A gas indicator provided with a gas sensor consisting of a semiconductive body incorporating two spaced electrodes. The body may be heated by means of one of the electrodes which is shaped as a filament for this purpose. When heated, the body is activated, whereby it obtains a high resistivity; however, this resistivity is reduced to a low value when the body is exposed to a gas. The gas indicator is operated by means of two bistable circuits, changing their states, respectively, at the end of the activating time of the body, and upon occurrence of a gas. The output signals of the two bistable circuits actuate an alarm circuit by means of a coincidence circuit. The filament of the gas sensor may be fed by the output energy of an oscillator.

8 Claims, 2 Drawing Figures
GAS INDICATOR WITH SEMICONDUCTIVE GAS SENSOR

BACKGROUND OF THE INVENTION

The invention relates to a gas indicator provided with a gas sensor consisting of a body of a semiconductive material incorporating two spaced electrodes of which one is constructed as a filament for heating the body, which is activated by the heating and thereby obtains the property that the electric resistivity is considerably reduced when the body is exposed to a gas, the current path between the electrodes of the sensor being inserted in a circuit containing a current source, so that the decrease of the resistivity gives rise to a current change whereby an alarm circuit is actuated.

A known sensor of the above-mentioned kind consists of an N-type metal oxide, such as tin oxide, zinc oxide, or ferroc sesquioxide, and is sensitive, inter alia, to hydrogen, carbon monoxide, methane, propane, volatile oils, acetylene, smoke, and carbon containing air. In a gas sensor of the above-mentioned kind, the resistance occurring between the electrodes is small when the semiconductive body is at room temperature. When the body is heated by means of the filament, the resistance between the electrodes obtains gradually a very high value. After about one minute, a final condition is reached in which the sensor has a maximum activity. When the semiconductive body is now exposed to a gas, such as carbon monoxide, hydrogen, hydrocarbons, or the like, the resistance between the electrodes is considerably reduced, whereby the alarm circuit may be actuated. During the heating time of about one minute, the operation of the alarm circuit must be inhibited.

BRIEF SUMMARY OF THE INVENTION

It is a main object of the invention to provide a simple and effective circuit arrangement for a gas indicator of the above-mentioned kind.

Another object of the invention is to provide a gas indicator of the above-mentioned kind adapted to be constructed as a portable apparatus.

According to the invention, a gas indicator is constructed in such manner that the operation of the alarm circuit is inhibited during the activating time by a delay circuit controlling a first bistable circuit changing its state at the end of the activating time, and the current flowing through the semiconductive body in the presence of a gas to which the sensor is sensitive causes a change of state of a second bistable circuit, the output signals of the two bistable circuits occurring after their changes of state being supplied to a coincidence circuit actuating the alarm circuit when both output signals are present.

In some cases, it is desirable to construct the gas indicator according to the invention as a portable apparatus, which may be carried along by persons working, for instance, in a mine, s ship hold or a sewer, so that they are warned upon the occurrence of harmful gases. A portable apparatus of this kind may also be arranged in a motor car to warn the passengers upon the occurrence of carbon monoxide.

Such a portable apparatus would, of course, have to be fed by a battery, which ought to have a voltage of at least 6 volts, and preferably of 12 volts in order to allow a sufficient energy for the alarm circuit. However, this leads to some difficulties in connection with the feeding of the filament which is laid out for a voltage of one volt at a current of one amperne. The required current of one amperne can only be furnished during a short time by a battery having a reasonable weight, and a series resistor must be used to reduce the battery voltage to the voltage of one volt required for the filament, whereby considerable energy is lost.

This difficulty may be removed by using, as a current source, a D.C. source also feeding an oscillator of which the output energy feeds the filament. The use of an oscillator for feeding the filament leads to an important additional advantage. If the oscillator frequency is suitably chosen, it is possible to insert a piezo-electric sound generator fed by the oscillator in the alarm circuit, so that a very strong acoustic alarm is obtained by simple means. For this purpose, the oscillator voltage may be supplied to a third input terminal of the coincidence circuit.

In a particularly effective embodiment of the invention, adapted to be fed from the A.C. mains, a voltage is supplied, when the indicator is switched on, to the series circuit of a resistor and a condenser, the first bistable circuit being constructed as a Schmitt trigger controlled by the voltage across the condenser, so that the first bistable circuit delivers a 1-signal during the activating time and a 0-signal after termination of the activating time, said 0-signal being inverted and the 1-signal obtained by this inversion being simultaneously supplied to one of the input terminals of a NAND-gate, and through a series resistor to the base of an emitter follower; furthermore, the current path between the electrodes of the sensor is connected between the base of said emitter follower and ground, and the emitter voltage of said emitter follower is supplied to the second bistable circuit which is constructed as an inverting Schmitt trigger and of which the output signal is supplied to the second input terminal of said NAND-gate, in such manner that the emitter voltage of said emitter follower disappears upon occurrence of a gas after termination of the activating time, whereby the second bistable circuit delivers a 1-signal and the NAND-gate is operated to deliver a 0-signal which actuates the alarm circuit.

The above-mentioned inversion of the 0-signal of the first bistable circuit may be performed by a third bistable circuit constructed as an inverting Schmitt trigger. Preferably, the 0-signal of the said NAND-gate is supplied, after inversion, to an input terminal of a second NAND-gate, of which the other input terminal is controlled by an oscillator, and of which the output signal feeds a loudspeaker. Furthermore, it is recommendable to supply the inverted 0-signal of the first-mentioned NAND-gate to one of the ends of a relay coil of which the other end is connected with the 1-voltage, so that the relay is de-energized and actuates, by means of a back contact, means for removing the dangerous condition, such as an exhaust fan.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further explained by reference to the drawings, showing two embodiments, and in which:

FIG. 1 shows a gas indicator according to the invention which is fed by a D.C. current source, so that it may be constructed as a portable apparatus; and

FIG. 2 shows a gas indicator according to the invention which may be fed from A.C. mains.
DETAILED DESCRIPTION

The circuit arrangement shown in FIG. 1 is fed by a D.C. source having a voltage of 12 volts, and connected with the terminals 1 and 2. The gas sensor proper consists of a semiconductive body 3, incorporating two electrodes 4 and 5. The electrode 4 has a helical shape and serves as a filament for activating the sensor. The electrode 5 may, in principle, have any desired shape; however, it is generally also shaped as a helix, so that each of the electrodes 4 and 5 may be used as a filament, as desired.

An oscillator 6 operating, for instance, at a frequency of the order of 800 cycles per second, is connected with the terminals 1 and 2. The output energy of the oscillator is supplied to the filament 4 through a transformer 7.

The filament 4 is also connected with the positive terminal 1 of the D.C. source, so that the entire voltage of this source is available for controlling the alarm circuit. During the activating time, the alarm circuit is blocked. Use is made, for this purpose, of a delay circuit provided with a condenser 8, which is charged by the D.C. source through an adjustable resistor 9. After 1 minute, the voltage across condenser 8 has obtained such a value that a unijunction transistor 10 is rendered conductive. A voltage impulse is thereby generated across a resistor 11, and supplied through a resistor 12 to the 1-input terminal of a bistable circuit 13. The voltage occurring at the 1-output terminal of the circuit 13 is supplied to one of the input terminals of an and-gate 14. The 0-input terminal of the circuit 13 is connected with the terminal 1 through the series connection of a resistor 15 and a condenser 16, so that the circuit 13 is always brought into its 0-condition when the indicator is connected with the D.C. source.

The electrode 5 of the sensor is connected with a resistor 17, and with the input terminal of a Schmitt trigger 18. When the resistance of the semiconductive body is reduced by the presence of a gas, a current flows through resistor 17, whereby the trigger 18 changes its state. The output terminal of the trigger 18 is connected with a second input terminal of the and-gate 14.

The oscillator voltage is supplied through a conductor 19 to the third input terminal of the and-gate 14. The output circuit of the and-gate 14 contains a piezoelectric sound generator 20 tuned to the oscillator frequency.

It will be clear that the oscillator voltage is transmitted to the piezoelectric sound generator if two conditions are satisfied, namely that the activating time has expired so that the bistable circuit 13 is in its 1-condition, and that the resistance between the electrodes 4 and 5 has a low value, so that the Schmitt trigger 18 has changed its state. Thus, an alarm is given when the said conditions are satisfied.

The transformer 7 may form a part of the frequency determining circuit of the oscillator 6, and may be provided with a third winding for feedback purposes.

In the gas indicator shown in FIG. 2, the inhibition of the alarm circuit during the activating time is also obtained by means of a delay circuit comprising a condenser 8 and a resistor 9, this delay circuit is connected with a D.C. voltage when the indicator is switched on. The voltage across condenser 8 controls a Schmitt trigger consisting of two transistors 21 and 22 having a common emitter resistor; the collector of each transistor is connected through a resistor with the base of the other one. When the indicator is switched on, the condenser 8 is not yet charged, so that transistor 22 is cut off. Thus, the collector of this transistor carries a positive voltage, which may be considered as a 1-signal, and which is supplied to the output line 23 of the trigger. At the end of the required activating time, the voltage across condenser 8 has increased to such a value that the trigger 21, 22 changes its state, so that a 0-signal appears in line 23.

The 0-signal in line 23 is converted into a 1-signal by means of an inverting Schmitt trigger 24, this 1-signal is supplied to one of the input terminals of a nand-gate 25, and through an adjustable series resistor 26 to the base of an emitter follower 27. The base of transistor 27 is also connected with the electrode 5 of the sensor 3; the filament 4 is fed with an A.C. voltage of 1 volt at a current of one ampere, derived from the A.C. mains by means of a transformer. The activated sensor has a high resistance, so that the base voltage of transistor 27 is not influenced by the sensor. In this case, the emitter of transistor 27 carries a 1-signal, which is supplied to an inverting Schmitt trigger 28, so that this trigger delivers a 0-signal. This 0-signal is supplied to the second input terminal of the nand-gate 25, and through two inverting amplifiers 29 and 30 to a green indicating lamp 31, so that this lamp is ignited to indicate that no gas is present.

Upon occurrence of a gas to which the sensor is sensitive, the base of transistor 27 is grounded through a small resistance, so that the emitter delivers a 0-signal which is converted into a 1-signal by the trigger 28. The green lamp 31 is now extinguished, and both input terminals of the nand-gate 25 carry 1-signals, so that the gate is operated and delivers a 0-signal, which is converted into a 1-signal by an inverting amplifier 32. This 1-signal is supplied to one of the ends of a relay coil 33, of which the other end is connected with the 1-voltage, so that the relay is de-energized. A back contact of the relay actuates means for removing the dangerous condition, such as an extinguisher. Through an inverting amplifier 34, a red indicating lamp 35 is ignited, indicating a dangerous condition.

The 1-signal at the output terminal of amplifier 32 is also supplied to one of the input terminals of a nand-gate 36, of which the other input terminal is connected with an oscillator 37. The oscillator signal is now supplied through amplifiers 38 and 39 to a loudspeaker 40, whereby an acoustic alarm is obtained.

The above-described circuit arrangement may be composed of integrated circuits, in such manner that the triggers 24 and 28 are incorporated in a first integrated circuit, the amplifiers 29, 30, 32, 34, 38 and 39 in a second integrated circuit, and the gates 25 and 26, together with the oscillator 37, in a third integrated circuit. It will be understood that the assembly of the circuit arrangement is rendered very simple in this manner.

The D.C. voltage for feeding the various parts of the circuit arrangement may, for instance, amount to 5 volts, and is derived from the A.C. mains voltage by transformation and rectification. Instead of the delay circuit 8, 9, thermal devices may be used for the inhibition of the alarm circuit during the activating time, for instance a bimetal switch or a resistance with a negative temperature coefficient.
case, the thermal device is gradually heated after the gas indicator has been switched on, so that it may bring about a change-over after expiration of the desired activating time.

1. A gas indicator, comprising a semiconductive body serving as a gas sensor adapted to be thermally activated and having in activated condition the property that the resistivity thereof is substantially reduced upon exposure to a gas, a first electrode incorporated in said body and shaped as a filament for activating the same, an alternating current source, means for connecting said alternating current source across said first electrode, a second electrode incorporated in said body and spaced with respect to said first electrode, a circuit interconnecting the said electrodes and including a direct current source, a current change occurring in the said circuit when the resistivity of said body is reduced, a delay circuit coupled to said direct current source and actuated when the indicator is energized, a first trigger controlled by said delay circuit to change state at the end of a determinable activating time, a second trigger controlled by said current change so as to change state when the resistivity of said body is reduced, a coincidence gate controlled by output signals of the said triggers occurring after their changes of state, and an alarm circuit actuated by the output signal of said coincidence gate, the alternating current source being an oscillator coupled to and energized by said direct-current source.

2. A gas indicator as claimed in claim 1, further comprising means for supplying the output voltage of said oscillator as a heating voltage to the ends of said first electrode.

3. A gas indicator as claimed in claim 2, further comprising a piezo-electric sound generator inserted in said alarm circuit, and means for supplying the output voltage of said oscillator as an energizing voltage to said sound generator.

4. A gas indicator as claimed in claim 3, wherein said coincidence gate has a third input terminal, further comprising means for supplying said oscillator voltage to said third input terminal.

5. A gas indicator, comprising a semiconductive body serving as a gas sensor, adapted to be thermally activated and having, in activated condition, the property that the resistivity thereof is substantially reduced upon exposure to a gas, a first electrode incorporated in said body and shaped as a filament for activating the same, an alternating current source coupled across said first electrode, a second electrode incorporated in said body and spaced with respect to said first electrode, a circuit interconnecting the said electrodes, a direct current source coupled to said interconnecting circuit such that a current change occurs in the same when the resistivity of said body is reduced, a delay circuit including a first resistor and a condenser in series with said first resistor, a first Schmidt trigger controlled by the voltage across said condenser so as to deliver a 1-signal during the activating time of said body and a 0-signal after expiration of said activating time, a second inverting Schmitt trigger, an inverter controlled by the 0-signal of said first trigger, a nand-gate having at least two input terminals, means for supplying the output signal of said inverter to one of the said input terminals, a second resistor, an emitter follower having a base, an emitter and a collector, means for supplying the output signal of said inverter through said second resistor to the base of said emitter follower, means connecting one of the said electrodes with the base of said emitter follower, means for grounding the other of the said electrodes, means connecting the emitter of said emitter follower with the input terminal of said second trigger, means connecting the output terminal of said second trigger with a second input terminal of said nand-gate with said alarm circuit, in such manner that the emitter voltage of said emitter follower disappears upon occurrence of a gas after expiration of the activating time of said body, whereby said second trigger delivers a 1-signal, and said hand-gate is operated to deliver a 0-signal for actuating said alarm circuit.

6. A gas indicator as claimed in claim 5, wherein said inverter is an inverting Schmitt trigger.

7. A gas indicator as claimed in claim 5, further comprising a second inverter connected with the output terminal of said nand-gate, a second nand-gate having at least two input terminals, means for supplying the output signal of said second inverter to one of the input terminals of said second nand-gate, an oscillator, means for supplying the output voltage of said oscillator to another input terminal of said second nand-gate, a loudspeaker, and means connecting said loudspeaker with the output terminal of said second nand-gate.

8. A gas indicator as claimed in claim 7, further comprising a relay having a coil and at least one back contact, means for supplying the output signal of said second inverter to one of the ends of said coil, means connecting the other end of said coil with the 1-voltage, and means for removing the dangerous condition due to the presence of a gas, such as an exhaust, actuated by said back contact when said relay is de-energized.