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[54] **IONIC FLAME MONITOR**

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[51] **Int. Cl.** **G08b 21/00**
[58] **Field of Search** .... 307/117; 328/6; 340/228.2, 228.1, 228 R

[56] **References Cited**

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2,766,440 10/1956 Marsden .... 340/228 R
3,437,884 4/1969 Mandock et al. .... 307/117 X

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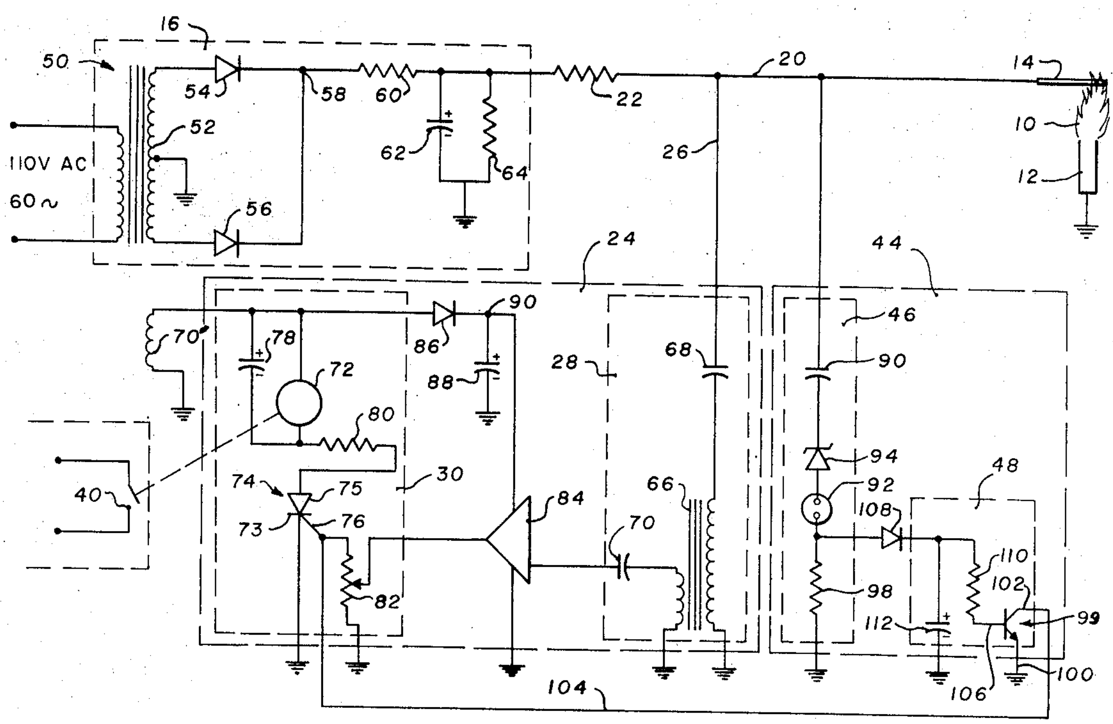
[57] **ABSTRACT**

A protection circuit for an ionic flame monitor to insure that high voltage AC signals appearing across the flame electrodes and arising from sources other than a flame will not be effective to provide a false output indication of flame presence. The flame monitor is sensitive to AC signals above a certain frequency or above a certain voltage to indicate flame presence. Non-flame AC signals having voltages above or below the certain frequency, but above the certain voltage are prevented from indicating flame presence if their voltage is above a second certain level which is above that of most flame signal voltages.

A voltage level detection circuit clamps the monitor output circuitry to a "no-flame" condition whenever the AC signal voltage is above the second certain level.

7 Claims, 4 Drawing Figures



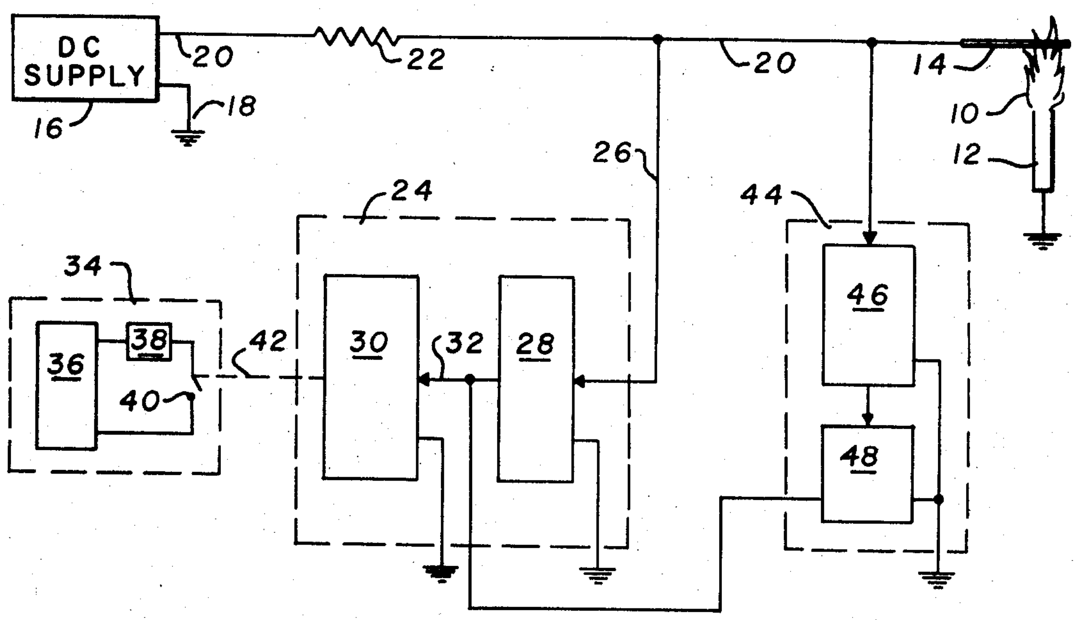


FIG. 1

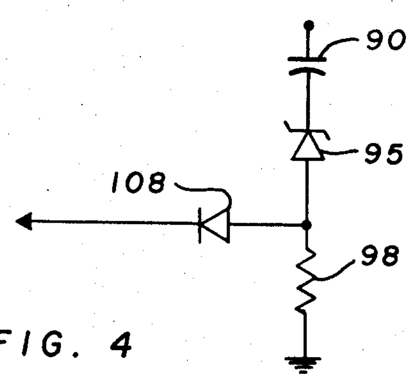


FIG. 4

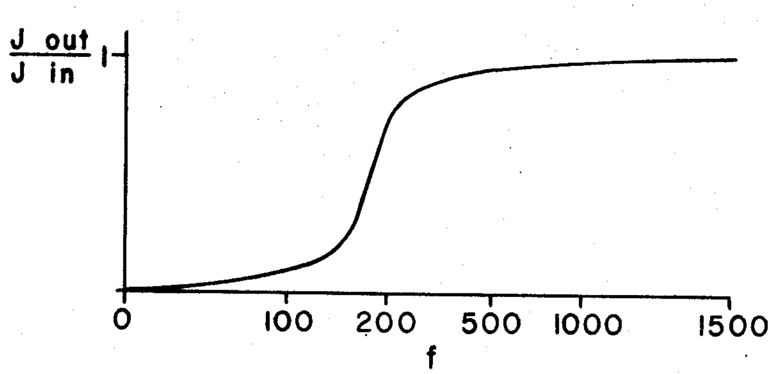


FIG. 3

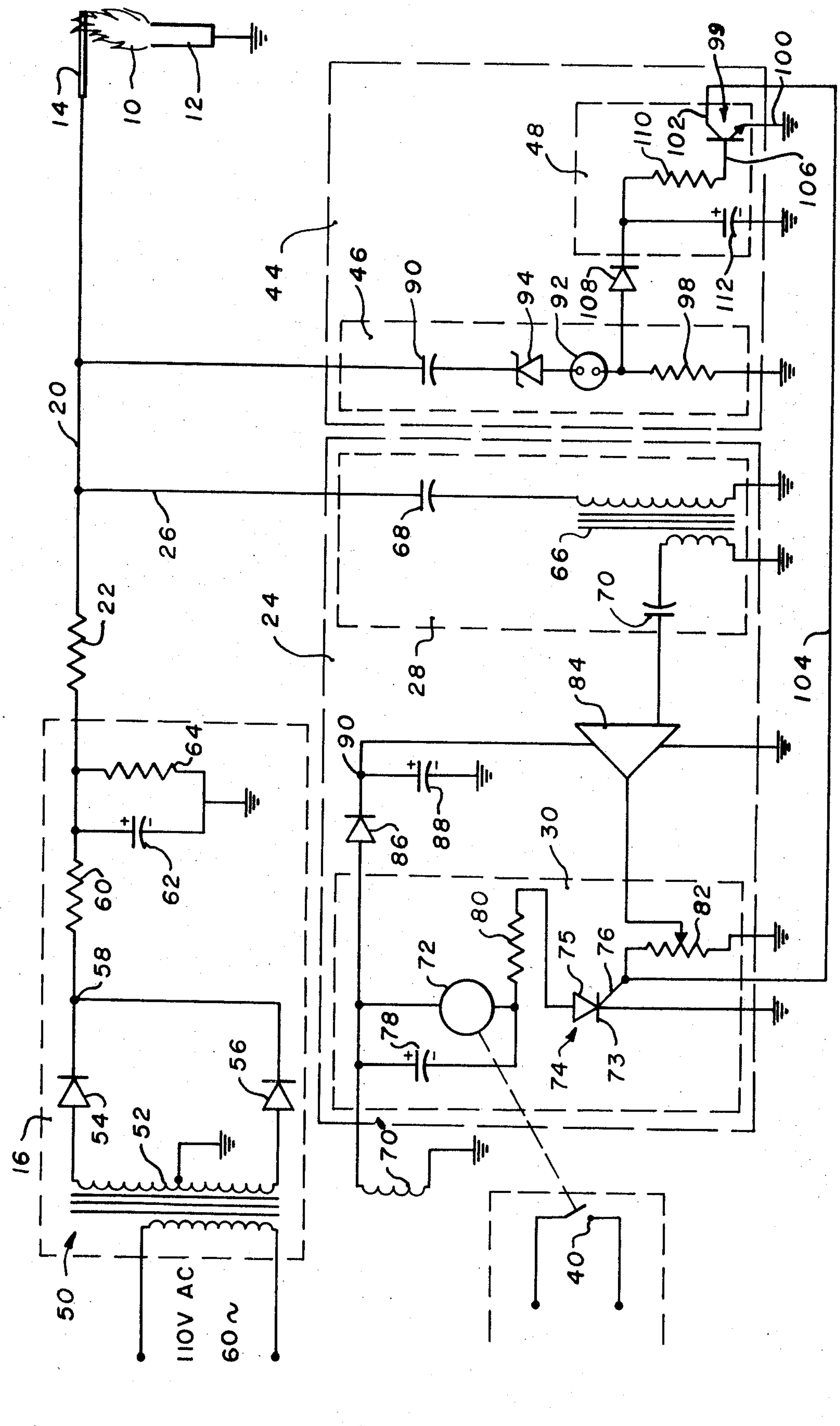


FIG. 2

IONIC FLAME MONITOR

BACKGROUND OF THE INVENTION

The invention relates to flame monitors and more particularly to flame monitors of a type which use the principle of flame ionization for determining the presence or absence of a flame.

In many applications, including both home and industry, flame combustion of fuels is used as a source of heat. It is essential in most such applications, in the interests of safety and economy, that there be at no time a sizable accumulation of unburned fuel in the combustion zone (such as might occur upon flame failure or initial failure of the fuel to ignite). Such unburned fuels may be ignited due to spurious causes and precipitate an explosion. There are available today various types of flame monitors or detectors for indicating flame failure and preventing the resulting buildup of the potentially hazardous condition. These flame monitors may be light sensitive devices or they may respond to differential pressures within a combustion chamber or they may rely upon the electrical properties of the flame to provide an indication of flame presence or absence.

The latter mentioned technique of flame monitoring has various advantages which have lead to its increased usage. More particularly, flame monitors have been developed which exploit the fact that an ionizing process occurs within the flame due to the fuel combustion. In the combustion process, excess energy is liberated by the combining of two or more elements to form a compound with a lower potential energy level. Ions, taking the form of electrons and positive atom nuclei, are formed by the heat of the combustion process. High speed photography has shown that most flames do not burn in a continuous uniform manner, but rather as many tiny discreet packets, the sum total of which form the flame seen by the eye. In each of these burning packets is a collection of ions having positive and negative potentials.

If an electrical potential, preferably a DC potential, is placed across the flame, an AC current will be generated. The AC current so generated may be used to develop a flame signal which is subsequently used to indicate the presence or absence of flame. An early example of this utilization of the AC voltage fluctuations generated by the action of a flame between a pair of spaced electrodes will be found in U.S. Pat. No. 2,766,440 issued Oct. 9, 1956 to R. S. Marsden.

More recently, ionic flame monitors have been developed which exploit the fact that the AC voltage fluctuations generated by the flame are rich in frequencies within a particular range. Signal analysis has revealed that the flame generated AC signal is particularly rich in frequencies within the range from 200 Hz to 2,000 Hz. This characteristic of the flame generated AC signal has permitted the development of flame monitors which attempt to recognize only a particular range of flame signal frequencies as being indicative of flame presence, and thereby preclude the possibility of a false external signal at a different frequency, for instance 60 Hz line voltage, being sensed as an indication of flame presence. This type of ionic flame detector typically uses some form of frequency discriminator connected intermediate the flame electrodes and the flame switch in the output circuitry of the monitor to pass, to the switch, flame signal energy within the range of frequencies most common in a flame and to reject or strongly

attenuate other signal frequencies, such as stray 60 Hz currents.

However, these frequency discriminators are often effective for this purpose only within a limited range of input voltages and may pass sufficient signal energy to indicate flame presence when the strength of the signal applied to the discriminator is of extremely high magnitude, even though the frequency of the applied signal may be within the normal rejection or attenuation range. This problem may arise with flame monitors operating in a region where 60 Hz line voltage and second harmonic components thereof are present. Also, instances may occur in which AC voltages appear at the input to the frequency discriminator and have frequency characteristics similar to those generated by a flame but are of a larger amplitude than the flame signal generated by a flame. These false signals may arise due to high voltage, high frequency noise associated with ignitor spark plugs and they may also arise through 60 Hz line voltage appearing across the flame electrodes because of electrical leakage or a direct short in the line supply system. In these such instances the frequency discriminator passes false triggering energy to the flame switch because the input signal amplitude is above its rejection capabilities. When this occurs, the flame monitor output circuitry will respond in a manner commensurate with flame presence, when in fact there may be no flame present. Obviously, such an occurrence may have dangerous consequences.

therefor, it is an object of the present invention to provide an ionic flame monitor which will accurately indicate and/or respond only to an AC signal of the frequency and magnitude actually generated by a flame and will indicate flame absence at all other times including those in which high voltage signals from sources other than a flame are passed by the frequency discriminator.

SUMMARY OF THE INVENTION

According to the invention, there is provided a flame monitor for determining the presence or absence of a flame within a flame zone through detection of a flame generated AC voltage. A pair of electrodes or flame rods are spaced apart from one another and disposed within the flame zone such that they are in contact with the flame when it is present. A source of DC potential is impressed across the flame electrodes for increasing the rate of ion migration to the oppositely poled electrodes, thus resulting in a flame generated signal of significant strength. Flame signal processing means are operatively connected across the electrodes to sense any AC signals appearing thereacross and have circuit characteristics which process the signals in a manner which normally provides an output response indicative of flame presence whenever the AC signal sensed is substantially any voltage within a particular frequency range characteristic of a flame generated signal or is above some particular AC voltage level in a frequency range other than that characteristic of a flame.

In order to prevent the flame signal processing circuitry from providing an output response indicative of flame presence in those instances in which the AC signal at the input thereto arises from sources other than the flame, means are provided to effect an output response indicative of flame absence whenever the AC voltage across the electrodes exceeds a predetermined peak value. This peak value is selected such that it is slightly greater than the highest AC peak voltages normally generated in the actual flame signal, thus permitting that output response commensurate with flame presence only when the AC signal across the electrodes is within both the frequency and voltage ranges characteristic of a flame generated signal.

The signal processing mean preferably include a flame switch and signal coupling means, said flame switch being responsive to signal energy passed from the electrodes by said coupling means for controlling the output response indicative of the flame presence or absence. The coupling means preferably are frequency discriminating and may include a filter which has high-pass characteristics. A clamp is applies to the flame switch circuit to effect the "flame absent" response whenever the AC voltage across the electrodes exceeds the above mentioned predetermined particular peak value.

A discharge device having a break-down potential at said particular value of peak voltage is connected across said electrodes. When the AC voltage exceeds this level, the discharge device conducts, providing a voltage drop across an impedance means in series therewith. In the preferred embodiment of the invention, this voltage drop is utilized to actuate a switch and close a low impedance circuit between the flame switch input circuit and ground. This low impedance circuit to ground clamps the flame switch input and prevents it from responding to signal energy in the manner required to indicate flame presence. The flame switch, having its input circuit clamped to ground potential, effects an output response indicative of flame absence, thus insuring that only an AC signal as generated by a flame, will be able to effect the "flame present" response of the flame switch.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of the flame monitor of the invention.

FIG. 2 is a schematic circuit diagram illustrating one form of the ionic flame monitor of the invention.

FIG. 3 is a plot of the attenuation characteristics versus frequency of the coupling means connecting the flame signal with the flame switch.

FIG. 4 is an alternate form of the AC voltage level detection circuit of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a functional block diagram of the ionic flame monitor of the invention. A flame 10 issues from some type of burner, for instance ignitor 12. An electrode, such as flame rod 14, is spaced from ignitor 12 and positioned such that it is contacted by the flame 10 in a zone occupied by the flame when a normal flame condition exists. Ignitor 12 is electrically connected to a reference potential, in this instance ground, and comprises a second electrode in contact with flame 10 when it is present. A DC potential of several hundred volts is connected across electrodes 12 and 14 by means of conductors 18 and 20 connected between a DC power source 16 and the respective electrodes. A voltage dropping resistor 22 is connected in series with conductor 20 intermediate flame rod 14 and power source 16 for developing a flame signal.

As earlier described, the ion packets within a flame 10 create potential variations between electrodes 12 and 14 giving rise to an AC current therebetween. The amplitude of this current is enhanced by the DC potential impressed across the flame 10 between electrodes 12 and 14 and a flame signal may be derived from the AC voltage fluctuations appearing across resistor 22 due to the flame generated AC current in the circuit including resistor 22 and the electrodes.

The AC flame signal developed across resistor 22 is connected to flame signal processing means 24 through conductor 26. Conductor 26 is connected at one end to conductor 20 intermediate resistor 22 and flame rod 14 and is connected at its other end to the input of signal processing means 24. The signal energy appearing at conductor 26 will comprise, when flame 10 is present, an AC signal as generated by the flame, superimposed on a DC potential provided by supply 16. Signal processing means 24 include coupling means 28 and flame switch means 30. The input circuit of signal processing means 24 is also the input to coupling means 28. Coupling means 28 typically serves to separate the AC component of the signal from the DC component and to pass to the output thereof signal energy having a magnitude determined by the AC frequency of the signal applied at the input thereto. This signal energy appearing at the output of coupling means 28 is connected to the input circuit of flame switch means 30 by conductor means 32.

Flame switch means 30 comprise circuit means responsive to the magnitude of the signal energy connected thereto by conductor means 32 to provide a first output response when the signal energy magnitude is equal to or greater than a certain value and to provide a second output response when the signal energy magnitude is below said certain value. The response of flame switch means 30 may be electrical or electromagnetic in nature and typically serves to place utilization means 34 in one of two states. Utilization means 34 typically includes a two state load device 36 such as a lamp, a fuel control valve or the like, a power supply 38 and connecting circuit means including switch contacts 40. The circuit means serve to apply power to said load device 36 when switch contacts 40 are closed and the power is interrupted when contacts 40 are open.

The output response of flame switch 30 and accordingly of signal processor 24 is here represented by broken line 42 in FIG. 1 and may be indicative of an electromagnetic field created by flame switch means 30 and operative to open or close contacts 40 associated with load device 36. It is desirable to recognize only certain AC signal frequencies as being indicative of the existance or presence of flame 10. Therefore, the coupling means 28 have frequency discriminating characteristics which strongly attenuate signals having frequencies below those characteristically present in a flame signal and passing, with only slight attenuation, signals having frequencies in the range characteristic to a flame generated AC voltage. Thus, the signal energy magnitude at the output of coupling means 28, for an input signal of the same magnitude, will be greater when the input signal is in the flame frequency range than when it is below this frequency range. The larger output signal magnitude from coupling means 28 is utilized to effect said first output response from flame switch means 30 and, when the magnitude of the output signal is below a certain value, then said second output response from switch means 30 is effected. Thus said first output response from flame switch means 30 and accordingly flame signal processor 24 is commensurate with flame presence and said second output response is commensurate with flame absence.

Under normal circumstances when a flame 10 is present, an AC signal of fairly uniform magnitude will appear at the input to coupling means 28 resulting in an output signal therefrom of fairly uniform magnitude. The sensitivity of the input circuit to flame switch means 30 may be initially adjusted to effect that output response indicative of flame presence for input signals of this magnitude and greater and to effect that output response indicative of flame absence when the input signal magnitude is below this value. However, the nature of coupling means 28 are often such that when the voltage amplitude of the input signal thereto is increased the magnitude of the signal output therefrom is also increased regardless of frequencies. Thus, an AC signal appearing on conductor 26 and having a voltage significantly above that of a normal flame signal may provide a signal of large enough magnitude at the output of coupling means 28 to effect the "flame present" response from switch means 30 even though it is at a lower frequency than an actual flame signal. This condition might arise through a short of the AC line supply across electrodes 12 and 14 or it may also occur as the result of high voltage arcing or discharges occurring in close proximity to the electrodes and associated circuitry. If a flame 10 is not present when these signals occur, an output response from switch means 30 commensurate with flame presence could have dangerous consequences particularly if load device 36 is a fuel control valve.

In order to avoid the consequences which might arise due to an output response from flame switch 30 which inaccurately indicated flame presence, circuit means are provided to prevent the "flame present" response whenever the AC voltage appearing across electrodes 12 and 14 exceeds a particular value. The particular value chosen is such that it is slightly greater than substantially any AC voltage which would be generated by flame 10. Accordingly, clamping means 44 are operatively connected across electrodes 12 and 14 to sense the amplitude of AC voltage appearing thereacross and responds in a manner which clamps the input circuit to flame switch 30 whenever the AC voltage appearing across electrodes 12 and 14 exceeds the particular value. Typically, the input circuit to flame switch 30 is clamped by connecting it through a low impedance circuit to ground potential thus preventing the output response commensurate with flames presence and rather providing that response commensurate with flame absence.

Clamping means 44 include voltage level detection means 46 and a clamping switch 48. Clamping switch 48 includes means for responding to a switching voltage to open or to close a circuit between ground potential and the input circuit to flame switch 30. Voltage level detection means 46 are connected across electrodes 12 and 14 to sense the AC voltage appearing thereacross and to provide said switching voltage to close clamp switch 48 when the AC voltage sensed is greater than said particular value referred to above.

A more thorough understanding of the invention may be derived from a detailed description of the circuitry of a preferred embodiment of the invention as shown in fIG. 2. Ignitor 12 is electrically connected to ground and is the source for a flame 10. Flame rod 14 is spaced from ignitor 12 and is positioned to be in contact with flame 10 under normal flame conditions.

A transformer 50 having its primary connected to a source of 60 Hz 120V line current is used to provide the necessary power to the flame monitor. A secondary coil 52 is center tapped to ground and diodes 54 and 56 connected to opposite ends thereof in parallel provide a full wave rectified DC voltage at the junction 58. Resistor 60 and capacitor 62 are connected in series between junction 58 and ground and serve to limit and filter the voltage appearing at junction 58. A second resistor 64 is connected in parallel with capacitor 62 to ground and acts as a bleeder to discharge the capacitor when AC power to the circuit is removed. A resistor 22 is connected at one end to the junction between resistor 60 and capacitor 62 to receive a filtered DC voltage of several hundred volts, in this instance 500V DC. The other end of resistor 22 is connected to conductor 20 which is in turn connected to flame rod 14, thus impressing a DC potential of some 500V across electrodes 12 and 14. Resistor 22 typically has a value of 100 K ohms and is utilized to develop the flame signal. When flame 10 appears between and contacts electrodes 12 and 14, the flame generated AC current, described earlier, results. This current through resistor 22 provides a voltage drop thereacross which results in an AC flame signal voltage appearing at conductor 20 between resistor 22 and flame rod 14. This AC flame signal is connected to the input of flame processing means 24 by conductor means 26.

Conductor 26 applies the signal voltage resulting between electrodes 12 and 14 to signal coupling circuit 28. In the preferred embodiment, coupling means 28 is comprised of a transformer 66 and capacitors 68 and 70 connected to form a combination double tuned circuit and impedance matcher. The input circuit of coupling means 28 includes the primary of transformer 66 connected in series with capacitor 68 and connected across electrodes 12 and 14 through conductor 26. The output circuit of coupling means 28 includes the secondary of transformer 66 in series with capacitor 70. One side of both the primary and secondary of transformer 66 is connected to ground. The turns ratio of transformer 66 primary to secondary is typically ten to one. Capacitor 68 is connected to conductor 26 to receive the AC signals appearing across the electrodes. The output from coupling means 28 appears at that plate of capacitor 70 remote from the secondary of transformer 66. In the preferred embodiment, transformer 66 is a TA-47 manufactured by Stancor and capacitors 68 and 70 respectively have values of 0.01 μf and 0.33 μf.

The tuned impedance matching circuit of coupling means 28 serves to couple the high impedance flame rod circuit to the low impedance input of the circuitry coupled thereafter with maximum signal development and also strongly attenuates signals below about 200 Hz to eliminate 60 and 120 Hz AC pickup. Because of the high input and low output impedance characteristics of coupling means 28, the circuit across flame electrodes 12 and 14 is not heavily loaded, thus permitting the development of a strong flame signal at the input, and subsequently at the output, of the coupling means. The signal energy at the input to coupling means 28 appears as a high voltage, low current whereas the energy at the output is of higher current and lower voltage.

The filtering or energy transfer characteristics of coupling means **28** are seen graphically in FIG. **3** wherein the ratio of energy-out to energy-in, measured along the vertical axis, is plotted against frequency measured along the horizontal axis. It will be noted that the output signal energy from coupling means **28** relative to the signal input energy thereto is only slightly attenuated for signal frequencies above 200 Hz, but that for frequencies below 200 Hz and particularly below 150 Hz the attenuation is great. It must, however, be noted that at a particular frequency the output energy is a particular function of the input energy as determined by the filter characteristics, and an increased input signal will result in an increased output signal even though at that frequency the output signal may be greatly attenuated relative to the input. As has earlier been mentioned, the AC signal generated by flame **10** is rich in frequencies of 200 Hz and above and coupling means **28** have been tuned to pass this frequency range and attenuate lower frequency signals. Under normal flame conditions, an AC signal voltage of some 60V will be developed across the input to coupling means **28** and will result in an output voltage of about 1V. However, in those instances in which a non-flame generated high voltage AC signal appears across the electrodes, it may also be coupled to the output circuitry through coupling means **28.** This will be particularly true if its frequency is in the filter pass range, but a signal of substantial magnitude may also appear at the output of the coupling means for input signals having frequencies in the 60 to 120 Hz range if the input voltage is sufficiently large.

In the preferred embodiment, flame switch means **30** are connected to a low voltage (26V) source of AC voltage provided by secondary **70′** of transformer **50.** Flame switch means **30** include a load relay coil **72** in series with gate means, such as silicon control-rectifier (SCR) **74,** across the AC voltage of transformer secondary **70′**. Relay **72** operates to electromagnetically actuate the contacts **40** in utilization circuit **34** described above. Contacts **40** are open when relay **72** is not energized and are electromagnetically closed when the relay is energized. Relay **72** is energized by current conduction therethrough when SCR **74** is in its triggered conductive state.

SCR **74** includes a cathode **73** connected to ground, an anode operatively connected to one end of relay coil **72** and a trigger electrode **76.** A trigger circuit, comprising the SCR trigger electrode **76** and cathode **73,** is in the input circuit to flame switch means **30** and is responsive to the magnitude of a signal, in this instance a triggering voltage, applied thereto to initiate conduction by the SCR only when the signal is above a certain magnitude. As an AC supply voltage is used, SCR **74** will cease to conduct after each cycle unless the enabling trigger signal is maintained at trigger electrode **76.** A capacitor **78,** connected in parallel with relay coil **72,** and a resistor **80,** connected in series with said coil **72** and SCR **74** serve to delay the initial energization of the relay coil **72** by 0.25 second following triggering of the SCR. Further, capacitor **78** maintains the relay coil **72** energized for a short period, 1.5 – 2 seconds, following termination of conduction by and through SCR **74.**

The trigger signal applied to trigger electrode **76** is a function of the signal output from coupling means **28.**

This trigger signal is developed across a resistor, such as potentiometer **82,** connected in the trigger circuit between trigger electrode **76** and ground. In some instances, the magnitude of the signal energy appearing at the output of coupling means **28** may be sufficient to use as the trigger signal applied to potentiometer **82** to provide the trigger signal. However, this is not usually the case and it is preferred that an amplifier **84** be interposed between the output coupling means **28** and the SCR trigger electrode **76** in order to insure that the coupling means output signal is of sufficient magnitude to trigger SCR **74** when a flame is present.

Amplifier **84,** here shown in functional block form, is any one of a common type which preferably have a single stage and provide high gain over a large range of input signals. Amplifier **84** may be considered part of the output circuit of coupling means **28,** or part of the input circuit to flame switch **30,** or more generally, as merely a signal conductor between the two. A DC power source for amplifier **84** is provided by means of rectifying diode **86** and filter capacitor **88** operatively connected across the secondary **70** of transformer **50.** A 40V DC potential appears at the junction **90** between capacitor **88** and the cathode of diode **86.** This DC potential is connected to amplifier **84.** The output of amplifier **84** is an AC voltage, the magnitude of which is proportional to the magnitude of the input signal thereto. This amplifier output signal is applied to the wiper arm of potentiometer **82.** Through use of amplifier **84** and potentiometer **82,** the AC signal energy passed by coupling means **28** is scaled such that it will provide a triggering voltage to the trigger electrode of SCR **74** when it is above a certain selected magnitude and will be below the triggering potential when it is below the certain magnitude. The threshold magnitude at and above which the signal output from coupling means **28** is intended to trigger SCR **74** into conduction is established as that which occurs for a normal flame signal voltage of about 45–60 peak volts AC across electrodes **12** and **14** and being predominantly above about 150 Hz in frequency. If it is desired that a flame signal of lesser magnitude be capable of triggering SCR **74,** the sensitivity may be readily adjusted by varying the setting of potentiometer **82.** Potentiometer **82** typically has a resistance value of 0–1 K ohm.

As earlier mentioned, coupling means **28** does not attenuate all input signals to the same energy levels for a particular frequency, but rather attenuates them by some amount relative to input amplitude. Thus, input signals from sources other than a flame and having AC voltages greater than 60–80V, whether in the normal flame frequency range or below it, may be passed by the coupling means at a sufficient magnitude to effect triggering of SCR **74,** which energizes relay **72** causing a response commensurate with flame presence when in fact a flame may not be present.

To prevent a "high voltage" non-flame generated AC signal which might appear across electrodes **12** and **14** from effecting an erroneous response indicating flame presence, clamping means **44** are provided. The term "high voltage" is meant to refer to AC voltages greater than those occurring in a normal AC flame signal. Clamping means **44** include a switch **48,** responsive to a signal provided by AC voltage level detection means **46,** to close a low-impedance circuit to ground across the input or trigger circuit of SCR **74** and accordingly, flame switch means **30.** This low impedance circuit serves to clamp the trigger electrode 76 to the ground potential of cathode 73, thus preventing triggering of the SCR into conduction.

Voltage level detection means 46 comprise a circuit connected across electrodes 12 and 14 including, in series, DC isolation means such as capacitor 90, voltage threshold break-down means such as neon lamp 92 and Zener diode 94, and impedance means, such as resistor 98, across which a switching voltage may be developed. One terminal of capacitor 90 is connected to conductor 20 and the other is connected to the voltage threshold break-down means. Resistor 98 is connected between the voltage threshold break-down means and ground. Capacitor 90 will be charged to the DC potential applied across the electrodes 12 and 14 and thus serves to isolate or prevent that DC potential from appearing across the voltage threshold break-down means. With the DC potential thus isolated, the only potential appearing across Zener diode 94 and neon lamp 92 is the AC voltage appearing between electrodes 12 and 14. This AC potential is "passed" by capacitor 90.

The voltage threshold break-down means are selected to break down and conduct when a potential difference greater than about 70 or 80 volts is impressed across them. This potential is slightly above the 45–60 peak AC voltage appearing between electrodes 12 and 14 of the aforedescribed flame monitor due to the presence of flame 10. In the preferred embodiment, neon lamp 92 has a break-down potential of about 60V and Zener diode 94 has a break-down voltage of about 15V. Zener diode 94 might be replaced with a Diac. The Zener diode 94 is poled to conduct freely when electrode 14 is negative relative to ground and to break down and conduct at and above about 15V when the electrode is positive relative to ground. The fact that Zener 94 conducts at a much lower voltage than 15V for the former (or negative) polarity does not interfere with proper operation of the clamping switch 48, as will become evident hereinafter.

The combination of neon lamp 92 and Zener diode 94 might be replaced with a single Zener diode 95, as seen in FIG. 4, having a break-down voltage of 70 to 80V. However economics suggest the use of a Zener or Zeners with lower break-down voltages and further, the neon lamp 92 serves to visually indicate the presence of the excessive AC voltage across the electrodes when it conducts. The lamp may signal this condition to an operator.

When the Zener diode and neon lamp conduct, the current through resistor 98 creates a voltage drop thereacross. This voltage will be that instantaneous voltage appearing across electrodes 12 and 14 minus the voltage drop of about 70V across the Zener diode and neon lamp. Resistor 98 has a resistance of 47 K ohm.

The voltage developed across resistor 98 is utilized as a switching voltage for the clamping switch 48. The clamping switch includes a transistor 99 having its emitter 100 connected to ground and its collector 102 connected to the input circuit of flame switch means 30. More particularly, collector 102 is electrically connected by conductor 104 to the trigger electrode 76 of SCR 74. Transistor 99 will be switched on, or conduct, when the voltage at base 106 is a positive 0.6V. The switching voltage developed across resistor 98 is connected to the base 106 of transistor 99 through diode 108 and current limiting resistor 110. The anode of diode 108 is connected to the junction of resistor 98 and the voltage threshold break-down means, with its cathode being connected to one end of resistor 110. The other end of resistor 110 is connected to the base 106 of the transistor. A capacitor 112 is connected between the cathode of diode 108 and ground. Capacitor 112 serves as a pulse stretcher to provide a fairly constant base drive to transistor 99 when and if the switching voltage across resistor 98 is somewhat intermittent and occurs only several times per second. Diode 108 prevents discharging of capacitor 112 by the opposite (or negative) polarity of the AC voltage across electrodes 12 and 14, and further, applies to base 106 only that polarity of voltage capable of biasing the transistor 99 into conduction.

With the Zener diode 94 of FIG. 2 or Zener diode 95 of FIG. 4 poled as described above and diode 108 connected as described hereinbefore, Zener 94 or Zener 95 will be connected to permit a positive voltage on the anode of diode 108 only when the AC potential applied to the opposite electrodes of the Zener exceeds its break-down voltage. Though the Zener may conduct in the opposite direction at much lower voltages, diode 108 will then be reverse biased and will not conduct.

In operation, if an AC signal having a voltage greater than about 70 peak volts appear across electrodes 12 and 14, it will cause break-down and conduction by the voltage level detection means 44 and will switch transistor 99 into conduction. When transistor 99 conducts, it serves to provide a low impedance path from SCR trigger electrode 76, through conductor 104, collector 102, and emitter 100 to ground. This low impedance circuit clamps the trigger electrode 76 to ground and prevents any signal passed by coupling means 28, regardless of magnitude, from triggering SCR 75 and providing a possibly false indication of flame presence.

The flame switch means 30 are thus prevented from indicating flame presence so long as the "high" AC voltage is present across electrodes 12 and 14. When the over-voltage condition ceases or is corrected, the flame switch means will resume operation in its normal manner. An SCR might be substituted for transistor 99 if it is desired to permanently clamp the input circuit to flame switch means 30 when an excessive AC voltage is first detected, and would not release the clamp until some operator action was taken.

It will be understood that the embodiment shown and described herein is merely illustrative and that changes may be made without departing from the scope of the invention as claimed.

What is claimed is:

1. In a flame monitor for determining the presence or absence of a flame within a flame zone through detection of a flame generated AC signal, a pair of electrode means spaced from one another and disposed within said flame zone to be in contact with said flame when present; circuit means operatively connected to said electrode means for applying a direct current potential between said electrode means to develop a flame generated AC signal additionally appearing between said electrode means when a flame is present; coupling means having an input and an output and adapted for passing to said output thereof AC signal energy characteristic of AC signal energy applied to said input thereof; means electrically connecting said electrode means with said coupling means input for applying AC signal energy thereto; flame switch circuit means hav-

ing an input circuit operatively connected to the output of said coupling means and responsive to signal energy appearing thereat for providing an output response commensurate with flame presence when the magnitude of said signal energy is at least as great as a certain value and providing an output response commensurate with flame absence when the magnitude of said energy is less than said certain value; and clamping means operatively connected between said electrode means and said flame switch circuit means and responsive to AC voltage magnitude for effecting said flame switch circuit means output response commensurate with flame absence when the AC voltage across said electrodes exceeds a predetermined level, regardless of the signal energy passed by said coupling means.

2. The apparatus of claim **1** wherein said clamping means include AC voltage level detection means connected across said electrode means for developing a switching voltage when AC voltage exceeding said predetermined level appears across said electrode means; and switch means responsive to the presence of said switching voltage for clamping the input circuit of said flame switch circuit means to a maximum electrical energy level less than that required to provide said response commensurate with flame presence, whereby the output response of said flame switch circuit means is commensurate with flame absence.

3. The apparatus of claim **2** wherein said flame generated AC signal applied to the input of said coupling means comprises AC electrical energy above a certain frequency and having an AC voltage substantially entirely within a range less than said predetermined level and said coupling means include filter means operatively connected between the input and output of said coupling means for attenuating the input signal of said coupling means to an output magnitude less than that required to provide said response commensurate with flame presence when said coupling means input signal is less than said certain frequency and said predetermined level of AC voltage and for passing the input signal of said coupling means to the output thereof at a magnitude at least as great as said certain value required to provide said response commensurate with flame presence when said AC flame signal is present and the AC voltage at said input is below said predetermined level and when said AC voltage present at said input is above said predetermined level.

4. The apparatus of claim **3** wherein said voltage level detection means include at least one gas filled discharge device having a breakdown potential no greater than said predetermined level of AC voltage and resistance means for developing said switching voltage, said resistance means and said discharge device being connected in series across said pair of electrode means and said switching voltage being that across said resistance means when said discharge device conducts.

5. The apparatus of claim **3** wherein said voltage level detection means include, in series, threshold discharge means for conducting only when a potential thereacross exceeds said predetermined level of AC voltage; means for isolating said threshold discharge means from said DC potential established between said pair of electrode means; and impedance means for developing thereacross said switching voltage when said threshold discharge means conducts.

6. The apparatus of claim **5** wherein said switch means for clamping said input circuit of said flame switch circuit means comprise an electronic switch having first, second, and third electrodes, said first electrode being operatively connected to said impedance means across which is developed said switching voltage and acting to close a circuit between said second and third electrodes when said switching voltage is applied thereto and said second and third electrodes respectively being connected to ground potential and to the input circuit of said flame switch circuit means.

7. The apparatus of claim **6** wherein said flame switch circuit means include a load relay for providing a response commensurate with flame presence when energized and triggerable gating means for gating energizing power to said load relay when triggered by a trigger signal, said gating means comprise a silicon controlled relay having an anode, cathode, and a trigger electrode and wherein energizing power is passed by circuit means from a power source to said relay by a current path through said anode and cathode in a triggered conductive state, said trigger signal being provided by that signal energy connected to the input circuit of said flame switch circuit means and being above said predetermined level.

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