, 1968, and entitled Flame Detector, which application has been abandoned.

This invention relates to the art of flame detection and, more particularly, to an improved flame detector as well as to a multiple burner, flame failure detector.

Flame detectors are frequently used to sense the flame conditions of a burner, and if flame failure occurs to provide an indication thereof. These detectors normally include a sensor, such as a photocell or a flame rod, together with an electrical detector circuit. Many of these circuits are designed so as to use either a photocell or a flame rod as the sensor and, accordingly, the operating voltage requirements must be sufficiently high to provide operating potential for the photocell.

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 the 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 in the series circuit to charge the capacitor. The value of the voltage stored by the capacitor is reflected 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 the first stage. Thus, the first stage become nonconductive causing the second stage to become conductive, providing an indication that flame is present.

Such prior art flame failure detector circuits require 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 malfunction, the first stage may inadvertently become nonconductive, causing the second stage to become conductive, thereby providing a false indication of a flame condition.

Another problem noted with prior art flame failure detector circuits is that complete detector circuit is associated with each burner. Thus, in the example given above, the second stage of each detector circuit is coupled to an associated relay for controlling a load, dependent on the flame condition of the associated burner. In a multiple burner application, the expense required to provide a complete circuit for each burner is considerable.

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 failure detector for overcoming the aforementioned difficulties of such previous flame failure detectors.

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: an elongated electrically conductive flame rod positioned so as to be within a flame emitted from the burner member; electronic control means, such as a semiconductor, having first, second and third electrodes, the burner member, and the flame rod in a series circuit across an alternating current voltage source, whereby when flame is emitted from the burner member, flame rectified direct current flows through the series circuit; and, an output circuit controlled by the electronic control means for providing an indication as to whether a flame is present.

In accordance with another aspect of the present invention, a multiple burner flame failure detector is provided for detecting flame failure of at least one of a plurality of burners and comprising: a plurality of individual flame detector circuit means, each associated with one of the burners and having a "flame on" condition in accordance with the actual condition existing at its associated burner; and, a common output circuit coupled to and controlled by all of the flame detector circuit means for providing an output indication only when all of the flame detector circuit means are in a particular one of the noted conditions.

In accordance with another aspect of the invention, circuitry is provided for detecting a detector circuit "flame on" indication, due to a component malfunction or an actual flame condition, during a safe start time delay period.

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

Another object of the present invention is to provide an improved flame detector wherein the operating voltage level required for the detector circuit is well below line voltage.

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

A still further object of the present invention is to provide a flame detector wherein flame presence detection requires that a detector circuit detect the presence of flame rectified current.

A still further object of the present invention is to provide a multiple burner flame failure detector circuit having a common output load control circuit.

Another object of the invention is to provide circuitry for detecting a "flame on" condition, arising from either a component malfunction or actual flame condition, during a safe start time delay period.

The foregoing and other objects of the invention will become more readily apparent from the following description of the preferred embodiment of the invention taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a combined block diagram, schematic illustration of the invention as shown in conjunction with a multiple burner application;

FIG. 2 is a schematic illustration of the circuitry used with the application illustrated in FIG. 1; and

FIG. 3 is a schematic illustration of the circuitry of a second embodiment of the invention.

GENERAL DESCRIPTION

Referring now to the drawings wherein the showings are for purposes of illustrating a preferred embodiment of the invention only, and not for purposes of limiting same, FIG. 1 illustrates a multiple burner application of the present invention, and which comprises: flame rods FR1, FR2, FR3 located so as to be within the gaseous flame emitted from burners B1, B2 and B3 of a metal burner B; an electronic control package incorporating a power supply and detector circuits PS/DC which are coupled to the flame rods; an alternating current voltage source V coupled to electronic circuits PS/DC by means of a transformer T; and, a common output relay CR2 for coupling a load L across voltage source V. Each of the flame rods FR1, FR2 and FR3 incorporates an electrically conductive electrode **10** constructed of a high-temperature alloy, and which is approximately one-eighth inch in diameter, and extends through a porcelain insulator **12**. Burner circuits **1**, **2** and **3** electrically connect electrodes **10** of flame rods FR1, FR2, and FR3, respectively to the electrical package PS/DC. The operating temperature of the flames emitted from burners B1, B2 and B3 is on the order to 1600 F. to 3000° F., and the flame is gaseous. The ratio of the burner area face to area of flame rod in contact with the flame is preferably on the order of 4 to 1.

The alternating voltage source V may take the form of line voltage, on the order of 120 volts, 60 cycles. Voltage source V is coupled across the primary winding W1 of transformer T through normally open relay contacts CR1–1 of a relay CR1. 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. Tap X is also electrically connected to a burner body B.

Briefly, when power is applied to the circuit, 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 25 volts is applied between the burner body B and flame rod electrodes 10. So long as a flame is emitted from each of the burners B1, B2, B3, relay coil CR2–C is energized to close contacts CR2–2 and thereby energize load L, which, for example, may take the form as a gas safety shutoff valve.

POWER SUPPLY

Reference is now made to FIG. 2 wherein the power supply PS is schematically illustrated. As shown, power supply PS includes a capacitor 14 connected across winding portions W2 and W3 by means of a diode rectifier 16, poled as shown. 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 a common line CL which extends through the detector circuits DC–1 and DC–2. The junction of resistor 26 and Zener diode 24 is connected to a power supply line PS–1, which provides a direct current level on the order of –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 on the order of –90 volts

DETECTOR CIRCUITS

Flame detector circuits DC–1 and DC–2 are identical, and like components are hereinafter identified with like character references. The description that follows is made with reference to detector circuit DC–1.

As shown in FIG. 2, detector circuit DC–1 includes a two-stage detector circuit incorporating PNP transistors 30 and 32. These two transistors have their emitters connected together and, thence, to the common line CL. A filter capacitor 34 is connected between the common line CL 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 burner circuit 1 and, thence, to flame rod FR1 (see FIG. 1). The junction of resistors 38 and 40 is connected through a neon lamp 42 and thence to tap X on transformer T. The collector of transistor 30 is connected to the base of transistor 32 and is also connected through a resistor 44 to power supply line PS–1. The collector of transistor 32 is connected through a neon lamp 46 and thence through a common 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 the output circuit point Y.

It will be appreciated that diodes 50 circuits DC–1, DC–2, and all other detector circuits in accordance with the number of burners being monitored, have their cathodes connected together in common with point Y, and hence define an AND circuit. Preferably, two detector circuits, such as detector circuits DC–1 and DC–2, are connected together as shown in FIG. 2, on a single printed circuit card. Then, depending upon the number of printed circuit cards used, they will all be interconnected with each other so that the cathodes of all diodes 50 are connected to point Y. The power supply inputs for all the remaining printed circuit cards are connected to common line CL and power line PS–1, PS–2, in the manner as indicated for the circuits shown in FIG. 2.

COMMON OUTPUT CIRCUIT

The common 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 supply means, particularly so if a triac is substituted for transistor 60. As shown, however, transistor 60 has its emitter connected to the common line CL and its base connected through a diode 62, poled as shown, to point Y. Point Y is also connected through a resistor 64 to power supply line PS–1. 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, current will flow from source V through normally closed relay contacts CR2–1 to energize 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 circuits DC–1 and DC–2. Accordingly, transistors 30 are reverse biased and nonconductive. Transistors 32 is the detector circuits DC–1 and DC–2 will be forward biased through resistors 44 to power supply lines PS–1. These transistors will conduct, and, assuming transistor saturation, diodes 50 will be forward biased clamping point Y to essentially saturation potential existing on the collectors of transistors 32. The forward voltage drop of diodes 50 is on the order of 0.6 volts and, hence, point Y is essentially at 0.8 volts positive. This potential is insufficient to forward bias PNP transistor 60.

If a flame is emitted from burner B1, then negative polarity flame rectified current is obtained and applied to filter capacitor 34 which commences to charge in accordance with the polarity indication shown in FIG. 2, so as to forward bias transistor 30 into conduction. The time constant of the filter capacitor 34 and the resistor 38 is long in comparison with the 60-cycle per second alternating voltage so as to provide an integrating effect and delay in actuation of the transistor 30. Thereafter, flame rectified current will flow from common line CL, through the emitter to base electrodes of transistor 30, and thence through resistors 36, 38 and 40, burner circuit 1, flame rod FR1, the flame and metal burner B. So long as this flame rectified current flows, transistor 30 is conductive so that its collector potential is essentially clamped to that of the common line potential, whereupon transistor 32 becomes reversed biased. This removes the previous low positive potential at point Y, providing that the same conditions exist at each of the other detector circuits; to wit, that a flame is emitted from each of the monitored burners. 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 contacts CR2–2 to become closed to energize load L, which, as discussed before, may take the form of suitable alarms or shutoff valves or timers, as desired by the user.

If for some reason flame failure occurs at burner B1, transistor 30 in detector circuit DC–1, 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 point Y is returned to a potential of essentially that existing on the common line CL and, as stated before, this potential is insufficient to maintain transistor 60 forward biased. Thus, transistor 60 will become reverse biased, causing relay CR2 to become deenergized. As transistor 32 becomes forward biased and conductive, a series circuit is completed from common line CL, through the emitter to collector path of transistor 32, neon lamp 46 and resistor 48 to the power supply line PS–2, which, as stated before, provides a negative potential on the order of 90 volts. As is well known, a neon lamp, such as lamp 46, normally presents a high resistance to current flow therethrough until a voltage of sufficient magnitude is applied thereacross, 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 transistor 32 conducts, essentially of the voltage is applied across the neon lamp, whereupon the lamp fires. Resistor 48 has a resistance value on the order to 47 kilohms and, accordingly, after the lamp 46 fires, approximately 15 volts is obtained across resistor 48, leaving 75 volts for application across neon lamp 46.

If a second burner has a subsequent flame failure condition, only 75 volts is available for application across the neon bulb associated with its detector circuit. This is insufficient to fire the neon lamp in the second detector circuit. Accordingly, it is seen from the foregoing description that the first burner failure will result in energization of neon lamp 46 in its associated detector circuit. Only that neon lamp will be energized regardless of how many additional flame failures occur.

Neon lamp 42 in each detector circuit serves as voltage protective means to prevent damage to capacitor 34 and transistor 30 in the associated detector circuit. Thus, in the event that the electrode 10 of flame rod FR1 is short-circuited to burner B1, or for any other reason a short high flame rod voltage occurs (such as ignition voltages), neon lamp 42 breaks down and, along with current limiting resistor 40, a circuit is obtained to pass the harmful short circuit current to the burner body, and thereby prevent burnout of capacitor 34 and transistor 30.

The embodiment of the invention illustrated in FIGS. 1 and 2 operated quite satisfactorily during test conditions. The values of the components shown in these two drawings is 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
Capacitors 34	10 microfarads, 6 volts
Resistor 18	15 kilohms
Resistor 44	1 megohm
Resistors 36, 38, 64	100 kilohms
Resistor 40	2.2 kilohms
Resistor 26	470 ohms
Resistor 48	47 kilohms

SECOND EMBODIMENT

Reference is now made to FIG. 3 which illustrates a second of invention. Much of the circuitry in this embodiment is identical to that CL, in FIGS. 1 and 2, and, accordingly, like components are identified with like reference characters for purposes of simplifying the understanding discussed contacts of the invention. This embodiment employs the power supply circuit PS as well as detector circuits DC–1 and DC–2, all identical to that as shown in FIG. 2. Briefly, this embodiment further includes a time delay circuit TD together with logic circuitry coupled between the outputs of the detector circuits DC–1, and DC–2 and a flame relay coil CR4–C.

The time delay circuitry TD includes a diode 100 connected in series with a resistor 102 and a capacitor 104 across voltage source V. A neon lamp 106 is connected from the junction of the capacitor 104 and resistor 102 to the gate of a triac 108. A resistor 110 is connected in parallel with capacitor 104. Triac 108 is connected in series with normally closed relay contacts CR4–1, of the flame relay, and coil CR3–C, of a safe start relay. Normally open relay contacts CR3–1, are connected in parallel with the series circuit of triac 108 and relay contacts CR4–1. In this embodiment, transformer T is directly coupled across voltage source V. Normally open flame relay contacts CR4–2 serve to connect load L, which may take the form of a main valve, across the safe start relay coil CR3–C.

In this embodiment, the cathodes of diodes 50 in detector circuits DC–1 and DC–2 are not connected together. Instead, the cathode of diode 50 in circuit DC–1 is connected to the emitter of a transistor 120 and the cathode of diode 50 in circuit DC–2 is connected to the emitter of a transistor 122. The collector of transistor 120 is connected through a resistor 124 to the power supply line PS–1. Similarly, the collector of transistor 122 is connected through a resistor 126 to the power supply line PS–1. The base electrodes of transistors 120 and 122 are connected together in common at point U and thence through a resistor 128 to power supply line PS–1.

The flame relay coil CR4–C is connected between power supply line PS–1 and the collector of a transistor 130, having its emitter connected to the common line CL. The base of transistor 130 is connected through normally closed relay contacts CR3–3 and thence to the emitter of a transistor 132. The collector of transistor 132 is connected through a resistor 134 to power supply line PS–1. The base of transistor 132 is connected through a diode 136, poled as shown, and thence through a resistor 138, which is commonly connected to the anodes of diodes 140 and 142. The emitter of transistor 132 is also connected to the cathode of diode 136 through a resistor 133. The cathodes of diodes 140 and 142 are respectively coupled to the collectors of transistors 120 and 122. The base of transistor 130 is also connected through normally open contacts CR3–2 and thence through series connected diodes 144, 146, 148, and 150, poled as shown, to point U. A resistor 152 connects the junction of normally open contacts CR3–2 and diode 144 to common line CL. A surge suppressing diode 154 is connected across relay coil CR4–C.

OPERATION OF SECOND EMBODIMENT

After power is applied to the circuit, and prior to flame being emitted from the burners, current will flow from voltage source V and be sufficiently rectified by diode rectifier 100 to provide direct current for the time delay circuit TD. When the voltage stored by capacitor 104 reaches approximately 80 volts, neon tube 106 will become conductive and apply a trigger pulse of sufficient magnitude and duration to gate triac 108 into conduction. So long as the flame relay coil CR4–C has not been energized, alternating current will flow through the triac 108 and normally closed contacts CR4–1 to energize the safe start relay coil CR3–C. The time delay from application of power to the circuit and energization of relay coil CR3–C may be adjusted as desired, and, for example, may be on the order of 4 seconds. Once relay coil CR3–C becomes energized, its normally open contacts CR3–1 close to shunt the time delay circuit TD. If relay coil CR4–C becomes energized during the time delay period, as upon detection of a flame or a component malfunction in the detector circuitry, then normally closed contacts CR4–1 will open, preventing energization of safe start relay coil CR3–C. The circuit must then be reenergized and recycled in order to apply alternating voltage to load L.

During the safe start time delay period, power from source V is applied to the power supply circuit PS and its output leads CL, PS–1 and PS–2 provide operating power for the detector circuits DC–1 and DC–2 in the same sense as discussed hereinbefore with reference to FIG. 2. If through a component malfunction of any of the detector circuits, or if a flame is actually present at any one of the monitored burners during this safe start operation, relay coil CR4–C will become energized to prevent energization of safe start relay coil CR3–C. Thus, for example, if the output of diode 50 from detector circuit DC–1 is indicative of a "flame on" condition, then an OR gate made up of the circuitry including normally closed relay contacts CR3–3, transistor 132, resistor 133, diode 136, resistor 138 and diode 140 will be conductive to forward bias transistor 130 into conduction. This, of course, will energize relay coil CR4–C. If a circuit malfunction exists in detector circuit DC–1, or a flame is being detected by this circuit during the safe time delay period, then diode 50 will be forward biased sufficiently to forward bias transitor 120 into conduction. This will lower the potential on the collector of transistor 120 sufficient to forward bias diode 140, and thereby also forward bias transistors 132 and 130. Consequently, current will flow through the emitter of collector of transistor 130 to energize relay coil CR4–C. Energization of relay coil CR4–C causes its normally closed contacts CR4–1 to open, thereby preventing energization of the safe start relay coil CR3–C upon completion of the time delay period.

In the event there is no circuit malfunction indicative of a flame condition, or not actual flame condition exists at any of the monitored burners during the safe start period, then diode 50 in each circuit DC–1, DC–2, etc., will be reverse biased. During such condition, the voltage drop across resistors 124, 126, etc., is sufficient that the potential of the collectors of transistors 120, 122, etc., is not sufficiently negative to forward bias diodes 140 and 136 as well as transistors 132 and 130 in the OR gate. Consequently, transistors 132 and 130 remain reverse biased and the flame relay coil CR4–C remains in its deenergized condition.

The operation which ensues once the relay coil CR3–C has been energized is essentially the same as that discussed hereinbefore with reference to the embodiment shown in FIGS. 1 and 2. Consequently, only the differences resulting from the circuitry changes shown in FIG. 3 will be discussed hereinafter in detail.

Once relay coil CR3–C has become energized its normally open contacts become closed and its normally closed contacts become open to thereby deactivate the safe start time delay circuit TD and the OR gate logic circuitry. If no flame is detected by any of the detector circuits DC–1, DC–2, etc., then all of the diodes 50 associated with detector circuits DC–1, DC–2, are forward biased to, in turn, forward bias their associated transistors 120, 122, etc. Since all of the transistors 120, 122, etc., are forwardly biased and conductive, the potential at point U will be sufficiently positive that the forward drop from common line CL to point U is not sufficient to exceed the forward voltage drop of series connected diodes 144, 146, 148 and 150. Consequently, transistor 130 remains reverse biased and flame relay coil CR4–C remains deenergized.

So long as a flame is detected by all detector circuits DC–1, DC–2, etc., then all of the diodes 50 associated therewith will be reversed biased and thereby maintain transistors 120, 122, etc., reverse biased. Consequently, the potential at point U becomes sufficiently negative with respect to that existing on the common line CL to exceed the forward voltage drop of series diodes 144, 146, 148 and 150. Therefore, transistor 130 is forward biased into conduction and current will flow through its emitter to collector electrodes to energize flame relay coil CR4–C. So long as relay CR4–C remains energized, load L will be energized by the voltage source v. In the event that any of the detector circuits DC–1, DC–2, etc., detects a no flame condition, then the transistors 120, 122, etc., associated therewith will become forward biased to thereby increase the potential at point U in a positive direction sufficient that the forward voltage drop is insufficient to maintain transistor 130 forward biased and conductive.

The embodiment of the invention illustrated in FIG. 3 operated quite satisfactorily during test conditions. The values of the components shown in FIG. 3, and not previously referred to with respect to FIGS. 1 and 2, are listed below in TABLE II.

TABLE II

Resistor 102	47 kilohms
Resistor 134	100 kilohms
Resistors 133, 138	33 kilohms
Resistors 110, 124, 126, 152	1 megohm
Resistor 128	220 kilohms
Capacitor 104	50 microfarads, 100 volts
Diode 100	200 piv at 250 milliamperes
Diodes 136, 140, 142 144, 146, 148, 150, 154	40 piv at 10 milliamperes

Although this invention has been shown 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 requirements without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A flame detector for detecting whether a flame is emitted from an electrically conductive burner member and comprising:
- an elongated electrically conductive flame rod positioned so as to be within a flame emitted from said burner member;
- electronic control means having first, second and third electrodes normally in nonconducting condition;
- circuit means for connecting said first and second electrodes, said burner member and said flame rod in a series circuit across an alternating current voltage source, whereby when flame is emitted from said burner member, flame rectified direct current flows through said series circuit for causing conduction of said control means; and
- output means controlled by conductive condition of said electronic control means for providing an indication as to whether flame rectified direct current flows through said series circuit.

2. A flame detector as set forth in claim 1 including filtering means for filtering said flame rectified direct current.

3. A flame detector as set forth in claim 2 including circuit means coupling said filtering means to said electronic means in such a manner to bias said electronic means into conduction when a said flame is present.

4. A flame detector as set forth in claim 1 wherein said series circuit is coupled across a voltage stepped down secondary winding portion of a transformer having its primary winding connected across an alternating current line voltage source, whereby the value of the alternating current voltage applied between said burner body and said flame rod is substantially less than that of said line voltage source.

5. A flame detector as set forth in claim 1, wherein said output means includes energizable load control means for operating a load and gating means for energizing said load control means when a said circuit is conductive, indicative of a "flame on" condition.

6. A flame detector as set forth in claim 5, including timing means for timing a safe start period and logic circuit means operative during said period to actuate said gating means and, hence, said energizable load control means upon detection of a "flame on" condition, and circuit disconnect means operative only during said safe start period in response to energization of said load control means to prevent operation of said load.

7. A flame detector for detecting whether a flame is emitted from an electrically conductive burner member and comprising:

an elongated electrically conductive flame rod positioned so as to be with a flame emitted from said burner member;

electronic control means having first, second and third electrodes;

circuit mans for connecting said first and second electrodes, said burner member and said flame rod in a series circuit across an alternating current voltage source, whereby when flame is emitted from said burner member, flame rectified direct current flows through said series circuit;

output means controlled by said electronic control means for providing an indication as to whether a said flame is present in accordance with whether flame rectified direct current flows through said series circuit; and

circuit protective means to prevent alternating current from being applied to said electronic control means when said flame rod is short circuited to said burner.

8. A flame detector as set forth in claim **7** wherein said protective means includes a neon lamp coupled between said flame rod and said burner body.

9. A multiple burner flame failure detector for detecting flame failure of at least one of a plurality of burners and comprising: a plurality of individual flame detector circuit means, each associated with one of said burners and having a "flame on" condition and a "flame off" condition in accordance with the actual condition existing at its associated burner; and

common output circuit means coupled to and controlled by all of said flame detector circuit means for providing an output indication only when all of said flame detector circuit means are in a particular one of said conditions.

10. A multiple burner flame failure detector as set forth in claim **9**, wherein said common output circuit means includes energizable load control means for controlling a load and gating means for energizing said load control means when all of said flame detector circuit means are in said particular condition.

11. A multiple burner flame failure detector as set forth in claim **10** wherein all of said flame detector circuit means are coupled to said common output circuit means by circuit means defining an AND circuit.

12. A multiple burner flame failure detector as set forth in claim **11** wherein said AND circuit has a plurality of inputs, each coupled to one of said flame detector circuit means, and an output coupled to said gating means in said common output circuit means.

13. A multiple burner flame failure detector as set forth in claim **10** wherein said load control means includes means for switching an alternating current voltage source across a load.

14. A multiple burner flame failure detector as set forth in claim **10** wherein said load control means includes a relay coil having contacts for switching a voltage source across a load and said gating means includes a transistor having its emitter-collector circuit connected in series with said relay coil.

15. A multiple burner flame failure detector as set forth in claim **10** including timing means for timing a safe start period and logic circuit means operative during said period to actuate said gating means when any one of said detector circuit means is in a "flame on" condition to thereby energize said load control means, and circuit disconnect means operative only during said safe start period in response to energization of said load control means to prevent operation of said load.

16. A multiple burner flame failure detector as set forth in claim **10** wherein each said flame detector circuit means has an output circuit connected in parallel with the output circuits of said other flame detector circuit means;

a common resistance circuit connected in series with each of said output circuits across a voltage source;

each said output circuit including an impedance means connected in series with an electronic control means for conducting current from said source only when its flame detector circuit means is in a "flame off" condition, said impedance means exhibiting the characteristic of presenting a relatively high impedance to current flow therethrough until a voltage of at least a given value is applied thereacross, at which time said impedance means exhibits a relatively low impedance to current flow therethrough;

said resistance circuit having sufficient resistance so that when a said electronic control means of a first of said output circuits is conducting the value of the voltage applied across said impedance means is at least said given value to cause said impedance to have a said low resistance and thereafter the voltage applied across each of said parallely connected output circuits is below said given value.

17. A multiple burner flame failure detector as set forth in claim **16** wherein each said impedance means includes a neon lamp, whereby the neon lamp associated with the flame detector circuit means that first exhibits a "flame off" condition becomes energized to provide a visual indication and the remaining neon lamps are deenergized.

18. A multiple burner flame failure detector as set forth in claim **9** wherein each said burner is an electrically conductive member and each said flame detector circuit means includes:

an elongated electrically conductive flame rod positioned so as to be within a flame emitted from its associated burner;

electronic control means having first, second and third electrodes; and

circuit means for connecting said first and second electrodes, said burner and said flame rod in a series circuit across an alternating current voltage source, whereby when flame is emitted from said burner, flame rectified direct current flows through said series circuit.

19. In a flame detector system for detecting flame conditions In at least one burner and having a flame detector circuit associated therewith, said flame detector circuit having a "flame on" condition and a "flame off" condition in accordance with the actual condition existing at said burner, a voltage source, an output circuit for connecting said source with a load for energization thereby; the improvement for preventing energization of said load during a safe start time delay period and comprising:

circuit means for timing a safe start time delay period; logic circuit means operative only during said time delay period to provide an output signal when said detector circuit is in a "flame on" condition;

first actuatable switching means having a normal current passing condition connected in series with said source and said load; and

control means responsive to said output signal to actuate said switching means to a current blocking condition to prevent energization of said load.

20. In a flame detector system as set froth in claim **19** including a second normally nonconductive actuatable switching means connected in series with said voltage source and said first switching means, and said timing means provides a trigger signal upon completion of said time delay period for actuating said second switching means into conduction.

21. In a flame detector system as set forth in claim **20** wherein said source is an alternating current voltage source and said second switching means is a triac.

22. In a flame detector system as set forth in claim **20** including means for electrically shunting said first and second switching means upon completion of said safe start time delay period.

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

a flame responsive unit with unidirectional current properties and relatively low resistance when flame is present, positioned so as to be in operative relationship to a flame emitted from said burner member;

an electronic control means having first, second and third electrodes, normally in nonconducting condition

circuit means including a resistor for connecting said first and second electrodes and said flame responsive unit in a series circuit across an alternating voltage source;

a filter capacitor bridging the circuit of said first and second electrodes to serve with said resistor as an integrator, the capacitor and resistor having a long time constant in relation to the frequency of the alternating voltage, whereby when flame is emitted from said burner member, rectified direct current starts to flow through said series circuit for causing delayed conduction of said control means.