United States Patent

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[54] IONIZATION SMOKE DETECTOR

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[52] **U.S. Cl.**............**250/83.6 FT,** 250/44, 340/237 S
[51] **Int. Cl.**..**G08b 17/10**
[58] **Field of Search**..........250/44, 83.6 FT; 356/207; 340/237 S

[56] **References Cited**

UNITED STATES PATENTS

3,500,368 3/1970 Abe.................250/83.6 FT X
3,516,083 6/1970 Meyer......................250/44 X

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Assistant Examiner—Davis L. Willis
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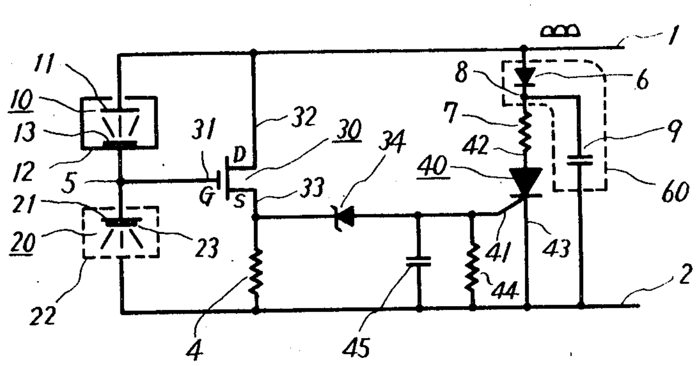
[57] **ABSTRACT**

An ionization smoke detector having open and closed ionization chambers each having at least two electrodes and a radioactive source. The electrodes are connected in series across a voltage supply and the change of impedance of the open ionization chamber is detected by a field effect transistor which in turn fires a silicon controlled rectifier. The silicon controlled rectifier is provided with a holding circuit so that when utilizing a pulsating voltage, the silicon controlled rectifier will be maintained in a conductive state even though the pulsating voltage periodically approaches zero. The invention further contemplates means for controlling the current through the source-drain path of the field effect transistor so that wide voltage fluctuations will not damage the transistor or produce erroneous alarm signals.

4 Claims, 4 Drawing Figures



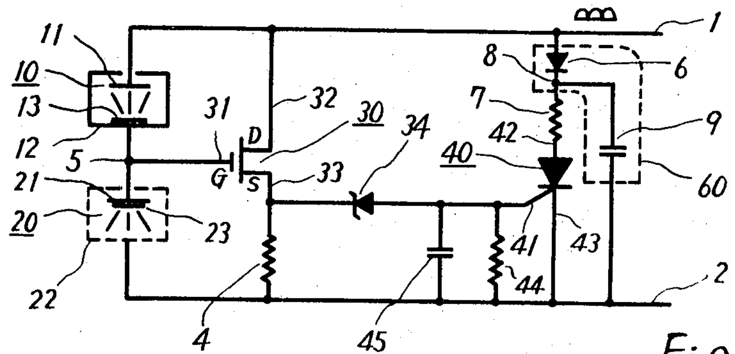


Fig. 1

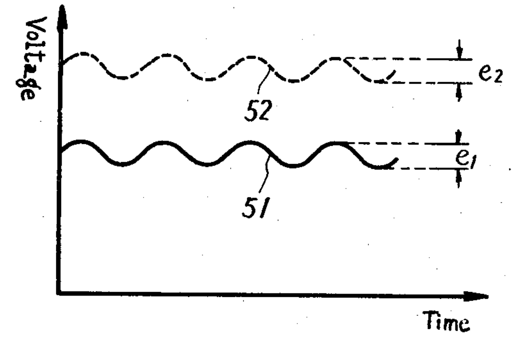


Fig. 2

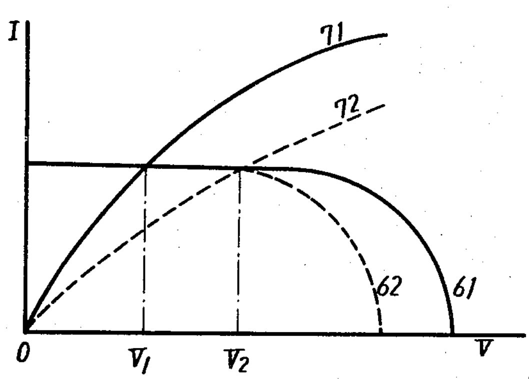


Fig. 3

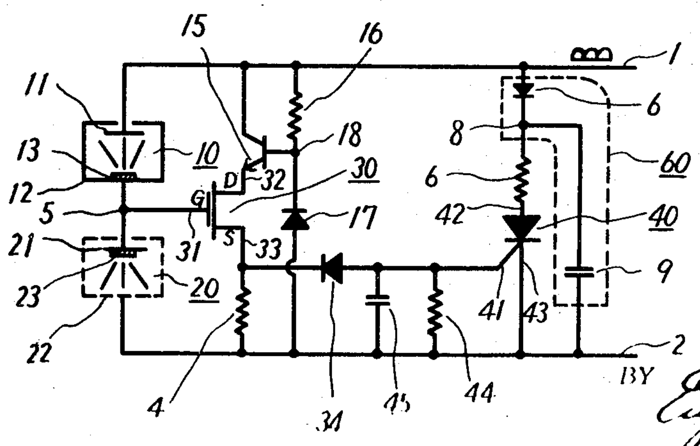


Fig. 4

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IONIZATION SMOKE DETECTOR

This invention relates to an ionization smoke detector and more particularly to a novel and improved ionization smoke detector that will afford accurate and dependable operation when energized by an insufficiently filtered pulsating voltage as well as a filtered voltage.

Prior known ionization detectors comprise open and closed chambers. The chambers of each detector each have a pair of electrodes and radioactive source. The electrodes of the chambers are connected in series across a voltage source for producing the current flow through the chambers. A field effect transistor is connected with the chambers to detect a voltage change at the junction of the chambers which results from an increase in impedance of the open ionization chamber by reason of the entry of smoke therein. A switching element such as a silicon controlled rectifier is driven into conduction by the output of the field effect transistor.

With such prior ionization smoke detectors, the use of a pulsating voltage such as rectified alternating current will not permit the silicon controlled rectifier to conduct should a signal be developed by the field effect transistor when the pulsating voltage is at zero. Accordingly, reliable operation will not be afforded by the detector, and a sufficiently filtered DC voltage must be utilized. This requirement materially increases the cost of the device.

One object of this invention resides in the provision of an improved ionization detector which will operate dependably on an inexpensive pulsating source. This is accomplished by the use of an improved holding circuit which will maintain the silicon controlled rectifier in a conductive state once it is driven into conduction even though it is operated from a pulsating voltage.

An improved ionization smoke detector in accordance with the invention includes a closed ionization chamber having a pair of electrodes and a radioactive source, an open ionization chamber exposed to the ambient atmosphere and having a pair of electrodes and a radioactive source, a pair of conductors providing an operating voltage which is applied across both ionization chambers, the latter being connected in series, a field effect transistor for detecting a voltage change at the junction of the chambers which results from the admission of smoke into the open chamber, a silicon controlled rectifier connected between said conductors and controlled by the output of the field effect transistor and a holding circuit for maintaining a silicon controlled rectifier in a conductive state even when a pulsating voltage is applied to the conductors.

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 schematic diagram illustrating one embodiment of an ionization smoke detector in accordance with the invention;

FIGS. 2 and 3 are graphs illustrating voltage wave forms for use in explaining the operation of the detector shown in FIG. 1; and

FIG. 4 is a schematic diagram of a modified embodiment of an ionization smoke detector in accordance with the invention.

Referring to FIG. 1, the detector includes a closed ionization chamber **10** having a pair of electrodes **11** and **12** and a radioactive source **12** and an open ionization chamber **20** also including a pair of electrodes **21** and **22** and a radioactive source **23**. The electrodes of the chambers are connected in series across a pair of conductors **1** and **2** which are connected to a voltage source not shown. The junction **5** between the ionization chambers **10** and **20** is connected to the gate electrode **31** of the field effect transistor **30**, the latter having its drain electrode **32** connected to the conductor **1**, and its source electrode **33** is connected through the load resistor **4** to conductor **2**. The anode **42** of the silicon controlled rectifier **40** is connected through a resistor **7** of relatively low value and a diode **6** to the conductor **1**. The cathode **43** of the silicon controlled rectifier **40** is connected directly to the conductor **2**. A capacitor **9** is connected between the junction **8** of the resistor **7** and the diode **6** and the conductor **2**. The capacitor **9** and the diode **6** form a holding circuit to maintain the silicon controlled rectifier **40** in a conducting state once it has been driven into conduction. A resistor **44** and a capacitor **45** are each connected between the gate electrode **44** of the silicon controlled rectifier **40** and the conductor **2**.

In the operation of the detector as described above it is assumed that a pulsating voltage produced merely by rectification of alternating current is applied by the conductors **1** and **2**. Inasmuch as the ionization chambers **10** and **20** have electrostatic capacitance and relatively high impedance, the pulsating voltage is filtered and the voltage at junction **5** varies as illustrated by the curve **51** of FIG. **2** when smoke does not exist in the ambient atmosphere surrounding the open ionization chamber **20**. When smoke enters the ionization chamber **20**, the ionization current flowing therethrough is reduced since the impedance of the chamber is increased so that the voltage at junction **5** increases as denoted by the dotted curve **52** of FIG. **2**. The fluctuating portions or ripple in the curves **51** and **52** have peak to peak values of e_1 and e_2, respectively, and these variations are substantially constant notwithstanding the presence or absence of smoke in the open ionization chamber **20**.

Inasmuch as a saturated ionization current always flows through the closed ionization chamber **10**, the ionization current flowing through the open ionization chamber **20** does not vary materially by a voltage change across that chamber which may be caused by an impedance change of the closed ionization chamber **10**. This condition is illustrated in FIG. **3** in which the abscissa represents the voltage at junction **5** and the ionization current is represented by the ordinate. It will be observed that the voltage across the closed ionization chamber **10** is high and this voltage is represented by the curve **61** when smoke does not exist in the ambient air surrounding the ionization chamber **20**. As previously pointed out, under these conditions the voltage at junction **5** is relatively low and represented by the curve **51** of FIG. **2**. When the voltage across the closed ionization chamber is low which condition occurs when smoke enters the open ionization chamber **20**, the voltage across chamber **10** is represented by the curve **62** and the voltage at junction **5** would then be represented by curve **52** of FIG. **2**. In both cases, however, a wide range of voltage (zero to V_2) is provided wherein the saturated ionization current of the closed ionization chamber 10 does not vary materially.

While the ionization current across the open ionization chamber 20 normally varies in a manner represented by the curve 71 of FIG. 3, it tends to vary in a manner represented by the curve 72 when smoke enters the open ionization chamber 20. However, the ionization current across the open ionization chamber does not vary materially even if a pulsating voltage is applied between the conductors 1 and 2 because of the inherently large time constant of the ionization chambers. Thus the voltage at junction 5 between the two chambers varies between V_1 and V_2 depending on the presence or absence of smoke in the open ionization chamber 20. This voltage change is detected by the field effect transistor 30 and produces a signal at the source electrode 33. When smoke enters the open ionization chamber 20, the voltage increases at junction 5 from V_1 to V_2 as illustrated in FIG. 3 and the current flowing through the source-drain path of the transistor 30 increases. This produces a voltage drop across resistor 4 which exceeds the critical voltage of the zener diode 34 and a control signal is applied to the gate electrode 41 of the silicon controlled rectifier 40 driving the latter into conduction. However, since a pulsating voltage is applied to the conductors 1 and 2, the silicon controlled rectifier 40 would normally become nonconductive when the voltage across conductors 1 and 2 becomes zero. This undesirable condition however is prevented through the utilization of a holding circuit 60. More specifically, since the capacitor 9 of the holding circuit 60 is discharged through the resistor 7 when the voltage between the conductors 1 and 2 becomes zero, the discharge current maintains the silicon controlled rectifier 40 in a conductive state and since the resistor 7 is of a relatively low value, the current drawn from the conductors 1 and 2 is materially increased, and this current is detected by any suitable means to produce an alarm.

Actual test results have indicated that the sensitivity of the ionization detector as described above does not vary materially provided however that the root mean square value of the pulsating or ripple voltage applied between the conductors 1 and 2 is maintained substantially constant. It is apparent, however, that the ionization smoke detector according to the detector may also be utilized with a direct current source.

With the detector as described above, an expensive DC voltage source is not required with the result that substantial savings are effected.

FIG. 4 is a modified embodiment of the detector according to this invention and it can be reliably operated with a nonstabilized voltage source. This is attained by providing a protective circuit for use with the field effect transistor so that the transistor which has a low breakdown voltage is never provided with a voltage higher than a predetermined value. In the drawing corresponding components of FIGS. 1 and 4 have been denoted by like numerals and a description of corresponding portions of FIGS. 1 and 4 has been omitted.

In FIG. 4 the drain 32 of the field effect transistor is connected through the collector-emitter path of transistor 15 to conductor 1. The base electrode of transistor 15 is connected through resistor 16 to conductor 1 and also through a zener diode 17 to conductor 2. With this arrangement the base electrode of transistor 15 is maintained at a fixed voltage determined by the diode 17 so that the transistor 15 functions as a constant voltage protection circuit for the field effect transistor 30.

With the foregoing arrangement should the voltage between the conductors 1 and 2 rise, the voltage at the drain electrode 32 of transistor 30 will also rise. However, since the voltage of the base electrode of transistor 15 is always maintained constant, this voltage increase at the drain electrode and consequently the emitter of transistor 15 results in the increase of impedance of the collector-emitter path of transistor 15, and the resultant increase in the voltage drop across the transistor 15. Thus the voltage of the drain 32 of transistor 30 can be maintained below a predetermined value.

In addition to the advantages afforded by the embodiment of the invention illustrated in FIG. 1, the embodiment shown in FIG. 4 has the further advantage that the field effect transistor which has a low breakdown voltage will not be damaged by a high transient voltage which may be produced by the relay or bell connected in series with the voltage source. Furthermore, the detector can be operated without any danger of damaging the field effect transistor by a voltage source of low quality and having relatively large fluctuations.

The foregoing embodiments of the invention are merely shown for illustrative purposes and various modifications and changes can be made without departing from the spirit and scope of the invention. For example, the foregoing embodiments of the invention each have a single closed ionization chamber and a single open ionization chamber each having a single pair of electrodes and a single radioactive source. It is evident, however, that ionization smoke detectors according to the invention may utilize any number of closed and open ionization chambers having any number of electrodes and radioactive sources depending on the nature of the application. The number of field effect transistors may also be selected in accordance with a specific application.

What is claimed is:

1. An ionization smoke detector, comprising at least one closed ionization chamber including at least one pair of electrodes and a radioactive source, at least one open ionization chamber including similarly at least one pair of electrodes and a radioactive source and connected in series to said closed ionization chamber, a pair of conductors for supplying an operational voltage to a series connection consisting of said both ionization chambers, at least one field effect transistor for detecting a voltage change at the junction between said both ionization chambers caused by smoke entering into said open ionization chamber, a silicon controlled rectifier having a main conduction path connected between said pair of conductors and controlled by said field effect transistor, and a holding circuit for supplying a current for keeping said silicon controlled rectifier in conduction once it conducts, even when a pulsating voltage is applied between said pair of conductors.

2. An ionization smoke detector, in accordance with claim 1, characterized in that said holding circuit in-

cludes a diode connected forwardly in series with said silicon controlled rectifier and one of said pair of conductors, and a capacitor connected between the cathode electrode of said diode and the other of said pair of conductors.

3. An ionization smoke detector comprising at least one closed ionization chamber including at least one pair of electrodes and a radioactive source, at least one open ionization chamber including similarly at least one pair of electrodes and a radioactive source and connected in series to said closed ionization chamber, a pair of conductors for supplying an operational voltage to a series connection consisting of said both ionization chambers, at least one field effect transistor for detecting a voltage change at the junction between said both ionization chambers caused by smoke entering into said open ionization chamber, a constant voltage protection circuit connected between the drain electrode of said field effect transistor and one of said pair of conductors for maintaining a voltage applied to said field effect transistor below a breakdown voltage of said field effect transistor, a silicon controlled rectifier having a main conduction path connected between said pair of conductors and controlled by said field effect transistor, and a holding circuit for supplying a current for keeping said silicon controlled rectifier in conduction once it conducts, even when a pulsating voltage is applied between said pair of conductors.

4. An ionization smoke detector, in accordance with claim 3 characterized in that said constant voltage protection circuit includes a transistor having an emitter-collector path connected between the drain electrode of said field effect transistor and one of said pair of conductors, a resistor connected between the base electrode of said transistor and one of said pair of conductors, and a zener diode connected between the base electrode of said transistor and the other of said pair of conductors.

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