

[54] IONIZATION SMOKE DETECTOR

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 340/237 S

[57] ABSTRACT

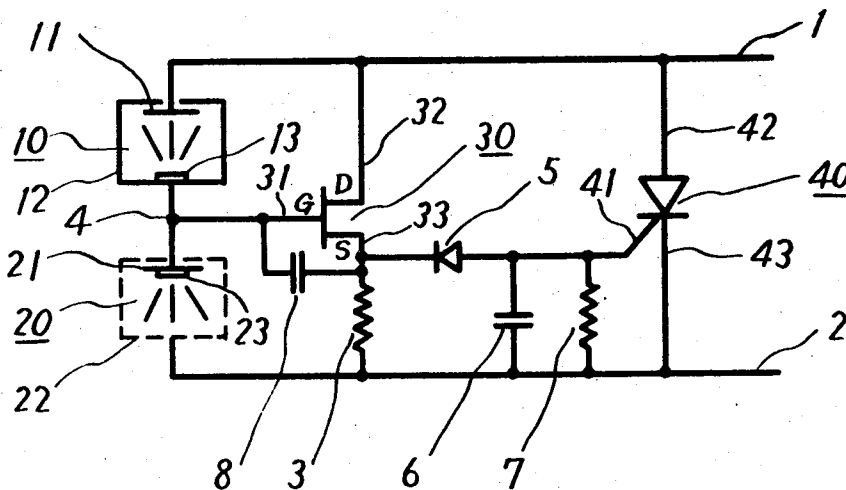
An ionization smoke detector having an open and a closed chamber, each including a pair of electrodes, the electrodes in the chambers being connected in series across a voltage supply. A field effect transistor interconnected with the chambers and the voltage supply to sense a change in impedance in the open chamber upon the admission of smoke and sensitivity controlling means interconnected with the field effect transistor to prevent the production of an erroneous signal from the transistor as a result of momentary increases of smoke concentrations in the ambient air.

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3 Claims, 2 Drawing Figures



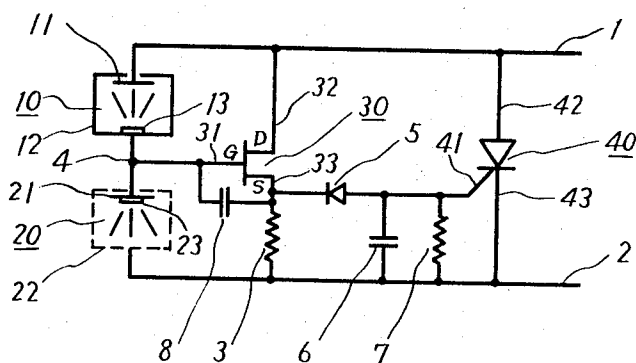


Fig. 1

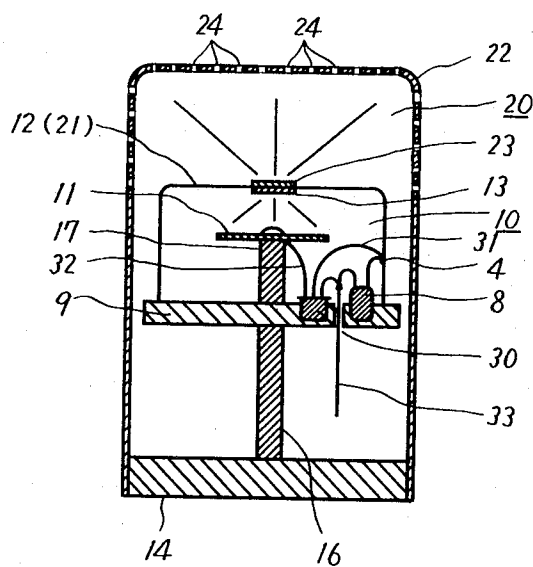


Fig. 2

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IONIZATION SMOKE DETECTOR

This invention relates to an ionization smoke detector and more specifically to a novel and improved smoke detector wherein an alarm will be activated when a smoke concentration continues for a predetermined time.

Ionization smoke detectors according to the prior art comprise a closed ionization chamber having a pair of electrodes and a radioactive source, an open ionization chamber having a pair of electrodes and a radioactive source, means connecting the electrodes of the chambers in series across a source voltage, a field effect transistor for detecting a voltage change at the junction of the ionization chambers as a result of smoke entering the open chamber and an alarm circuit operated by the field effect transistor.

In general ionization smoke detectors have such a high degree of sensitivity that an alarm signal will be produced in response to a small concentration of tobacco smoke or as the result of air flowing through the open chamber.

One object of the invention resides in the provision of an ionization smoke detector wherein the detection sensitivity is adjusted to conform with practical conditions so that an alarm will be sounded when a given smoke concentration continues for a predetermined time which thereby prevents the production of erroneous alarm signals.

The ionization smoke detector according to this invention includes a closed ionization chamber having a pair of electrodes and a radioactive source, an open ionization chamber having a pair of electrodes and a radioactive source, means connecting the electrodes of the ionization chambers in series across a voltage source, a field effect transistor having a gate electrode connected to the junction of the chambers and having the source-drain path connected through a load resistor and across the voltage source, and a capacitor connected between the gate electrode and the source electrode of the field effect transistor.

The above and other objects of the invention will become more apparent from the following description and accompanying drawings forming part of this application.

In the drawings:

FIG. 1 is a circuit diagram of an ionization smoke detector in accordance with the invention; and

FIG. 2 is a cross-sectional view of one embodiment of the ionization chambers illustrated diagrammatically in FIG. 1.

Referring to FIG. 1, the closed ionization chamber is denoted by the numeral 10 and includes a pair of electrodes 11 and 12 and a radioactive source 13. The open ionization chamber is denoted by the numeral 20 and includes a similar pair of electrodes 21 and 22 and a radioactive source 23. The ionization chambers 10 and 20 are connected in series across conductors 1 and 2 which in turn are connected to a suitable voltage source. The junction between the two chambers is denoted by the numeral 4. A field effect transistor 30 has its gate electrode 31 connected to the junction 4, the drain electrode 32 connected to the conductor 1 and a source electrode 33 connected through a load resistor 3 to the conductor 2. A sensitivity control capacitor 8 is connected between the gate electrode 31 and the source electrode 33 of the field effect transistor 30. The source electrode 33 is also connected through a zener diode 5 to the gate electrode 41 of a silicon controlled rectifier 40. A rectifier 40 has an anode 42 connected to the conductor 1 and the cathode 43 connected to the conductor 2. A RC network including a capacitor 6 and a resistor 7 is connected between the gate 41 of the rectifier 40 and the conductor 2.

FIG. 2 illustrates one embodiment of the principal elements of FIG. 1 and identical numerals have been used to identify like components in both figures.

The electrode 22 of the open ionization chamber 20 is in the form of a housing enclosing the other elements of the detector and includes a plurality of openings 24 to permit smoke to enter the chamber 20. The housing is supported by a base 14 of insulating material and may be affixed to the ceiling of a room, for example.

The numeral 12 denotes the second electrode of the open ionization chamber 20 and carries the radioactive source 23 on the upper surface thereof. The upper surface of the electrode 12 as shown in FIG. 2 functions as the electrode 21 of FIG. 1 while the lower surface functions as the electrode 12 of FIG. 1. The electrode 12 (21) is carried by an insulating plate 9 secured to the base 14 by a post 16. The bottom side of the electrode 12 (21) carries the radioactive source 13 of the closed ionization chamber 10. The electrode 11 of the closed ionization chamber is carried by a post 17 secured to the insulating base 9. If the posts 16 and 17 are in the form of a single member of conductive material such as metal, it may serve as the conductor for connecting the electrode 11 to the conductor 1. If the supporting posts 16 and 17 are formed of insulating material, a separate conductor must be provided for connecting the electrode 11 to the conductor 1. The field effect transistor 30 and the capacitor 8 are disposed within the closed ionization chamber 10 and are preferably carried by or partially embedded in the insulating plate 9. The gate electrode 31 of the transistor 30 is connected to the electrode 12(21) and the drain electrode 32 is connected to the electrode 11. The source electrode 33 is connected to a conductor which may extend downwardly through the insulating plates 9 and 14. One of the terminals of capacitor 8 is connected to the source electrode 33 while the other terminal is connected to the electrode 12(21).

In operation of the ionization smoke detector in accordance with the invention, a predetermined voltage is applied to the conductors 1 and 2 to provide a constant ionization current through both ionization chambers. When smoke does not exist in the ambient air, the voltage at junction 4 of the chambers 10 and 20 has a specific value determined by the internal impedances of the chambers. Under the same conditions the current flowing through the drain-source path of the field effect transistor is either substantially zero or is limited to a value that will produce a voltage drop across the load resistor 3 which does not exceed the critical voltage of the zener diode 5. Accordingly, a gate signal will not be applied to the gate electrode of the silicon controlled rectifier 40 so that the latter will not conduct and an alarm will not be generated by an alarm device which may be connected in series with the voltage source.

When smoke enters the open ionization chamber 20, its impedance is increased and the ionization current will decrease. This causes the voltage at junction 4 to increase. Should the smoke enter the open ionization chamber for a very short period of time, for instance, several seconds, the time during which smoke is present is insufficient to charge the capacitor 8 connected between the gate electrode 31 and the source electrode 33 of the transistor 30. Under these conditions the potential at the gate electrode of the field effect transistor 30 will not attain a value that will cause sufficient current to flow through the drain-source path to produce a voltage at the source electrode which exceeds the critical voltage of the zener diode 5. Accordingly, an alarm signal will not be generated. Thus the presence of smoke from a cigarette or a kitchen range for a short period of time will not activate the alarm.

When smoke enters the open ionization chamber 20 and continues for a predetermined time for example in excess of several seconds, the capacitor 8 will be charged to the voltage appearing at the junction 4 with the result that the potential of the gate electrode 31 will be increased. This action increases the current flowing through the drain-source path of the transistor 30 and increases the voltage drop at load resistor 3 to a value which exceeds the critical value of the zener diode 5. The zener diode 5 will then conduct and apply a gate signal to the electrode 41 of the rectifier 40 causing the rectifier 40 to conduct and produce an alarm signal.

The detector in accordance with this invention is particularly advantageous when providing detectors which are relatively small and compact. When making small ionization detectors, the ionization chambers 10 and 20 are necessarily

reduced in size with the result that the interelectrode electrostatic capacitances are also reduced. Reducing the interelectrode capacitances greatly increases the response of the detector to smoke which often results in the production of undesirable erroneous alarms caused by the entrance of minute amounts of smoke such as tobacco smoke or even the rapid flow of air through the chamber. With this invention, however, the sensitivity is adjusted to meet practical considerations through the utilization of the capacitor 8 connected between the gate electrode 31 and the source electrode 33 of the transistor 30.

While it is possible to control the response of the smoke detector by increasing the capacitance of the capacitor 6 connected between the gate 41 of the rectifier 40 and conductor 2, the capacitor 6 must be made very large in order to provide a satisfactory time constant since the input impedance to the gate electrode is relatively low. This presents a material disadvantage in the construction of miniaturized ionization detectors, and it is also undesirable from an economical standpoint. When using the capacitor 8, however, the input impedance as viewed from the junction 4 of the ionization chambers 10 and 20 is in effect the actual capacitance of capacitor 8 multiplied by $1 + \text{the gain of transistor 30}$. Thus the capacitor 8 may be made very small. Accordingly, the capacitor 8 though having a very small capacitance is nevertheless effective to attain the desired sensitivity. Since the capacitor 8 has a very small capacitance, its physical size is materially reduced and it can be readily positioned within the closed ionization chamber along with the field effect transistor 30. By enclosing both the capacitor and the field effect transistor within the closed ionization chamber, they are isolated from external air with the result that their characteristics can be stabilized and thus afford a more stable and dependable detector.

While only certain embodiments of the invention have been illustrated and described, it is apparent that alterations, modifications and changes may be made without departing from the true scope and spirit thereof as defined by the ap-

ended claims.

What is claimed is:

1. An ionization smoke detector, comprising a closed ionization chamber including a pair of electrodes and a radioactive source, an open ionization chamber having similarly a pair of electrodes and a radioactive source and connected in series with said closed ionization chamber, a voltage source for supplying a voltage to said series connection of said both ionization chambers, a field effect transistor having a gate electrode connected to the junction between said both ionization chambers and a source-drain conduction path connected through a load resistor to said voltage source for detecting a voltage at said junction between said both ionization chambers, and a sensitivity reducing capacitor connected between the gate electrode and the source electrode of said field effect transistor.

2. An ionization smoke detector, according to claim 1 characterized in that said sensitivity reducing capacitor is contained in said closed ionization chamber.

3. An ionization smoke detector, according to claim 1 characterized in that one of said pair of electrodes of said open ionization chamber is formed as a housing of the device in which a number of windows are bored for allowing smoke to come in, the other electrode of said open ionization chamber and one of said pair of electrodes of said closed ionization chamber are integrally formed as a single cup-shaped conductor whose open end is closed by an insulating plate and whose outer and inner surfaces serve functions of said other electrode of said open ionization chamber and said one electrode of said closed ionization chamber respectively, said radioactive sources of said open and closed ionization chambers are respectively arranged on said outer and inner surfaces of said cup-shaped conductor, the other electrode of said closed ionization chamber is located in said cup-shaped conductor and insulated from said conductor, and at least said sensitivity reducing capacitor is contained in said cup-shaped conductor.

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