United States Patent

Sasaki et al.

[15] **3,666,954**

[45] **May 30, 1972**

[54] IONIZATION SMOKE DETECTOR AND LEAKAGE SENSING MEANS THEREFOR

[72] Inventors: **Koju Sasaki**, Tokyo; **Naoki Takahashi**, Fujisawa; **Akihiro Kobayashi**, Yokohama, all of Japan

[73] Assignee: **Nittan Company, Limited**, Tokyo, Japan

[22] Filed: **June 18, 1970**

[21] Appl. No.: **47,427**

[30] **Foreign Application Priority Data**

June 21, 1969 Japan.....44/48669

[52] **U.S. Cl.** .....**250/83.6 FT**, 250/44, 313/54, 340/237 S

[51] **Int. Cl.** **G01t 1/18**, G08b 21/00

[58] **Field of Search**.....250/44, 83.6 FT; 340/237 S; 313/54

[56] **References Cited**

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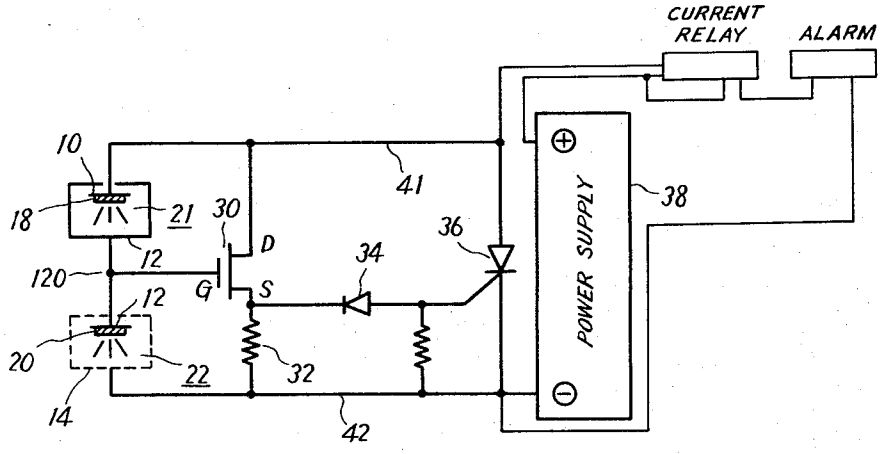
Primary Examiner—Archie R. Borchelt
Attorney—Eugene E. Geoffrey

[57] **ABSTRACT**

An ionization smoke detector embodying a closed ionization chamber and an open ionization chamber connected in series and interconnected with means for producing an alarm when smoke enters the open chamber, the detector further including means for sensing contamination of the leakage particularly between the electrodes in the open ionization chamber and producing an alarm when the leakage resistance falls below a selected value.

5 Claims, 3 Drawing Figures



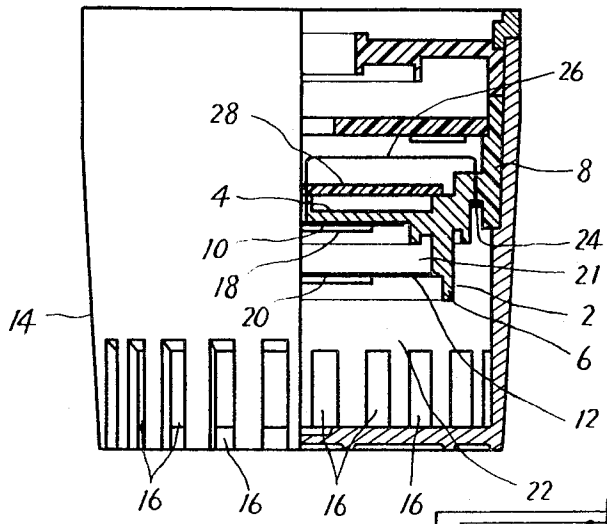


Fig. 1

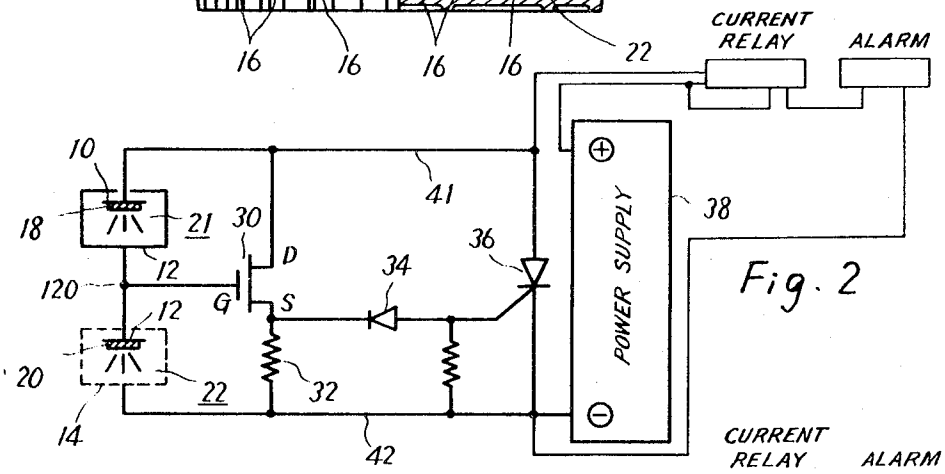


Fig. 2

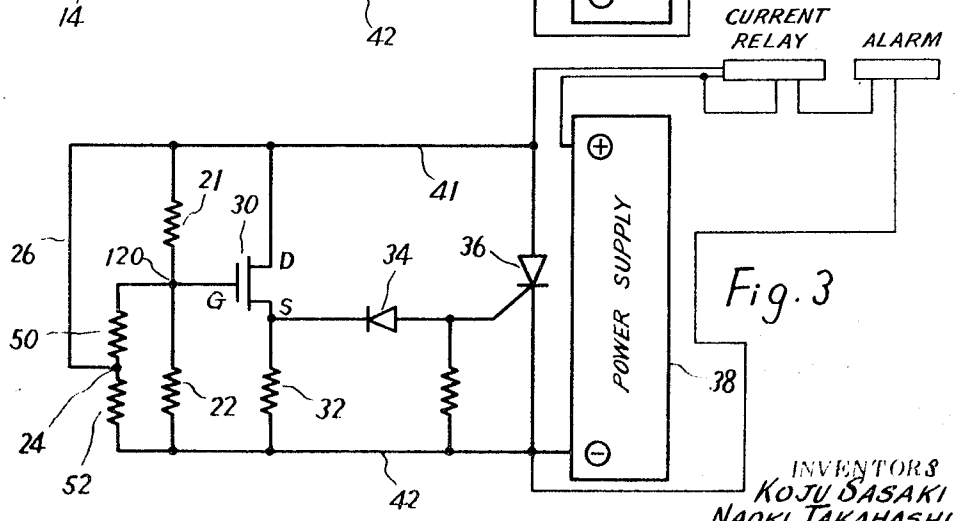


Fig. 3

INVENTORS
KOJU SASAKI
NAOKI TAKAHASHI
AKIHIRO KOBAYASHI
BY
ATTORNEY

IONIZATION SMOKE DETECTOR AND LEAKAGE SENSING MEANS THEREFOR

This invention relates to ionization smoke detectors and more specifically to a novel and improved ionization smoke detector embodying a novel and improved arrangement of elements which will provide an alarm signal to indicate a defective detector caused by contamination of the electrodes which would interfere with proper operation of the detector in the presence of smoke.

Ionization smoke detectors are generally provided with a closed ionization chamber and an open ionization chamber with each chamber including a pair of electrodes and a radioactive source. The electrodes of the chambers are connected in series and transistor circuitry is utilized to detect impedance variations of the open ionization chamber when smoke enters the open chamber. An alarm device is actuated by the transistor circuitry when the impedance change is detected.

In the foregoing detector when smoke enters the open ionization chamber, a saturation current flowing between the electrodes in the open chamber decreases. This decrease in current changes the potential at the junction of both chambers and produces an alarm. However, the insulation between the electrodes of the chambers decreases as a result of long use. This phenomenon is especially evident in the open ionization chamber. Thus should smoke enter the open ionization chamber to reduce the current flow between the electrodes, the resultant potential variation produced at the junction of the ionization chambers is insufficient to actuate the alarm.

Prior ionization smoke detectors have not been satisfactory since contamination of the chambers can prevent generation of an alarm in the event of an actual fire and the entrance of smoke into the ionization chamber.

This invention overcomes the disadvantages of prior known detectors and utilizes a novel and improved structure which will produce an alarm signal should the resistance between the electrodes decrease to a point that would not produce an alarm in the event of an actual fire.

The ionization detector in accordance with the invention is provided with a closed ionization chamber sealed within a base of insulating material and having an inner electrode, an intermediate electrode, and a radioactive source. An open ionization chamber is surrounded by a cup-shaped outer electrode supported by the insulating base and having ventilating openings therein. The above mentioned intermediate electrode includes a radioactive source and the intermediate electrode together with the outer electrode forms the open ionization chamber. A surface contamination detecting electrode is disposed between the intermediate electrode and the outer electrode and in contact with the surface of the insulating base. The surface contamination detecting electrode is connected with the inner electrode and a transistor is utilized to detect a potential variation at the intermediate electrode and produces an alarm upon occurrence of such variation.

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 side elevational view in partial section of one embodiment of an ionization smoke detector in accordance with the invention;

FIG. 2 is a circuit diagram showing the electrical connections of the detector illustrated in FIG. 1; and

FIG. 3 is an equivalent circuit diagram illustrating the operation of the smoke detector shown in FIG. 1.

Corresponding elements in the several figures have been denoted by like numerals.

Referring to FIG. 1, the device includes a base generally denoted by the numeral 2 and formed of insulating material. The base 2 includes a central flat portion 4, a depending annular flange 6 having an inwardly facing recess for supporting an intermediate electrode and an upwardly extending annular wall 8 of greater diameter than the annular flange 6. An inner electrode 10 is provided on the underside of the flat portion 4 and an intermediate electrode 12 is supported within the recess of the annular flange 6. A cup-shaped outer electrode 14 surrounds the base 2 and closely fits the annular wall portion 8. The electrode 14 may be secured to the base 2 by screws or other suitable means. The outer electrode further includes a plurality of ventilating holes 16 which permit the smoke to enter the outer electrode. A radioactive source 18 is carried on the inner electrode 10 and a second radioactive source 20 is carried by the intermediate electrode 12 which faces the outer electrode 14. Thus the closed ionization chamber 21 comprises the inner electrode 10 and the intermediate electrode 12 while the open ionization chamber 22 comprises the intermediate electrode 12 and the outer electrode 14. The radioactive sources in both of the chambers function to ionize the air in the respective chambers and cause ionization currents to flow between the respective pairs of electrodes.

The flange 6 of the base 2 which supports the intermediate electrode 12 has a plurality of annular grooves for increasing the leakage paths and the surface contamination detecting electrode 24 is disposed in the outermost annular groove which adjoins the inner surface of the annular wall 8. A printed circuit board 28 carries the components for detecting potential variations at the intermediate electrode 12 which occur when smoke enters the open ionization chamber. This printed circuit board is carried on the upper face of the base 2.

Referring to FIG. 2, the two ionization chambers are generally denoted by the numerals 21 and 22 and are connected in series between conductors 41 and 42 which in turn are connected to a potential source 38. The junction of the ionization chambers 21 and 22 is denoted by the numeral 120 and actually is the intermediate electrode 12 which as shown in FIG. 1 is common to both chambers. The junction 120 is connected to the gate electrode of a field effect transistor 30 and the drain electrode of that transistor is connected to the conductor 41 while the source electrode is connected through a resistor 32 to a conductor 42. The source electrode of the transistor 30 is also connected through a zener diode 34 to the gate or control electrode of the silicon controlled rectifier 36 which is also connected between conductors 41 and 42.

When the surface of the insulating base 2 of a smoke detector shown in FIG. 1 is not contaminated, and the leakage resistance of the surface portions of the base between the intermediate electrode 12 and the contamination detecting electrode 24 and between the contamination electrode 24 and the outer electrode 14 are relatively large, then the electrical circuit of the smoke detector will be as shown in FIG. 2. Thus when smoke enters the open ionization chamber 22 through the opening 16, the saturation current of the open chamber decreases and the potential at the junction 120 (intermediate electrode 12) increases. As a result, the current flowing between the source and the drain electrodes increases with the result that an increased potential drop occurs across the resistor 32. When the potential across resistor 32 exceeds the voltage of the zener diode 34, a signal is applied to the control electrode of the rectifier 36 firing the electrode and causing it to conduct and effectively short circuit the conductors 41 and 42. This action may be detected by the power supply 38 and produce an alarm signal. Detection of the increased current drawn from the power supply may be accomplished by the utilization of a current detecting relay or other suitable means.

When the surface of the insulating base 2 and particularly that portion exposed to the open ionization chamber 22 is contaminated so that the surface leakage resistance is reduced after long periods of use, the sensitivity of the open ionization chamber will be materially reduced and in many instances will not produce an alarm even in the presence of smoke. This condition will be more readily understood with reference to FIG. 3.

Referring to FIG. 3, the closed ionization chamber 21 and the open ionization chamber 22 are represented respectively

by resistors 21 and 22 in FIG. 3 since they constitute the electrical equivalent of the actual chambers 21 and 22. Assuming that the surface of the insulation base 2 exposed to the open ionization chamber 22 is contaminated, the insulating resistance of the surface portions of the base between the intermediate electrode 12 and the contamination detecting electrode 24 as well as the outer electrode 14 are materially decreased. This condition can be effectively represented by connection of small resistances in parallel between the intermediate electrode 12 and the outer electrode 14 or in other words between both electrodes of the ionization chamber 22. This equivalent resistance is indicated by the series connection of two resistors 50 and 52 as shown in FIG. 3. The resistor 50 represents the leakage resistance between the intermediate electrode 12 and the surface contamination detecting electrode 24. The resistor 52 represents the leakage resistance between the surface contamination detecting electrode 24 and the outer electrode 14. If the surface contamination detecting electrode 24 were not provided, the potential at the junction 120 of both chambers would not rise enough in the presence of smoke to drive the field effect transistor 30 into full conduction because of the leakage resistors 50 and 52. Under this condition therefore an alarm signal would not be produced. With the detector in accordance with the invention the surface contamination detecting electrode 24 is connected to the electrode 10 which in turn is connected to the conductor 41. In this way the lowering of the resistance of the leakage resistors 50 and 52 by reason of surface contamination of the insulating base 2 is the equivalent of the lowering of the internal resistance of the closed ionization chamber 21. This causes the voltage applied to the gate electrode of transistor 30 to increase in the same manner as if smoke entered the open ionization chamber. This increase in potential drives the transistor 30 into conduction and in turn fires the silicon controlled rectifier 36 to produce an alarm.

With the foregoing invention the production of an alarm in the absence of actual smoke or fire indicates a defect in the detector so that prompt repair can be made and thereby insure complete reliability of the detector. Thus when deterioration of the insulation between the electrodes or contamination thereof can be located at an early stage, a more reliable detector is provided.

While only one embodiment of the invention has 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 appended claims.

What is claimed is:

1. An ionization smoke detector comprising a base member having an inner electrode and an intermediate electrode with said electrodes defining a closed ionization chamber, a radioactive source within said closed chamber, an outer electrode having opening therein and surrounding said intermediate electrode, said outer and intermediate electrodes defining an open ionization chamber, a radioactive source within said open chamber, a surface contamination electrode between said intermediate electrode and said outer electrode and in contact with the surface of said base member and an electrical connection between said contamination detecting electrode and said inner electrode.

2. An ionization detector according to claim 1 wherein said base member is annular and said contamination electrode is on an inner wall of said base member.

3. An ionization detector according to claim 1 wherein said outer electrode encloses said base member.

4. An ionization detector according to claim 1 wherein said radioactive source in said closed chamber is carried by the surface of said inner electrode facing said intermediate electrode and said radioactive source in said open chamber is carried on the surface of the intermediate electrode facing said outer electrode.

5. An ionization smoke detector comprising a base member having an inner electrode and an intermediate electrode with said electrodes defining a closed ionization chamber, a radioactive source within said closed chamber, an outer electrode having opening therein and surrounding said intermediate electrode, said outer and intermediate electrodes defining an open ionization chamber, a radioactive source within said open chamber, a surface contamination electrode between said intermediate electrode and said outer electrode and in contact with the surface of said base member, an electrical connection between said contamination detecting electrode and said inner electrode, a transistor interconnected with said contamination detecting electrode to detect potential variations of the last said electrode and an alarm connected with said transistor and controlled by the output of said transistor.

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