

[54] **IONIZATION-TYPE FIRE SENSOR**

[75] Inventors: **Andreas Scheidweiler**, Stafa;
Hanspeter Thalmann, Urdorf, both
of Switzerland

[73] Assignee: **Cerberus AG**, Mannedorf,
Switzerland

[22] Filed: **June 28, 1973**

[21] Appl. No.: **374,310**

[30] **Foreign Application Priority Data**

July 17, 1972 Switzerland..... 10655/72

[52] U.S. Cl..... **340/237 S; 340/378 R**

[51] Int. Cl..... **G08b 17/12**

[58] Field of Search..... **340/237 S, 378, 213 R,**
340/331; 250/381, 382, 384, 385

[56] **References Cited**

UNITED STATES PATENTS

3,665,441 5/1972 Suchomel et al..... 340/237 S

FOREIGN PATENTS OR APPLICATIONS

1,088,976 10/1967 United Kingdom 340/237 S

Primary Examiner—John W. Caldwell

Assistant Examiner—Daniel Myer

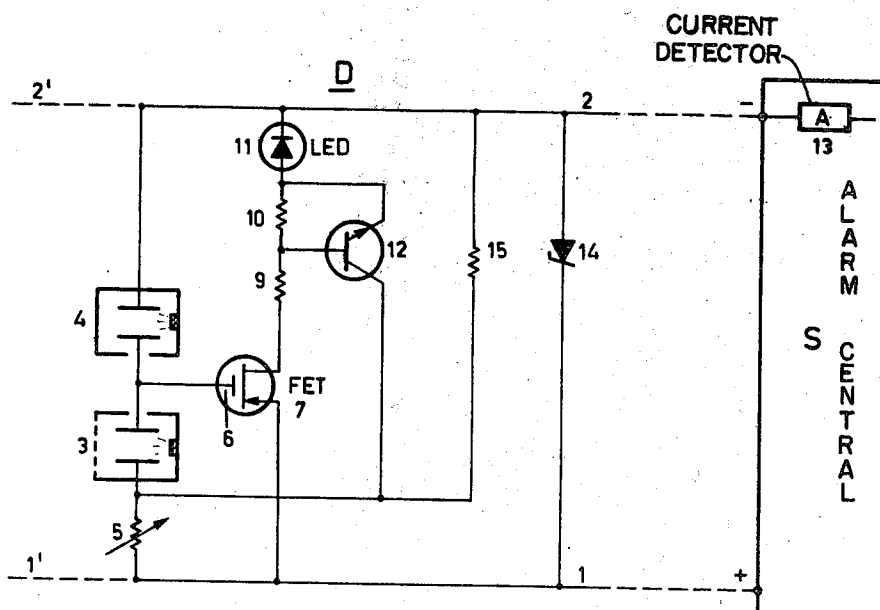
Attorney, Agent, or Firm—Flynn & Frishauf

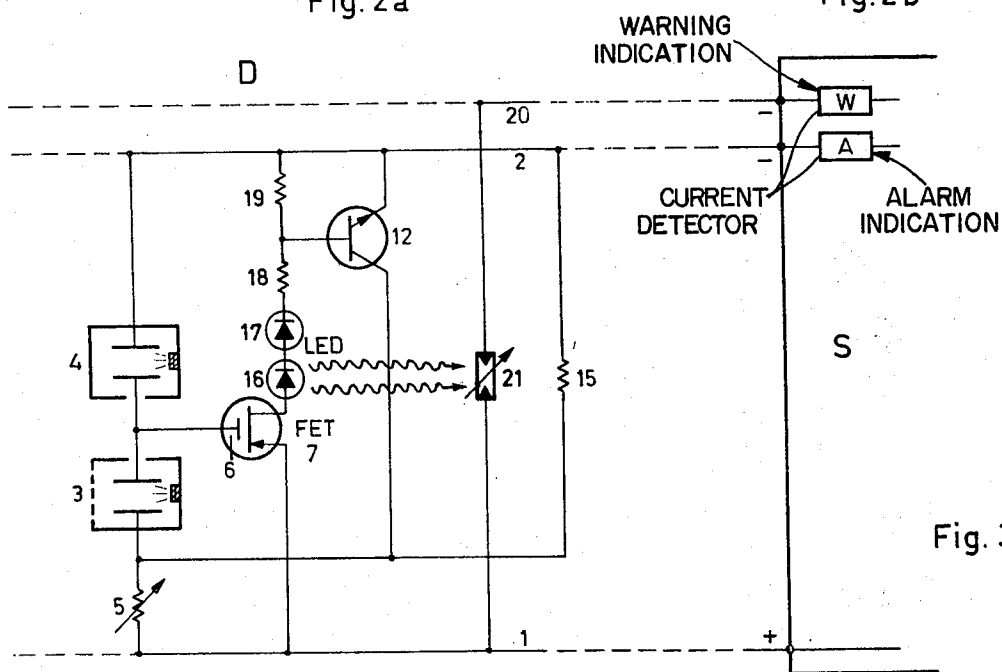
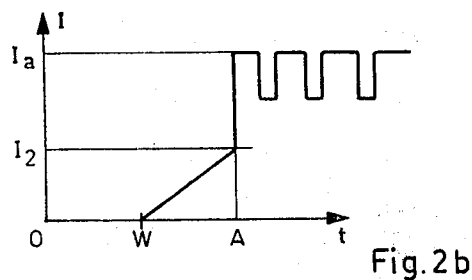
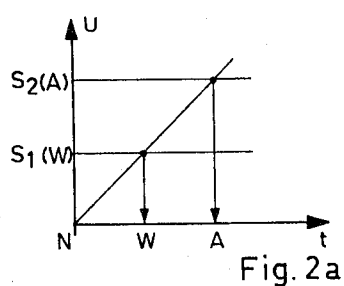
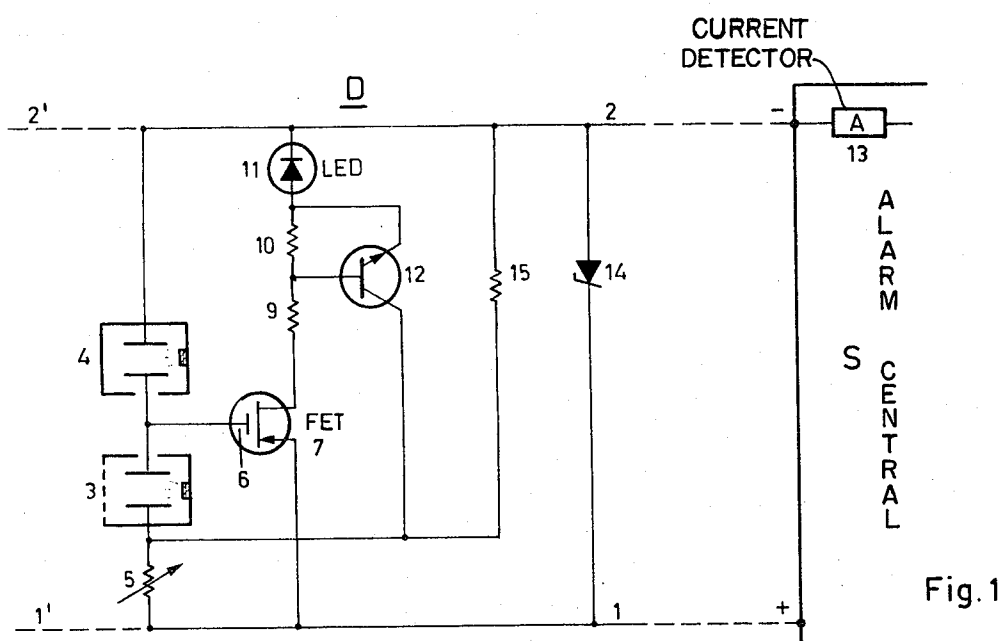
[57]

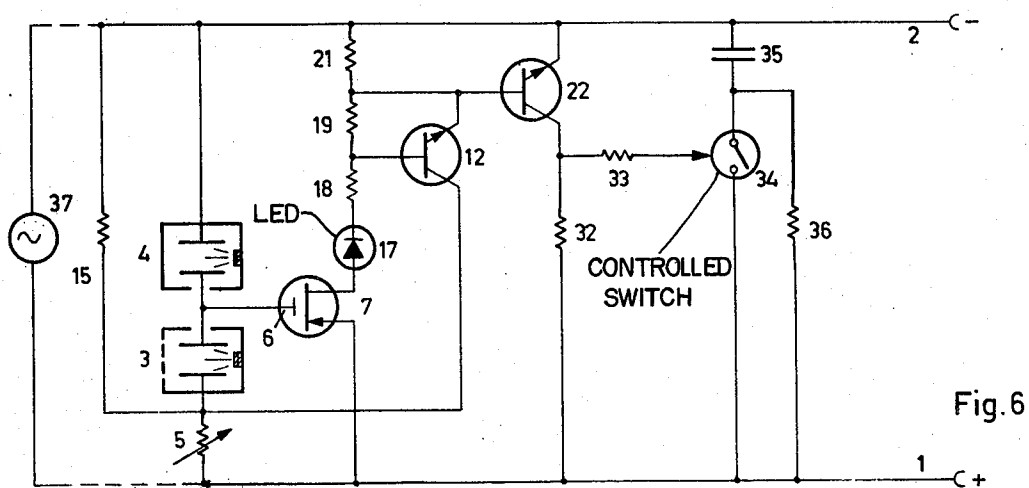
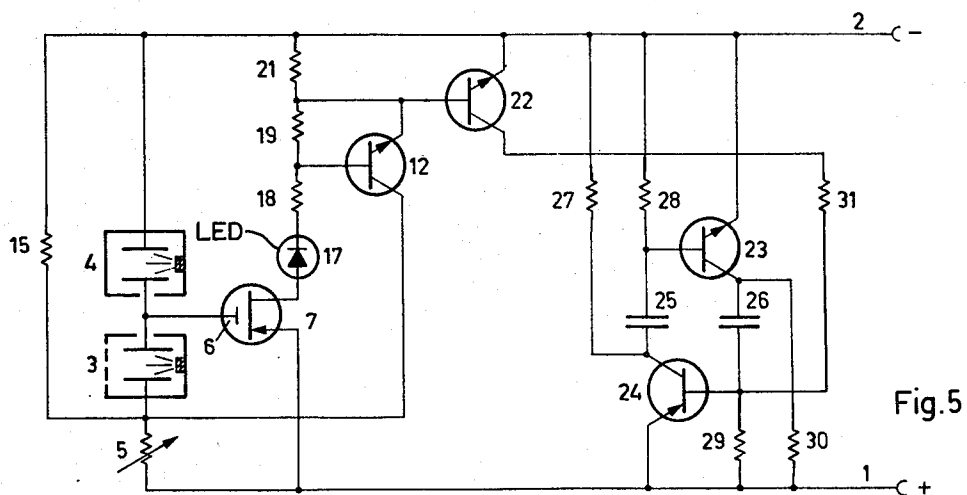
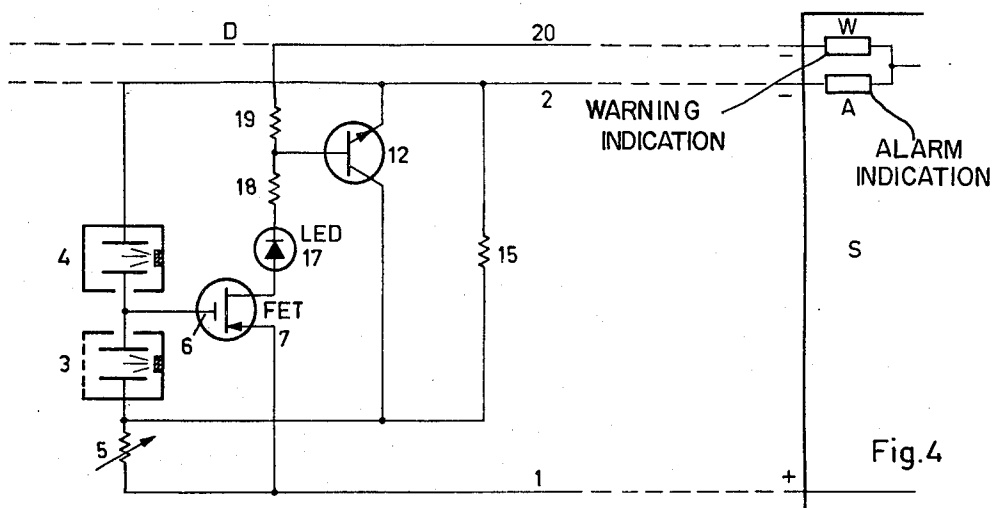
ABSTRACT

An ionization chamber includes an ionizing element which, in combination with an electrical circuit, is so arranged that the electrical resistance of the chamber increases when smoke, or fire aerosols are detected; the sensor further includes an electrical circuit which has a first threshold detector responsive to a first threshold value of increase of resistance to permit generation of a warning signal, and a second threshold level with a second threshold detector, which responds upon exceeding of the second threshold level to provide an alarm signal different from the first warning signal arising at the first threshold level. Preferably, the warning signal is a constantly arising current, and the alarm signal is a signal of varying intensity.

20 Claims, 7 Drawing Figures







IONIZATION-TYPE FIRE SENSOR

Cross reference to related applications

U.S. Pat. No. 3,767,917, Oct. 23, 1973

U.S. application Ser. No. 374,795 filed June 28, 1973

The present invention relates to an ionization-type fire alarm sensor, and more particularly to this type of sensor in which an ionization chamber is provided in which a radioactive substance is located. The electrical resistance of the ionization chamber rises when fire is sensed; the sensor further includes an evaluation circuit including at least one threshold detector, as well as an alarm indicator.

Ionization type fire sensors, in which a radioactive substance generates ions are so arranged that, upon application of an electric voltage between the electrodes of the ionization chambers, a current is generated which decreases upon penetration of smoke, or fire aerosols into the chamber. Decrease of ion current in the ionization chamber is detected by an electrical circuit which includes a threshold detector. Upon detection, an alarm circuit can be activated. In one form, the ionization chamber is connected in series with a resistance element, for example another ionization chamber which may be termed a reference ionization chamber since it is so constructed that it is substantially separated from ambient air, and thus not subject to smoke or fire aerosols. The relative voltage drops across the ionization chambers are sensed and applied to a threshold detector, for example to a field effect transistor (FET). If the voltage drop across the sensing ionization chamber rises, due to increase in its resistance, then the threshold level of the FET is exceeded, it begins to become conductive, and provides a fire alarm signal.

Known ionization-type fire sensors are connected to a signal central. The increased FET current is conducted directly to the signal central, or over a further switching element, such as a relay, a SCR, or the like. The signal central provides an alarm signal. The sensor further includes, in its structure, or in its vicinity, an alarm indicator, such as a lamp or other illuminating device which permits an indication that a specific sensor has responded. This is of particular advantage when a plurality of sensors are connected, in parallel, over a common line to a signal central. The signal central, in such a case, can determine that one of the sensors on the line was responded to give an alarm, but it is difficult to determine which one of the sensors has responded. By checking the alarm indicators of the various sensors, the location of the responding sensor can be determined.

Known ionization fire sensors utilize electrical components with very high resistances. For example, the inherent or inner resistance of the ionization chamber is in the order of 10^{10} ohms. The input resistance of the connected electrical circuit, particularly of the FET, must be higher by an order of magnitude. To further increase sensitivity, and to decrease the activity of the radioactive substances, it has recently been tried to still further decrease the ion current, that is, to further increase the resistance of the ionization chamber. It has been found to be very difficult, in actual practice, to maintain such high isolation resistances in an ionization fire sensor over long periods of time, for example over years. The resistance may change, particularly due to precipitation of dust within the fire sensor, slow changes of some materials, and the like. As a result, the voltage drop across the ionization chamber will change

slowly. In many instances it has been found that the voltage drop, in time, slowly approaches the alarm threshold level. An erroneous fire alarm may thus result.

It is an object of the present invention to provide an alarm indicator for fires of the ionization-type, which provides an indication that the voltage in the ionization chamber approaches the alarm threshold. This permits identification of alarm sensors which may have a tendency to give a false alarm, so that such sensors may be replaced, exchanged, or cleaned and maintained before a false alarm has been signalled. It is well known that false alarms are as dangerous as undetected real fires.

SUBJECT MATTER OF THE PRESENT INVENTION

Briefly, the ionization fire alarm sensor has more than one threshold level. A first, lower threshold detector is provided which, when a first lower threshold level of resistance is exceeded provides a pre-warning signal; when a second threshold level is exceeded, indicative of fire, or the like, then a second alarm signal, clearly distinguishable from the pre-warning signal is given.

The ionization fire sensor of the present invention has the advantage that an incipient fire provides, already in a very early stage, a pre-warning signal, before the real fire alarm signal is generated. A certain warning will thus be provided between the real fire alarm, and quiescent conditions. This warning time permits investigation whether, really, a fire is beginning, or whether other reasons are present which might cause the sensor to provide the pre-warning signal, such as, for example, excessive cigarette smoke, welding gases, high dust or particle concentrations, or the like. The pre-warning signal may be used, for example, to prepare an otherwise deactivated fire extinguishing system, that is, to bring the system into a "get ready" state, the system itself being activated only when the final alarm signal, indicative of fire, is received. Thus, it is possible to avoid costly steps, or possible damage by the fire extinguishing system itself, before one is sure that a fire really has started, while, however, an indication is being made available that a possibly suspicious situation should be investigated.

The invention will be described by way of example with reference to the accompanying drawings, wherein:

FIG. 1 is a highly schematic circuit diagram of an ionization-type fire sensor in accordance with the present invention;

FIGS. 2a and 2b illustrate voltage and current characteristics useful in connection with the explanation of the operation of the device; and

FIGS. 3-6 are schematic circuit diagrams of various other embodiments of the invention.

Embodiment of FIG. 1 and principal system:

Construction of sensor in accordance with the present invention, with reference to FIGS. 1, 2a, 2b: A fire sensor D is connected by means of lines 1, 2 to a signal central S. The lines extend, as schematically shown by lines 1', 2', for parallel connection of further sensors, for example of the same type.

Each sensor has an ionization chamber 3 which is open to ambient air. It includes two electrodes and a radioactive source. The chamber is in series with a reference ionization chamber 4, which is essentially closed off against ambient air. A controllable resistor

5 is connected in series with the chamber 3, 4, across lines 1, 2.

The voltage drop over ionization chamber 3, which varies, is applied to the control electrode 6 of FET 7, or an equivalent electronic element. As an equivalent element, an entire integrated network may, for example, be used. The source-drain path of the FET is connected with the series circuit of resistors 9, 10, and a light-emitting diode (LED) 11, the series circuit being likewise connected across lines 1, 2. LED 11 may be a gallium arsenide, or a gallium phosphide diode, or may include other light-emitting material.

The input voltage, that is, the voltage on gate electrode 6 of FET 7 is so controlled by means of resistor 5 that, under ordinary quiescent condition, the FET is blocked. Under such conditions, no fire has been sensed, there are no smoke or fire aerosols in the air penetrating into chamber 3. Below an input voltage across the gate electrode 6 of FET 7, indicated as S_1 (FIG. 2a) no current will flow through LED 11. If, however, the input voltage at the control electrode 6 rises above the warning level S_1 , FET 7 becomes conductive and, depending on input voltage across lines 1, 2, current will flow through the FET 7. The LED 11 becomes luminescent. The brightness of LED 11 is a measure for the extent by which the voltage drop across ionization chamber 3 has exceeded the warning threshold level.

The junction point between resistors 9 and 10 is connected to the base of a further transistor 12, the emitter of which is connected over LED 11 to the supply line 2. The collector is connected to the controlled resistor 5. If the current through the FET 7 and resistor 10 exceeds a predetermined threshold level I_2 (FIG. 2b), corresponding to a threshold voltage S_2 at the input 6 of the control electrode of the FET 7 (FIG. 2a) transistor 12 becomes conductive, which increases the voltage drop across resistor 5. The voltage at the gate electrode 6 of FET 7 increases, which causes a still further increase in current through transistor 12.

Resistor 5 thus has a dual function: first, it sets the first, or warning threshold level and, secondly, it acts as a feedback resistor to ensure that when the alarm threshold level S_2 is reached, current through the sensor D rises abruptly and extensively. The circuit will then, also, be self holding; in other words, the sensor changes state to an alarm condition which cannot be terminated by reversion of the ionization chamber to its normal lower value.

Lines 1, 2, will thus, suddenly, have current flow therethrough of suddenly increased amplitude, which current is supplied by signal central S. A current detector 13 (block A) is included in the signal central S which responds when such a current is detected, in order to provide an external alarm system (for example an alarm notification to a fire signalling station, an acoustical signal, optical indication or the like, or direct alarm to a fire department). The current detector 13 further causes periodic changes in the supply voltage supplied to lines 1, 2, so that the LED 11 is supplied with a pulsed supply voltage and will flash in the same rhythm. A suitable frequency is about 1 Hz.

The alarm central may have other circuits, for example voltage evaluation circuits and the like, as referred to in the cross referenced application Ser. No. 374,795 filed June 28, 1973, assigned to the assignee of the present application.

A Zener diode 14 is connected across lines 1, 2 to protect against over voltages and inverse polarity upon connection of the sensor to the lines 1, 2. Resistor 15 forms, together with resistor 5, a voltage divider to adjust the bias on the gate control electrode 6 of FET 7.

Operation (with reference to FIGS. 2a, 2b): Under normal, quiescent conditions, when no fire is being sensed, the total current drawn by the sensor is very small, and essentially the current which flows through the two ionization chambers 3, 4, and the practically negligible current through the parallel resistor 15. Upon penetration of smoke, or fire aerosols into ionization chamber 3, the resistance of the chamber 3 will increase. As soon as this resistance has increased to such an extent that the voltage at the input 6 of FET 7 exceeds the lower, or warning threshold levels S_1 (W), current starts to flow, and the LED 11 begins to light with a brightness which depends on the amplitude by which the input voltage exceeds the threshold level. If the voltage increases further and reaches the second or alarm threshold level S_2 (A), the sensor changes suddenly into alarm condition and a highly increased alarm current I_a will flow to the signal central S. The signal central will thereupon command periodic dropping of the supply voltage, so that the LED 11 will blink, or flash, thus unambiguously indicating an alarm condition, and differentiating an alarm condition from a warning condition.

In the further examples, similar parts, having similar functions will not be described again, and have been given the same reference numerals.

Embodiment of FIG. 3: The drain electrode of FET 7 is connected over two LEDs 16, 17 and over a voltage divider formed by resistors 18, 19, to line 2. The tap point of the voltage divider 18, 19, controls the base of transistor 12, the collector-emitter path of which is in parallel to the series circuit formed of the two ionization chambers 3, 4. When the gate voltage on gate electrode 6 of FET exceeds the warning threshold S_1 , then FET 7 becomes conductive, and both LEDs 16, 17 become luminescent. Upon further increase of input voltage, to the gate 6 of FET 7, that is, when the alarm threshold S_2 is passed, transistor 12 will become conductive which switches the sensor into alarm condition, as in FIG. 1. LED 17 will indicate if the fire sensor is in normal condition, warning condition or alarm condition. Under alarm conditions, a highly increased alarm current will flow over line 2 to signal central S, which can be identified in the signal central, for example by current detector A, and utilized to provide an alarm. The sensor further includes a photoresistor 21 which is in light receiving relationship to the light emitted from LED 16. One terminal of the photoresistor 21 is connected to line 1, and the other terminal to a line 20, likewise supplied from signal central S. The photoresistor is so arranged that it can be controlled only by light from LED 16. Under normal, quiescent condition when the diode does not emit light, photoresistor 21 has a very high dark resistance. When diode 16, upon passing the warning threshold level S_1 begins to luminesce, the resistance of resistor 21 changes suddenly and warning current flows over line 20 to signal central S, to be there evaluated by a further current detector W to provide a warning signal, as described. In this example, alarm indicator A indicates by a discrete signal if the sensor is under normal, warning or alarm conditions; additionally, the signal central can separately dis-

tinguish if one of the sensors connected thereto is in warning conditions or quiescent conditions, thus providing a remote indication. This circuit may also use a plurality of ionization fire sensors, connected in parallel over lines 1, 2, and 20 to signal central S.

Instead of two diodes 16, 17, a single diode can be used, so located that its light can be used simultaneously for visual indication, as well as for optical transmission to the photoresistor 21. The optical path to the photoresistor must, of course, be shielded against stray or extraneous illumination or light penetration.

Embodiment of FIG. 4: The warning signal is electrically indicated, the second LED 16 and photoresistor 21, and the optical path are eliminated. Rather, a resistor 19 is connected to third line 20 (instead of to line 2). When current flows through FET 7 upon passing of the warning level, the warning relay W in the signal central will have current flowing therethrough, so that not only LED 17 in detector D will provide a warning signal but, additionally, a warning signal will appear at the signal central S. If the alarm threshold of the second transistor 12 is exceeded, transistor 12 becomes conductive and line 2 will have an alarm current flowing through signal central S which, as before, provides pulsed voltage supply to effect flashing of LED 17, and additionally provides an alarm output. The embodiments of FIG. 3 and 4 require a three-wire circuit to provide separate alarm and warning indication. The embodiment of FIG. 5 provides discrete signals representative of warning condition and alarm conditions over two lines. A third transistor 22 is provided, having a threshold below the alarm threshold level of the second transistor 12. Its base is controlled over the voltage divider formed by resistors 18, 19, 21, by the current of the FET 7. When the warning level of the third transistor 22 is exceeded, a multivibrator oscillator is brought into oscillations. The oscillator includes transistors 23, 24, capacitors 25, 26 and resistors 27, 28, 29, 30. The multivibrator is of conventional construction, and coupled to transistor 22 over coupling resistor 31. Lines 1, 2, therefore will have a-c signals applied thereover when the warning threshold is exceeded. These signals can be coded by suitable dimensioning or construction of the multivibrator. When the alarm threshold is exceeded, however, transistor 12 will provide d-c over the lines 1, 2, to the signal central. The signal central includes circuits which can distinguish between a-c components and d-c warning currents, by well known isolating and filtering networks. Two lines can thus carry, separately, a warning signal and alarm signal from a sensor to a signal central. In many cases, the lines may already be subject to a-c in the kiloHertz range, particularly in cases in which a plurality of sensors are connected, in parallel, over a long line to the signal central, and continuity of the lines up to the last sensor is sensed by a terminating member 37, connected at the end of the line and providing pulsed output, or change of its internal resistance, in pulsed steps. FIG. 6 illustrates a circuit which still permits transmission of a warning signal, separate from an alarm signal over only two lines. Third transistor 22 controls a controlled switching element 34, which may be a transistor, an SCR, or the like, over collector resistor 32, connected between supply lines 1 and 2, and a resistance 33. The controlled switch 34 is connected in series with capacitor 35 which connects between lines 1 and 2. A resistor 36 is connected in parallel to switching element

34. When the warning threshold is exceeded, transistor 22 controls the switching element 34 to close, thus inserting capacitor 35 between lines 1, 2, and short circuiting pulses by the oscillator 37. The transistor 12 is triggered into conduction as previously explained.

Various changes and modifications may be made in the circuits of the present invention; for simplicity, a simple central station has been indicated, connected to the sensors by wire communication links. Wireless communication may also be used.

We claim:

1. Ionization-type fire sensor comprising an ion chamber (3) accessible to atmosphere subject to fire aerosols, smoke or the like, said ion chamber having electrical resistance which, upon detection of fire aerosols or smoke therein changes in resistance value, wherein the improvement comprises two threshold detectors of different threshold levels, a first threshold detector (7) connected to the ion chamber (3) sensitive to a first resistance condition of the chamber and having a first threshold level to provide a first warning output signal when the resistance value of the ion chamber changes and passes a first threshold level; and a second threshold detector (9, 10, 12) connected to the ion chamber sensitive to a second resistance condition, higher than the first condition, and having a second threshold level, higher than the first, to provide a second alarm output signal when the resistance value of the ion chamber passes a second level, higher than said first level; and wherein said second alarm output signal provided by said second threshold detector differs in characteristic from said first warning output signal.
2. Sensor according to claim 1 wherein the warning output signal is a continuous signal, and the alarm output signal is a signal of changing intensity.
3. Sensor according to claim 1 wherein the first threshold detector comprises an FET (7), the gate electrode (6) of the FET being controlled by the voltage drop across said ionization chamber.
4. Sensor according to claim 3 wherein said FET (7) is connected to the ionization chamber to become conductive when said first threshold level is passed; and a light-emitting indicating means (11) connected in the source-drain path of the FET.
5. Sensor according to claim 3 wherein the second threshold detector comprises a transistor (12), the base of which being controlled by the current through the FET (7), the transistor being connected to become conductive when the voltage drop across the ionization chamber, and thus the current through the FET (7) passes said second threshold level.
6. Sensor according to claim 5 further comprising a second ionization chamber (4) forming a reference ionization chamber, connected in series with said ionization chamber accessible to atmosphere; the collector-emitter path of said transistor (12) forming a parallel circuit to the series circuit formed by said ionization chambers; a resistor in series with said series connection of said chambers (3, 4) and the parallel connected transistor (12), and voltage supply lines (1, 2) connected to the free terminals of said parallel circuits, and said resistor (5).

7. Sensor according to claim 6 wherein the resistor (5) is a variable resistor to adjustably set said first warning threshold level.

8. Sensor according to claim 1 further comprising an alarm indicator (11), said alarm indicator providing a visual alarm indicating output.

9. Sensor according to claim 8 wherein said alarm indicator is a light emitting diode (LED 11, 16, 17).

10. Sensor according to claim 1 further comprising a light source (16) controlled to be illuminated when said first threshold level is passed;

a photosensitive sensor (21) disposed in light receiving relationship to said light emitting element, and a warning control line (20) connected to said photosensitive sensor, said warning control line having a signal placed thereon when said photosensitive sensor changes resistance due to illumination by said light emitting element.

11. Sensor according to claim 1 further comprising a current sensor (W);

a warning output signal line (20), said current sensor (W) being connected in an electrical circuit to said warning signal line, said warning signal line being activated and having current passing therethrough when said first threshold is passed, and providing a signal to said current, independently of the alarm signal, and in advance thereof.

12. Sensor according to claim 1 further comprising a signal central, and discrete signalling transmission links between the individual sensors and said signal central, said links being different for the warning output signal and the alarm output signal.

13. Sensor according to claim 1 comprising means (34, 35, 36) to suppress the warning output signal upon response of the second threshold detector which generates said second alarm output signal.

14. Sensor according to claim 1 further comprising a self holding or self locking circuit connected to the second threshold detector to hold the second alarm output signal even if said second threshold detector no longer senses conditions in excess of said second threshold

level.

15. Sensor according to claim 1 wherein the first threshold detector comprises a FET (7), the gate electrode of which is controlled by the voltage drop across the ionization chamber;

a switching transistor (22) is provided, the base of which is controlled by current through the FET (7), said switching transistor becoming conductive after the first threshold level is passed.

16. Sensor according to claim 15 further comprising an oscillator controlled by conduction of said transistor (22) to provide a-c signals indicative that said first threshold level has been passed.

17. Sensor according to claim 16 wherein said oscillator (FIG. 5) comprises a multivibrator-type oscillator (23, 24).

18. Sensor according to claim 15 further comprising (FIG. 6) a circuit (35) of low a-c impedance connected between the supply lines (1, 2) to the sensor;

and a controlled switch (34) connected to and controlled by said transistor (22) and switching said low a-c impedance circuit (35) in parallel to the sensor upon conduction of said transistor (22).

19. Sensor according to claim 15 comprising an additional transistor (12), the base of which is controlled by the current through the FET (7), and voltage divider means in the source-drain path of the FET (7) setting the threshold response levels of said switching transistor (22) and said additional transistor (12) to be at different levels to provide said first and second threshold levels, conduction of said transistors, respectively, controlling said first and second output signals.

20. Sensor according to claim 1 further comprising (FIG. 6) a circuit (35) of low a-c impedance connected between the supply lines (1, 2) to the sensor;

and a controlled switch (34) connected to and controlled by said first threshold detector (7) and switching said a-c low impedance circuit (35) in parallel to the sensor when the first threshold level of the first threshold detector (7) is exceeded.

* * * * *

45

50

55

60

65