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[54] **FLAME ROD SAFETY CONTROL SYSTEM**
10 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **431/25,** 431/31, 431/78
[51] **Int. Cl.** **F23n**
[50] **Field of Search** 431/25, 30, 31, 78

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ABSTRACT: A flame rod safety control system for power-type gas burners as generally employed on agricultural type crop dryers employs apparatus for providing safe starting, stopping and monitoring of the operation of the burner. A purge timer is provided to prevent operation of the fuel supply circuit and the burner ignition circuit until sufficient time has elapsed for evacuation of residual fuel vapors from the combustion chamber. A flame rod sensing circuit is provided to monitor operation of the burner and includes as an operational component thereof the flame of the burner and its electrical rectification characteristic which in turn provides for the utilization of low voltage conductors between the flame rod and the remainder of the control system. The sensing circuit provides a fail-safe feature in that any opening, shorting or high resistance condition across the detection terminals will permit a safety timing circuit to operate and inhibit operation of the fuel supply and ignition circuits. A plurality of lamps are provided to indicate the operational condition of the burner and control system.

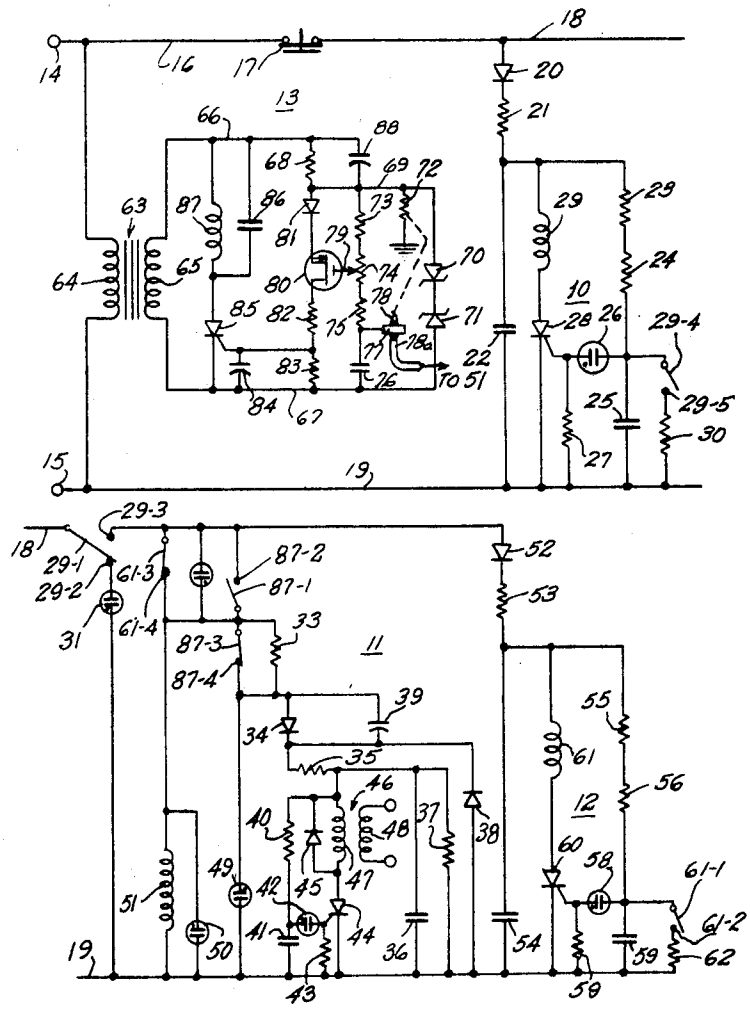


Fig-1A

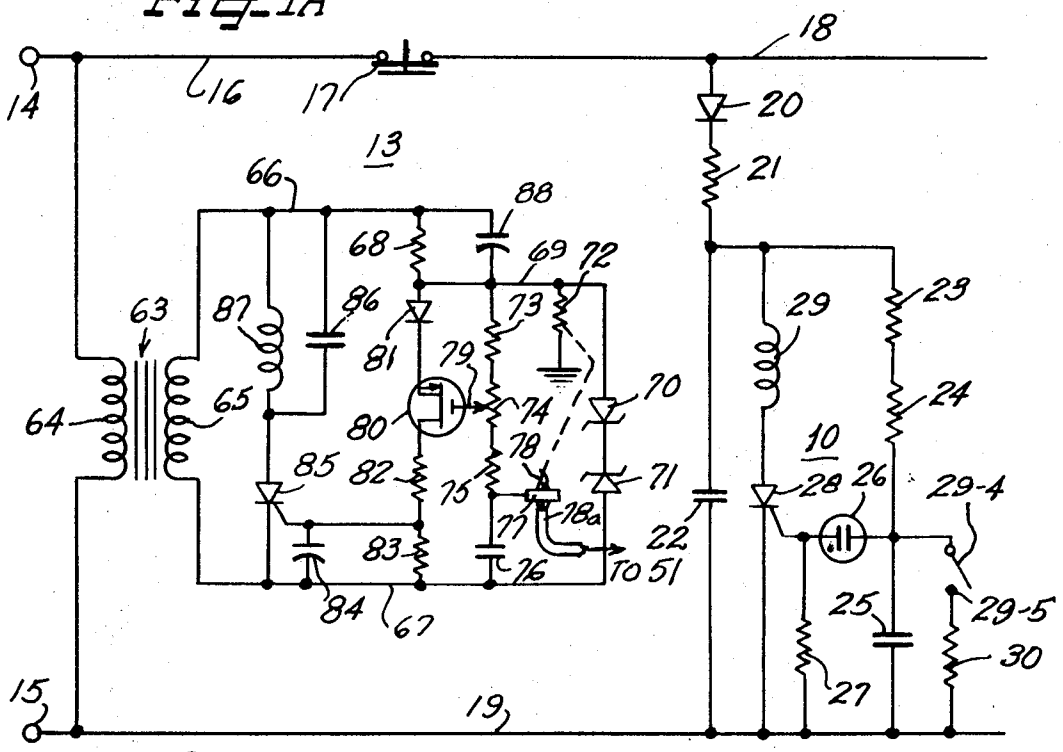
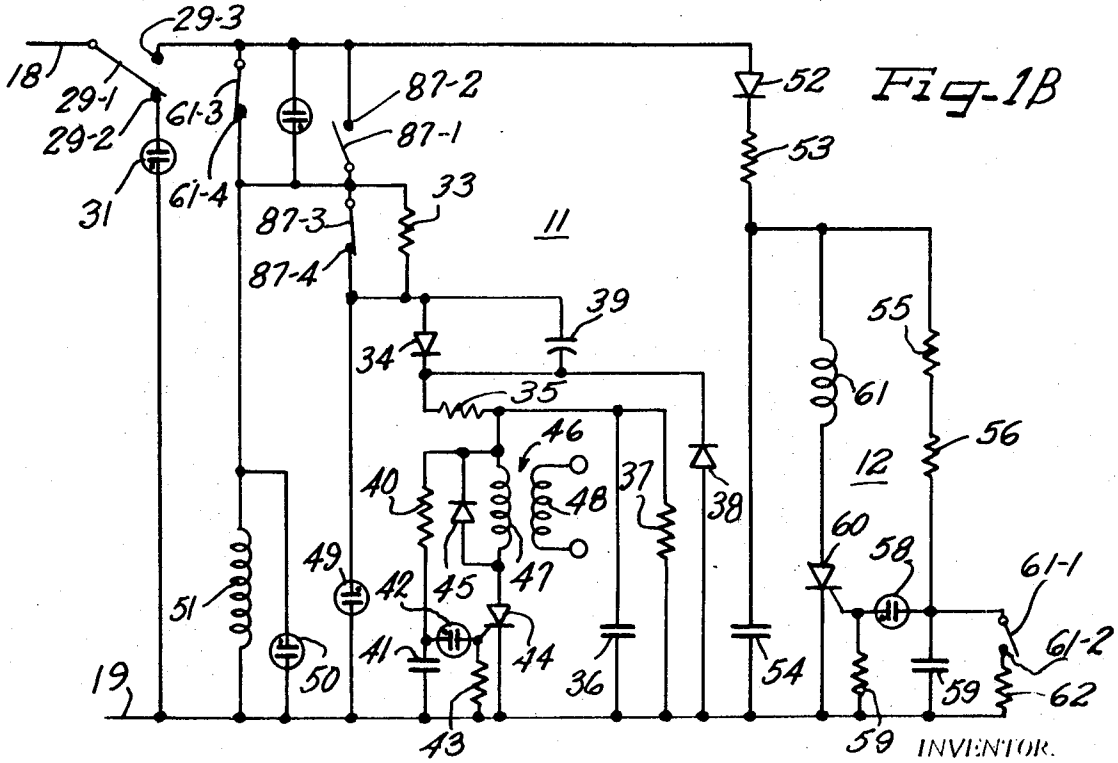


Fig-1B



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FLAME ROD SAFETY CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to control apparatus for fuel-burning systems, and is particularly concerned with apparatus for controlling and monitoring the operation of power-type burners.

2. Description of the Prior Art

Power-type burners which utilize combustible gases or vaporized liquids for fuel have been employed to great advantage in agricultural-type crop dryers. Heretofore, however, the control apparatus for igniting and monitoring operation of such burners have employed apparatus and techniques which were borrowed from related apparatus and adapted for use in power-type burners for reasons of economical expediency. For example, apparatus and techniques employed in residential burners have found wide use in power-type gas burners. The most serious drawback encountered in following such an approach to power-type equipment is the lack of safety for those who operate and maintain the equipment. High-voltage lines have been employed to a great extent in such burners, for example, in order to provide sufficient potentials to the burner for detecting the operational condition thereof. Such lines, of course, provide a shock hazard to maintenance personnel and must be enclosed within protective conduit.

It is therefore highly desirable, and a primary object of the present invention, to provide an electronic control system for power-type burners, which system provides for the safe starting, stopping and monitoring of the operation of the burner and provides a safe working environment for operational and maintenance personnel.

SUMMARY OF THE INVENTION

According to the invention, a control system for a power-type burner employs a purge timer to prevent the application of fuel to the burner and the operation of an ignition system for a period of time sufficient to permit evacuation of residual fuel vapors from the combustion chamber of the burner. The system also provides a circuit for sensing ignition of the fuel and the burning thereof and a second timer which is placed in a race condition with the sensing circuit to inhibit operation of the control system if flame detection does not occur within a predetermined interval.

The sensing circuit utilizes low-voltage techniques for detecting the presence of a burner flame, which in turn provides for the utilization of low voltage, low-cost wiring between the control system and the flame detection rod and the attendant elimination of any shock hazard heretofore connected with flame detection. BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention, its organization, construction and operation will be readily apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure, and in which FIGS. 1A and 1B together form a schematic representation of a flame rod safety control system constructed in accordance with the principles of the present invention. DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawings, a flame rod safety control system is illustrated as comprising a purge timer **10**, an ignition circuit **11**, a safety timer **12** and a flame sensing circuit **13**, all of which are connectable to a commercial electrical supply, for example, 120 V., 60 Hz., at input terminals **14** and **15**. The application of the electrical supply to terminals **14** and **15** may, of course, involve the utilization of switches for applying power thereto and applying power to other apparatus such as a blower for purging vapors from the combustion chamber.

Input terminal **15** is connected to a conductor **19** which is common to the purge timer **10**, the ignition circuit **11** and the safety timer **12**. The input terminal **14** is extended by way of conductors **16**, a reset switch **17** and a conductor **18** to the purge timer **10**, and by way of contacts **29—1**, and **29—3** to the ignition circuit **11** and the safety timer **12**.

Upon the application of electrical energy to terminals **14** and **15** the purge timer **10** is energized for a predetermined interval to permit purging of residual vapors from the combustion chamber. The purge timer **10** comprises a controlled rectifier **28** for operatively connecting a relay winding **29** in circuit with the conductors **18** and **19**. To effect operation of the controlled rectifier **28** a capacitor **25** is charged over a series circuit including a diode **20**, a resistor **21**, a resistor **23** and a resistor **24**. The time constant of this charging circuit provides the purge time interval. A gas-filled lamp **26** is fired in response to the potential developed across capacitor **25** to develop a gating pulse across a resistor **27** which is connected to a gate electrode of the controlled rectifier **28**. The controlled rectifier then conducts to provide an energizing path for relay winding **29**.

The relay **29** operates to close its contacts **29—4** and **29—5** to provide a low impedance short across resistor **30** and capacitor **25** in parallel to extinguish the gas-filled lamp. The capacitor **22** maintains a sufficient potential at the anode of the rectifier **28** to maintain the rectifier conductive and the relay **29** operated. Contacts **29—4** and **29—5** insure full timing cycle in the event of a need to recycle. The relay **29** also includes a movable contact **29—1** which is transferred from contact **29—2** to engage contact **29—3** and provide operating power to the ignition circuit **11** and the safety timer **12**.

Upon the mating of contacts **29—1** and **29—3** the safety timer **12** begins an operation that is identical to that of the purge timer **10**, as will be readily apparent from the drawing. Therefore, any detailed description of the operation of the safety timer **12** will be given in conjunction with the operation of the ignition circuit **11** and the flame sensing circuit **13**.

A winding **51** of a solenoid valve is energized over a circuit including conductor **18**, contact **29—1**, contact **29—3**, contact **61—3**, contact **61—4**, the winding **51** and the conductor **19**. A gas-filled lamp **50** is provided in parallel with the winding **51** to indicate the application of operating energy to the solenoid valve. The winding **51** is thereby energized to provide fuel flow to the burner by way of conduit **78***a* (FIG. 1A).

The ignition circuit **11** includes a controlled rectifier **44** which is operated to pulse an ignition transformer **46**. A capacitor **36** is charged to provide the anode potential for controlled rectifier **44**, as were capacitors **22** and **54** for their respective controlled rectifiers **28** and **60**, over a path including contact **61—3**, contact **61—4**, contact **87—3**, contact **87—4**, diode **34**, resistor **35** and capacitor **36** to the conductor **19**. At the same time the capacitor **39** is receiving a charge, it being in parallel with the diode **34**. Similarly, a capacitor **41** is receiving a charge over a circuit in parallel with the capacitor **36** including a resistor **40** and the capacitor **41** to fire the gas-filled tube **42** and develop a gating potential across resistor **43** for the gate electrode of the controlled rectifier **44**.

Upon gating of the controlled rectifier **44**, the capacitor **36** discharges therethrough and through the primary winding **47** of the transformer **46**, and the capacitor **39** adds to the discharge of the capacitor **36** by discharging through the resistor **35**, the primary winding **47** and the controlled rectifier **44**. The additive discharge of capacitor **39** is provided by virtue that its original charging was accomplished on the negative half cycles as permitted by the diode **38**. The primary winding **47** of the transformer **46** is therefore provided with an additional "kick" to induce an ignition voltage in the secondary winding **48**. The secondary winding **48** is, of course, connected to a spark-generating device for igniting the fuel at the burner.

It will be clearly evident from the drawing that ignition must occur prior to the operation of the relay **61** of the safety timer **12** in that operating potential for the solenoid **51** to supply fuel and for the ignition circuit **11** is provided over contacts **61—3** and **61—4** of the relay **61**. It is therefore a timing race between

the safety timer 12 and ignition and detection of the burner flame 78 by the flame sensing circuit 13 which determines whether power to the solenoid 51 will be interrupted at contacts 61—3 and 61—4 or if power will be provided over a circuit in shunt to those contacts by way of contacts 87—1 and 87—2 of the relay 87 (flame sensing circuit 13).

The flame sensing circuit 13 comprises an input stepdown transformer 63 having a primary winding 64 connected across the input terminals 14 and 15, and a secondary winding 65 which is connected by way of a conductor 66, a capacitor 88 and a conductor 69 to a first Zener diode 70 and by way of a conductor 67 to a second Zener diode 71. The Zener diodes 70 and 71 have their cathodes connected in common and their anodes respectively connected to opposite terminals of the secondary winding 65 over the just-traced paths. The Zener diodes are effective to convert the commercial alternating current voltage into an alternating square wave voltage to render the flame sensing circuit insensitive to normal variation in line voltage. In a particular exemplary application, conductors 66 and 67 were maintained at 24 volts and conductor 69 at 18 volts.

The flame-sensing circuit includes a controlled rectifier 85 which is gated to provide an energizing path for a direct current relay winding 87 which controls the provision of operating potentials to the solenoid valve winding 51 over contacts 87—1 and 87—2, as mentioned above. The relay 87 also includes contacts 87—3 and 87—4 which removes the direct connection of the indicating lamp 49 and the ignition circuit 11.

The control rectifier 85 is gated and maintained in an ON condition by a potential developed across a resistor 83 which is serially connected to one electrode of a MOS field-effect transistor in series with a resistor 82. Another electrode of the transistor 80 is connected to the conductor 66 by way of a resistor 68 and a diode 81. Conduction of the transistor 80 therefore provides a positive gating pulse to the gate electrode of the controlled rectifier 85.

In order to obtain the gating potential for the control rectifier 85, a base electrode 79 of the transistor 80 is connected to a movable contact of a resistor 74 which is serially connected across the aforementioned Zener diodes 70 and 71 by way of resistors 73, 75 and a capacitor 76. The sensing potentials supplied to the flame rod 77 are rectified by the flame 78 which appears as a high resistance diode rectification circuit including the resistor 72 (symbolic of flame resistance) across the resistors 73, 74 and 75. The rectified sensing potentials are therefore supplied to the last-mentioned resistors and a portion of such signals are utilized to operate the transistor 80 to derive the required potential across the resistor 83 for operating the controlled rectifier 85 and the relay 87.

The flame-sensing circuit 13 is fail-safe in operation in that any short, open or high resistance developed in the circuitry for deriving the correct potential across the resistor 83 will prevent operation of the relay 87 thereby permitting the safety timer to inhibit operation of the burner system.

A capacitor 88 is provided as a high frequency bypass to prevent high frequencies from interferring with the operation of the circuit of the transistor 80. Also, a capacitor 84 is provided to prevent spurious voltage spikes from inadvertently triggering the controlled rectifier 85. Additionally, the capacitor 76 is provided with a charge during flame detection which is sufficient to maintain the flame-sensing circuit operative for a predetermined time to render the flame-sensing circuit insensitive to minute flame variations and flickering.

In the operation of a typical burner controlled by the above-described apparatus power would be applied to the circuit and the combustion blower motor would be started to purge the combustion chamber of residual vapors. A purge time of 30 to 60 seconds would generally be employed and the purge indication lamp 31 would be illuminated. Upon operation of the purge timer, contacts 29—1 and 29—2 would part and contacts 29—1 and 29—3 would engage to extinguish the purge lamp 31 and provide operating potential to the ignition circuit 11 and the safety timer 12. The gas solenoid valve winding 51 would be energized and its companion indicating lamp 50 would be illuminated. Also, the ignition indication lamp 49 would be illuminated and the ignition circuit 11 would be operated to provide a high-voltage signal, for example 10 KV, to ignite the burner at the secondary winding 48 of the transformer 46.

If ignition is established contacts 87—3 and 87—4 render the ignition lamp 49 and the ignition circuit 11 inoperative and contacts 87—1 and 87—2 maintain the gas solenoid valve winding 51 energized to provide fuel flow to the burner. If, however, ignition is not established within a predetermined interval, say within 15 seconds, and detected by the flame rod of the flame sensing circuit 13, the safety timer 12 is operative to energize relay 61 and interrupt the powering circuit to the solenoid winding 51 at contacts 61—3 and 61—4. The reset switch 17 must then be operated to deenergize relays 29 and 61 and reset the corresponding timers 10 and 12.

If the flame should be extinguished for a short time, say less than 3 seconds, the delay provided by the capacitor 76 will maintain the system operative. A delay of longer than this preset interval will interrupt the powering circuit to the solenoid valve 51 and the ignition circuit 11 at contacts 87—1 and 87—2, the safety timer 12 having in the interim open contacts 61—3 and 61—4.

In the event of a power failure, it is clearly evident from the foregoing description and the drawing that the burner will be shut off and the control system will automatically be restarted and recycled on the restoration of power.

Generally then, there has been described a flame rod safety control system for use with industrial or power-type burners utilizing flame rod detectors in which the flame itself is included as a portion of the sensing circuit. The circuitry of the control system differs from controls heretofore known in several respects. First, the flame detection is on a low-voltage basis as opposed to the 200–300 volts now utilized in commercial systems. Low-voltage sensing eliminates any shock hazards and permits the utilization of more economical wiring. Secondly the sensing circuit employs a pair of Zener diodes to convert the low-sensing voltage into a square wave shape in order to render the sensing circuit insensitive to normal variations in line voltage. Thirdly, simplified techniques and apparatus have been utilized to provide a short time delay of the system to render the circuit insensitive to variations in and minute losses of burner flame. In addition the sensing circuit is provided with a fail-safe feature in that any opening, shorting or high-resistance condition across the detection terminals will not effect operation of the relay device therein to indicate flame operation. Such relay device will operate only when a flame is present.

I claim:

1. Sensing apparatus for controlling fuel combustion in an industrial burner, comprising

input means for connection to an electrical supply line to provide a low-voltage alternating potential as powering energy for said sensing apparatus;

conversion means connected to said input means for converting said low-voltage alternating potential to a low-voltage alternating square wave sensing voltage;

means for applying said sensing voltage to the flame of the burner, including a flame rod, the flame having a rectification characteristic to provide a rectified signal between said flame rod and a reference potential; and

detecting means connected to said flame rod and operated in response to said rectified signal to maintain fuel delivery to said burner.

2. Sensing apparatus according to claim 1, wherein said conversion means comprises

a pair of Zener diodes each including an anode connected to said input means and a cathode connected to the cathode of the other to provide said square wave sensing voltage and render said sensing apparatus insensitive to variations of potential on the supply line.

3. Sensing apparatus according to claim 1, wherein said detecting means comprises

first switching means including a transistor which is rendered conductive in response to said rectified signal, and

second switching means operated by said first switching means to control fuel delivery to said burner.

4. Sensing apparatus according to claim 3, wherein said transistor is a field effect transistor, and said first switching means further includes

means for biasing said field effect transistor nonconductive in the absence of a flame.

5. Sensing apparatus according to claim 3, wherein said second switching means comprises

an electromagnetic switching device including an operating winding, and

a semiconductor switch connected to said operating winding and including a gate input connected to said first switching means,

said semiconductor switch being operable to connect said winding of said electromagnetic switching device across said input means to enable energization thereof.

6. Sensing apparatus according to claim 5, wherein said winding of said electromagnetic switching device requires direct current for operational energization thereof, and

said semiconductor switch includes a controlled rectifier connected in series with said winding.

7. Sensing apparatus for monitoring and controlling the operation of a burner having a solenoid valve for delivering fuel thereto and an ignition circuit for igniting the fuel to produce a flame, said sensing apparatus comprising:

a stepdown transformer including a primary winding for connection to a supply line carrying sinusoidal alternating voltage thereon, and a secondary winding;

a pair of Zener diodes connected together in series and in opposite polarity sense, the series combination thereof being connected across said secondary winding to covert the sinusoidal alternating voltage to a square wave alternating voltage;

a flame rod to be disposed in the flame connected to carry said square wave voltage, said flame rectifying said square wave voltage;

a voltage divider connected across the circuit of said flame rod and said flame;

a field effect transistor circuit including an input connected to said voltage divider, and an output for providing an output voltage signal by conduction of said transistor in response to signals at said voltage divider in response to said rectified voltage;

a controlled rectifier having an anode, a cathode and a gate, said gate connected to said output of said field-effect transistor circuit and said cathode connected to one side of said secondary winding; and

a relay including contacts for connection to the solenoid valve and ignition circuits, and an operating winding connected between said anode of said controlled rectifier and the other side of said secondary winding,

said controlled rectifier rendered conductive by an output voltage signal of said field effect transistor circuit to establish an energization path for said relay winding.

8. Sensing apparatus according to claim 7, comprising capacitor means connected across the cathode and gate of said controlled rectifier to render the apparatus insensitive to spurious signals at said gate.

9. Sensing apparatus according to claim 7, comprising capacitor means connected between said other side of said secondary winding and ground to bypass high frequency signals.

10. Sensing apparatus according to claim 7, comprising capacitor means connected to said flame rod and said voltage divider to store energy and maintain said transistor conductive for a predetermined interval and thereby render said apparatus insensitive to momentary losses of flame.