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## (54) IMPROVEMENTS IN OR RELATING TO SMOKE DETECTORS

(71) We, HOCHIKI CORPORATION of No. 2-10-43 Kamiosaki, Shingawa-ku, Tokyo, Japan, a Japanese Company, do hereby declare the invention, for which We pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to smoke detectors. Such a detector may comprise a light-depreciation type smoke detector and, more particularly, a smoke detector of the kind described which is not sensitive to the depreciation of the light attributable to the secular change or the change of the ambient temperature, but can produce an alarm signal upon detection of an average smoldering fire, within a practically acceptable time.

The term "memoriode" as used herein means a device for storing a voltage, such as a capacitor or an electrolytic cell.

A typical conventional light-depreciation type smoke detector is disclosed in the specification of U.S. Patent No. 3,846,772, and therefore has been well known.

This detector incorporates a comparator adapted to produce an output when the voltage differential between a first and a second electric signals, which vary depending on the amount of received light and are input to the comparator at a suitable interval, comes to exceed a predetermined threshold voltage. In order that the second input signal may suitably be compared with the first input signal, a capacitor for holding the voltage of the first input signal and other capacitor for holding the voltage of the second input signals are connected to respective terminals of the comparator.

The output from the comparator is obtainable only when the reduction amount of the received light corresponding to the above mentioned threshold voltage for the functioning of the comparator takes place in the period from the time of receipt of the first input signal to the time of receipt of the second input signal. However, in the case of a smoldering fire in which the reduction of the amount of light takes place in quite a slow and gentle manner, a change of the voltage of the first input signal tends to occur, making it difficult to correctly make use of the predetermined voltage differential between the first and the second inputs.

According to the invention, there is provided a smoke detector as set forth in claim 2.

A preferred embodiment comprises a highly reliable light-depreciation type smoke detector, having a comparator to one input terminal of which is delivered a pulse signal corresponding to the amount of light received by a light receiving element, while a voltage memorized by a memoriode connected to the other input terminal is synchronously corrected by a correcting constant-value pulse produced in accordance with the amplitude of the pulse signal from the light receiving element, so that the change of condition of the smoke detector due to a slow change or contamination by dust during long use is substantially compensated by the aforementioned correction of the memorized voltage by the correcting constant-value pulse signal.

In the preferred embodiment, a value of the correcting constant-value pulse can be changed in accordance with the contaminating condition in the place at which the detector is to be installed, expectable temperature change, slow change and other conditions, so as to afford an optimum operating condition of the detector.

In the preferred embodiment, in order to detect a smoldering fire in which the reduction rate of the light input is small, the aforementioned correcting constant-value pulse is made to have a value which is smaller than the change of the light input per unit time, obtained through dividing the differential between the light inputs at the starting and the finishing times of the detecting period by the time length of the detecting period.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which

Fig. 1 is a block diagram showing an embodiment of the invention;

Figs. 2 to 5 are block diagrams of different embodiments of the invention;

Fig. 6 shows an example of the electric circuit of a practical embodiment of the invention; and

Fig. 7 shows output wave forms of various multivibrators, amplifiers and AND circuits.

According to the result of a smoldering smoke test, the rate at which the light transmission is decreased by the smoke of an average smoldering fire becomes substantially constant, about one hour after the beginning of the fire, and assumes a value of about 40%/hour per 30 cm.

On the other hand, the rate at which the amount of the received light is decreased due to change caused by the contamination of light emitting element, light receving element and the path of light by dusts and vapor of oil, as well as by the deterioration of the performance of the circuit elements, during long use of the detector, is considered to be less than 10% / day.

At the same time, the rate at which the amount of received light is decreased by the change of the ambient temperature, which takes place in such seasons of the year as having a large temperature variation or soon after the start of an air conditioner in winter and summer seasons, can be limited to less than 10%/hour.

A light-depreciation type smoke detector capable of producing an alarm signal after a practical time of about 3 hours from the time of commencement of an average smoldering fire, but not sensitive to slow change and ambient temperature change, is obtained when the distance between the light emitting and receiving sections, rate of correction of a stored voltage and the ratio of the voltage across the memoriode to the voltage corresponding the light input by which the alarming circuit is actuated, are 30 cm, 12%/hour and 1 : 2, respectively.

Hereinafter, a preferred embodiment of the invention will be described with reference to Fig. 1.

Referring to Fig. 1, a reference numeral 1 denotes a light-emitting section consisting of a light-emitting element, lenses and so forth. The light emitted from the light emitting section is delivered to a light-receiving section 3 consisting of a light-receiving element and lenses, through a detecting space 2. The light is depreciated by the presence of smoke in the detecting space 2, and the light-receiving section 3 produces an electric output corresponding to the amount of the light received by the same.

This electric output is amplified by an amplifier 4, and is delivered to a discriminating section 5 and to a comparator circuit 6.

The discriminating section 5 and the comparator circuit 6 perform a comparison of the amplified electric output with the output from a later-mentioned memory section 7. An alarm circuit 8 is actuated to drive an alarm, such as a bell, when a predetermined ratio of the electric signal from the amplifier 4 to the output from the memory section is reached.

The discriminating section 5 consists of a comparator formed by an operational amplifier and resistors $R_1$,$R_2$ which are adjustable to give any desired light-depreciation by which the alrm circuit is to be driven. More specifically, the output of the comparator is inverted to activate the alarm circuit 8, when the output from the amplifier 4 drops below 90% of the output from the memory section 7, i.e. when the light-depreciation has grown larger than 10%, provided that the ratio of the resistances $R_1 : R_2$ has been selected to be 1 : 9.

The aforementioned memory section 7 consists of a so-called voltage memory element 9 which may be a known electrolytic voltage memory element in which the voltage difference between two electrodes in an electrolyte is changed in dependence on the integration of the current between these electrode, by the ion movement through the electrolyte.

A voltage control section 10 has a switch 11 arranged to deliver a positive voltage V+ to the memory element 9 through a resistance $R_3$, and a switch 12 arranged to deliver a negative voltage V- to the memory element 9 through a resistance R4. These switches 11,12 are constituted by a switching circuit which is arranged to be opened and closed in accordance with the output from the comparator circuit 6.

More specifically, the switch 11 is closed, for instance, when the output from the memory section 7 is small as compared with the output from the amplifier 4, so as to complete a circuit for charging the memory element 9 from the positive voltage source V+. Consequently, the output from the memory section 7 approaches the level of the output from the amplifier 4, with a long time constant. To the contrary, when the output from the memory section 7 is large as compared with the output from the amplifier 4, the switch 12 is closed to complete a circuit for allowing discharging from the memory element 9 to the negative voltage source V-, so that the output from the memory section 7 is gradually lowered and approaches the output from the amplifier 4 with a long time constant.

The switches 11, 12 are opened when the output from the amplifier 4 and that from the memory section 7 are equal. Consequently, no charging and discharging to and from the memory element 9 is performed, and the level of the output from the memory section 7 is maintained.

Since the charging and discharging of the memory element 9 are effected gradually through the resistances $R_3$ and $R_4$, the output from the memory section 7 can follow the change of the output from the amplifier 4 attributable to the contamination of lenses, slow change of the light emitting and receiving elements, and a temperature change over a long period. Consequently, the discriminating section 5, which discriminates the output from the amplifier 4 from the output from the memory section 7, cannot detect the lowering of the level of the output from the amplifier 4 attributable to the contamination of the lenses and the like reasons.

However, when the rate at which the level of output from the amplifier 4 is lowered has become large, due to the presence of smoke or the like, the output from the memory section 7 cannot follow this change, so that the lowering of the level of the output from the amplifier 4 with respect to the output from the memory section 7 is discriminated by the discriminating section 5, so as to cause the actuation of the alarm circuit.

If a large noise light, such as a flash light of a camera, is received by the light-receiving section 3, the memory element 9 is charged if the level of this noise light is large enough to make the level of the output from the amplifier 4 larger than the level of the output from the memory section 7. However, the charging current is controlled by the resistance $R_3$ and, therefore, cannot cause a substantial change of the output from the memory section 7, in a short time over which the noise light lasts. Consequently, there is no fear of any error.

Fig. 2 shows an embodiment in which the present invention is applied to an analog sensor. In Fig. 2, the same reference numerals to those of Fig. 1 denote the same or equivalent parts.

A reference numeral 13 denotes a differential amplifier circuit. Representing the outputs from the amplifier 4 and the memory section 7, respectively, by I and Io, the differential amplifier circuits produces an output which is in proportion to the difference I - Io, i.e. to the depreciation of the light.

An operation circuit 14 is arranged to produce a signal corresponding to the light-depreciation ratio which is obtained through dividing the output K(I - Io) (K is a constant) from the differential amplifier 13 by the output Io from the memory section 7, i.e. an output represented by $K(\frac{I - Io}{Io})$.

Fig. 3 shows another embodiment in which the detector is driven by pulses, in order to reduce the power consumption. The voltage memory element is suitable for operation by pulses, since its content is never changed even when the power supply is interrupted.

In Fig. 3, the reference numerals same as those in Fig. 1 denote the same or equivalent parts. A power source circuit 15 has a pulse generating circuit 16 arranged to produce a pulse train of a constant duty ratio of, for example, 5 seconds period and 1 m sec pulse width. The pulse train is delivered to various parts of the detector through the power supply circuit 17.

A sampling pulse generating circuit 18 is arranged to deliver sampling pulses of 0.1 m sec width to the comparator circuit 6 and the discriminating part 5, after an elapse of a time of, for example, 0.5 m sec, from the time of supply of the power pulses to the circuits of the device until the operations of these circuits are stabilized, so as to avoid erroneous operation due to the unstable operations of these circuits which are likely to take place immediately after the application of the power pulses.

The use of pulses as described above is effective not only in diminishing the power consumption but also in affording an easy adjustment of the time constant for the charging and discharging of the voltage memory element. The time constant of the memory circuit constituted by the voltage memory element is determined, in the case of a pulse drive, by the duty ratio of the output pulse applied to the controlling section kO of the comparator circuit 6, and by the peak value of the charging and discharging current of the voltage memory element. For instance, provided that the time constant of the memory section 7 has been selected to be 10 hour/100% (the voltage memory element is charged from 0% up to 100% in 10 hours), 10 hours are required for obtaining the settled conditon of the device for the first time after the first power supply to the device following the completion of the assembling of the device.

This time can be shortened by making the duty ratio of the pulse train from the pulse generating circuit 16 adjustable externally. For instance assuming that the duty ratio of the pulse train is 1 m sec/5 sec and that the time constant of the memory section 7 is 10 hours/100%, the time constant can be reduced to 1/100, i.e. to 6 minutes/100%, by externally increasing the duty ratio by 100 times, i.e. to 1 m sec/50 m sec.

At the same time, it is desirable for the purposes of protective maintenance to make the time constant of the memory section remotely controllable from, for example, a central control station, after the installation of the detector.

Fig. 4 shows another embodiment of the invention, in which a capacitor C is used in place of the voltage memory element. In Fig. 4, same reference numerals as those of Fig. 1 denote the same or equivalent parts. A voltage controlling section 19 is arranged to charge the capacitor C at the initial stage at which the capacitor C has not been charged, so as to make the output from the memory section 7 equal to the output from the amplifier 4.

The charging of the capacitor C by the voltage controlling section 19 is effected gradually with a long time constant. However, it is preferred to provide a switching means so as to afford a quick charge of the capacitor C in the above mentioned initial stage.

The capacitor C has a leakage current of a long time constant. A contact 20 is provided for checking the leakage current flowing from the capacitor C to the voltage controlling section 19 or to the comparator circuit 6, and is arranged to be intermittently opened and closed by means of relays which are not shown.

In the detector under description, the voltage across the capacitor C is gradually lowered by the aforementioned leakage current, when the level of the output from the amplifier 4 is gradually lowered as is the case for contamination of the lenses, so that the output from the amplifier 4 becomes equal to the output from the memory section 7. At the same time, the voltage across the capacitor C is not changed substantially by a large noise light which lasts only for a short time, and can maintain the initial condition. In addition, when the output from the amplifier 4 is gradually changed by the temperature change over a day or seasons, the voltage across the capacitor C is also changed gradually to maintain the proper amount of content.

In case of a depreciation of light due to the presence of smoke, the level of the output from the light-receiving section 3 is drastically lowered, but the output from the memory section 7 is not changed substantially, so that the alarm circuit 8 is actuated by the discriminating section 5.

Fig. 5 shows still another embodiment arranged to produce a maintenance demand signal before making an erroneous operation, when the lenses are extraordinarily contaminated or when the light-emitting and/or light-receiving elements are extraordinarily deteriorated. In Fig. 5, the same reference numerals as those of Fig. 1 denote the same or equivalent parts.

A comparator circuit 21 is arranged to compare the output from the amplifier 4 with a reference signal from a terminal 22, so that a maintenance demand signal generating circuit 23 may be driven when the output level of the amplifier 4 drops below a predetermined level.

A practical example of the circuit incorporated in an embodiment of the invention will be described in detail hereinafter, with specific reference to Fig. 6.

A positive terminal of a ± 10V D.C .power source is connected to a diode 24. The diode 24 is connected at its other side commonly to the positive supply terminals of an astable multi-vibrator 25, monostable multi-vibrators 26, 27, and inverters 28,29. The other side of the diode 24 is connected commonly to the emitter of a transistor 30, resistance 31, light-emitting diode 32 and a resistance 33. The other sides of the light-emitting diode 32 and the resistance 33 are commonly connected to a resistance 34 which in turn is connected at its other side to the collector of a transistor 35. The collector of the transistor 30 is connected commonly to the positive supply terminals of amplifiers 36,37, constant-voltage source 38, comparators 39,40,41, and AND gates 42,43,44.

The negative terminal of the D.C. source is commonly connected to the negative power supply terminals of the astable multi-vibrator 26,27, inverters 28,29, amplifiers 36,37, constant voltage source 38, comparators 39,40,41 and AND circuits 42,43,44, and is grounded suitably. The negative terminal of the output terminals of the D.C. source is connected commonly also to the emitter of the transistor 35 and to a resistance 45. The base of the transistor 30 and the other side of the resistance 31 are commonly connected to a resistance 46 which in turn is connected at its other end to the output terminal of the astable multivibrator 25. The base of the transistor 35 is connected commonly to the other side of the resistance 45 and to a resistance 47 which is connected at its other side to the output terminal of the astable multi-vibrator 25.

The ± 10V D.C. voltage is thus applied to the astable multi-vibrator 25, monostable multi-vibrators 26,27, and inverters 28,29, as the source power. The transistors 30,35 function as switches in accordance with the output from the astable multi-vibrator 25, so as to supply the light-emitting diode 32, amplifiers 36,37, constant voltage source 38, comparators 39,40,41, and AND gates 42,43,44, with pulse voltages of ± 10 V. The pulse interval and the pulse width of the pulse voltage, i.e. the pulse interval and the pulse voltage of the astable multi-vibrator 25 are determined by resistances 48,49 and the capacitance of a capacitor 50.

The resistances 33,34 are provided for the purpose of temperature-compensation of the light-emitting diode 32. The resistances 31,46 are for regulating voltage for controlling the opening and closing of the switch constituted by the transistor 30, while the resistances 45,47 are provided for regulating the voltage by which the opening and closing of the switch constituted by the transistor 35 is controlled.

The diode 24 functions to prevent any reverse voltage acting on the circuit.

A photo diode 51 is connected at its both terminals to the corresponding terminals of an amplifier 36, so that the output current of this photo diode may be amplified. The electric signal appearing at the output terminals of the photo diode, corresponding to the light emitted from the light-emitting diode 32, is amplified by the amplifier 36. The output terminal of the amplifier 36 is connected commonly to resistances 52,53,54 The other sides of the resistances 52,53 and 54 are connected, respectively, to first input terminals of the comparator 39, comparator 40 and the comparator 41.

The output terminal of the constant voltage source 38 which gives a charging and discharging reference to the memoriode (voltage memory element) is connected to the memoriode 55, so as to maintain the potential of one end thereof at a constant level of - 8V. The output of the constant voltage source 38 is commonly connected also to resistances 56,57. The resistance 57 is connected at its other side to the inverting input of the amplifier 37.

The other side of the memoriode 55 is connected commonly to bilateral switches (switches which are opened and closed when the control terminals are maintained at high and low levels) 58,59 and to a resistance 60.

The other end of the resistance 60 is connected to the non-inverting input terminal of the amplifier 37, while the other side of the resistance 56 is grounded. Thus, the voltage across the memoriode 55 is amplified by means of the amplifier 37. The resistances 57 and 57′ are provided for adjusting the gain of the amplifier 37, and the resistance 60 controls the input level to the amplifier 37.

The output terminal of the amplifier 37 is connected to resistances 61,62,63. The other sides of the resistances 61,62 and 63 are connected, respectively, to the other input terminals of the comparators 39,40 and 41. The other input terminal of the comparator 41 is connected also to a resistance 64 which is grounded at its other side.

Thus, the comparators 39,40 and 41 function as the comparators which produce output signals in accordance with the ratio of the voltage obtained by amplifying the voltage across the photo diode 51 to the voltage obtained through amplifying the voltage across the memoriode 55.

The resistances 61,52,53,63,54 act as the input protection, and the resistances 62 and 64 are for adjusting the input level to the comparators, in other words for adjusting the points at which the outputs are produced in respective comparators.

The output terminals of the comparators 39,40 are connected to the input terminals of the AND gates 42,43, while the other input terminals of the AND gates 42,43 are connected commonly to the output terminal of the monostable multi-vibrator 26. The output terminals of the AND gates 42,43 are connected to the control terminals of the bilateral switches 58,59. The other side of the bilateral switch 58 is connected to a resistance 65 which in turn is connected at its other side to the collector of the transistor 30. The other bilateral switch 59 is connected to a resistance 66 which is grounded at its other side.

The AND gate 42 this controls the opening and closing of the bilateral switch 58 for charging the memoriode 55, in response to the output from the monostable multi-vibrator 26 and to the output from the comparator 39 which is arranged to produce an output in accordance with the ratio of the voltage obtained through amplifying the voltage across the photo diode 51 to the voltage obtained through amplifying the voltage across the memoriode 55.

The AND gate 43 controls the opening and closing of the bilateral switch 59 for discharging from the memoriode 55, in response to the output from the monostable multi-vibrator 26 and the output from the comparator 40 which functions to the contrary to the comparator 39. The resistances 65 and 66 are provided, respectively, for adjusting the charging and discharging speeds.

The output terminal of the comparator 41 is connected to the input terminal of the AND gate 44, while the other input terminal of the AND gate 44 is connected to the output terminal of the monostable multi-vibrator 27. The AND gate thus functions to actuate the alarm circuit, in response to the output from the monostable multi-vibrator 27 and to the output from the comparator 41 which produces the output in accordance with the ratio of the voltage obtained through amplifying the output current of the photo diode 51 to the voltage obtained through amplifying the voltage across the memoriode 55.

The output terminal of the astable multi-vibrator 25 is connected to the input terminal of the inverter 28 which is connected at its output side to a resistance 67. The resistance 67 is connected at its other side commonly to the input terminal of the inverter 29 and to a capacitor 68 which in turn is grounded at its other side.

The positive trigger terminal of the monostable multi-vibrator 26 is connected to the output terminal of the inverter 29. At the same time, the negative trigger terminal of the monostable multi-vibrator 27 is connected to the output terminal of the monostable multi-vibrator 26. The monostable multi-vibrator 26 thus can produce a pulse at a time lag determined by the resistance 67 and the capacitance 68 behind the starting end of the pulse produced by the astable multi-vibrator 25, while the monostable multi-vibrator 27 produces a pulse which starts at the time of the ending of the pulse generated by the monostable multi-vibrator 26.

A resistance 69 is connected to one end of the resistance 48 which is arranged to adjust the pulse interval of the pulses generated by the astable multi-vibrator 25. The resistance 69 is connected at its other end to a bilateral switch 70.

The bilateral switch 70 is connected at its other end to the other end of the resistance 48, while the controlling terminal of the same is connected commonly to the resistances 71,72. The resistance 71 is grounded at its other end. The value of the resistance 69 is selected to be sufficiently smaller than the resistance 48. The bilateral switch 70 is closed, as another D.C. current is supplied between the grounding and the other end of the resistance 72, so that pulses of a pulse width much smaller than the pulse determined by the resistance 48 and the capacitance 50 is generated by the astable multi-vibrator 25. Consequently, the memoriode 55 can be charged in a much shorter time.

The resistances 71,72 are provided for adjusting the voltage for controlling the opening and closing of the bilateral switch 70, while the resistance 69 is provided for adjusting the pulse interval. This operation is effected when it is necessary to diminish the long dead time in which the device is is inoperative, from the time of the starting of the device to the completion of the charging of the memoriode 55.

During normal operation, the gains of the amplifiers 36,37 and other conditions are selected so that the voltage across the memoriode 55 becomes 40 mV. In such a case, about 0.33$\mu$A.hour of charge is charged in the memoriode, in accordance with the of the memoriode 55. This electric charge of 0.33$\mu$A.hour will be consumed away by an intermittent discharge by pulses of 2mA, pulse interval of 5 sec and pulse width of 100 $\mu$sec, within 500 minutes.

That is to say, the discharge voltage rate, i.e. the rate of correction of the memorized voltage is 100%/500 min., 12% /hour. For charging and discharging of the memoriode 55 with pulse current of 2 mA, the resistances 65 and the resistance 66 for adjusting the charging and discharging rates are adjusted to be 9 K$\Omega$ and 1 K $\Omega$, respectively, because the one end of the memoriode 55 is fixedly maintained at the potential of -8V, so as to obtain the aforementioned rate of correction of the memorized voltage of 12%/hour.

Fig. 7 shows output wave forms of the various multi-vibrators, amplifiers and AND gates incorprated in the described embodiment of the invention.

The output wave forms of the astable multi-vibrator 25, monostable multi-vibrator 26, monostable multi-vibrator 27, amplifier 36, AND gate 42, AND gate 53, amplifier 37 and the AND gate 44, respectively, are shown in Fig. 7, as viewed from the upper side of Fig. 7.

Thus, the resistances 48,49 and the capacitance of the capacitor 50 are selected so as to make the astable multi-vibrator 25 produce pulses of 500 $\mu$sec at a period of 5 seconds. At the same time, the resistance 67 and the capacitance of the capacitor 68 are selected so that the monostable multi-vibrator 26 produces its pulses at a time lag of 100$\mu$ seconds behind the starting end of the pulses of the astable multi-vibrator 25. In addition, the pulse widths of the pulses produced by the monostable multivibrators 26,27 are selected to be 100 $\mu$ seconds.

Provided that the memoriode 55 has been charged at the starting time to such a level that its output Io is equal to the output I from the amplifier 36, if the level of the output I is lowered slightly in the period of the first pulse P-1, for any reason such as a temperature change or contamination, the AND gate 43 provides its output in synchronization with the output from the monstable multi-vibrator 26, so that the bilateral switch 59 is closed over that period. Consequently, a discharge from the memoriode 55 is effected thus performing the correction of the level of the output Io.

The second pulse P-2 shows a slight increase of the output I. In this case, the AND gate 42 provides its output in synchronization with the output from the monostable multi-vibrator 26, so that the bilateral switch 58 is closed over that period. Consequently, the memoriode 55 is charged to correct the level of the output Io.

Pulses P-3 to P-5 are shown to illustrate the operation of the detector in case of an abrupt or extraordinary change of the level of the output I, due to the presence of smoke between the light-receiving and light-emitting sections. In this case, although the level of Io is corrected successively, the rate of the correction is too small, so that the level of Io cannot follow up the drastic change of the level of the output I. Consequently, as the ratio of I to Io drops below the threshold value at which the comparator 41 produces its output (P-4), the AND gate 44 supplies a pulse signal for actuating the alarm circuit, in synchronization with the output from the monostable multi-vibrator 27.

WHAT WE CLAIM IS:

1. A light-depreciation type smoke detector comprising:

an oscillation circuit;

a light-emitting circuit including a light-emitting element arranged to receive pulses from said oscillation circuit;

a light-receiving circuit including a light-receiving element arranged to produce pulses upon receipt of the light emitted from said light-emitting element;

said light-emitting and light-receiving elements being shielded from the ambient light so that the amount of the light received by said light-receiving element may be reduced correctly in response to smoke coming into the space between said light-emitting and light-receiving elements;

a correction circuit including a memoriode, as hereinbefore defined, and two comparators having first input terminals connected to receive a voltage equal to or proportional to that across the memoriode, second input terminals of said comparators being connected to receive a voltage equal to or proportional to that supplied by said light-receiving circuit so as to receive said pulse signals, the output terminals of said comparators being connected so as to control charging of said memoriode so that the memorized voltage in said memoriode may be increased or decreased by the outputs from said comparators;

a detecting circuit including a third comparator having a first input terminal connected to receive the voltage equal to or proportional to that across the memoriode and a second input terminal connected to receive the voltage equal to or proportional to that supplied by said light-receiving circuit so as to receive said pulse signal;

whereby said third comparator is actuated to produce a fire alarm, when the level of said pulse signal is lowered at a rate larger than the rate at which said memorized voltage of said memoriode is lowered to make the value of said pulse signal less than the value if said memorized voltage by a predetermined amount.

2. A smoke detector comprising light-emitting means, light sensitive means spaced from the light-emitting means and arranged to be sensitive to light emitted therefrom to produce an output signal corresponding to the amount of light received, a memory, means for changing at a predetermined rate the contents of the memory towards a value corresponding to the output signal of the light-sensitive means, and a comparator arranged to compare the output signal from the light-sensitive means with the contents of the memory and to produce a signal indicative of the detection of smoke when the output signal is less than the value of the contents of the memory by a predetermined amount.

3. A detector as claimed in Claim 2, in which there is provided a pulse generator arranged to produce first and second sets of pulses of the same repetition rate with each pulse of the second set starting after and finishing before the corresponding pulse of the first set, the light-emitting means, the light-sensitive means, and the means for changing the contents of the memory being arranged to be actuated by the first set of pulses and the comparator being arranged to be actuated by the second set of pulses.

4. A detector as claimed in Claim 2 or 3, in which the memory comprises a voltage memory element and the means for changing the contents of the memory comprises first and second charging circuits arranged to increase and decrease, respectively the voltage stored in the voltage memory circuit and a control circuit arranged to actuate the first charging circuit or the second charging circuit when the output signal is greater than or less than, respectively, the voltage stored in the voltage memory element.

5. A detector as claimed in Claim 4, in which the voltage memory element is a capacitor.

6. A detector as claimed in Claim 4, in which the voltage memory element is an electrolytic voltage memory element.

7. A smoke detector substantially as hereinbefore described with reference to and as illustrated in any one of Figures 1 to 6 of the accompanying drawings.

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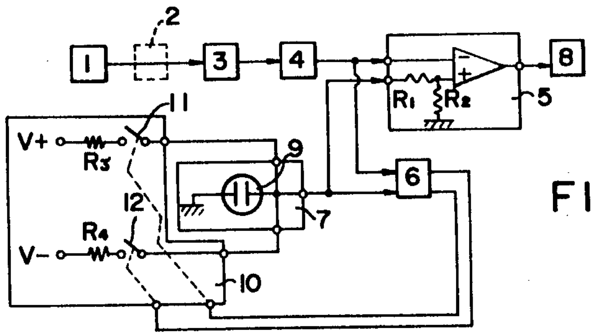


FIG. 1

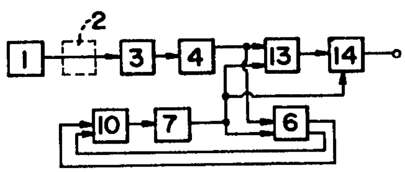


FIG. 2

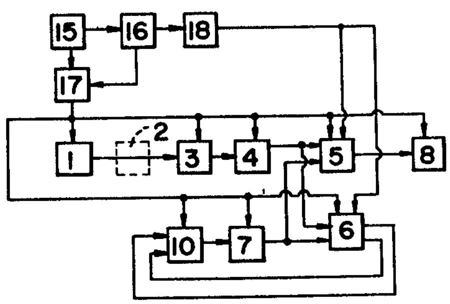


FIG. 3

1583935 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

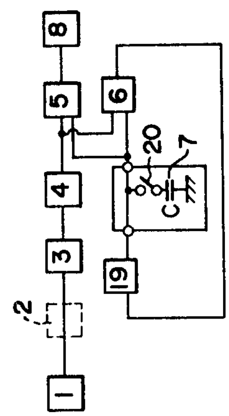


FIG. 4

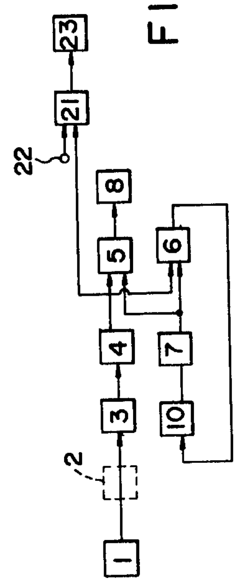


FIG. 5

1583935 COMPLETE SPECIFICATION

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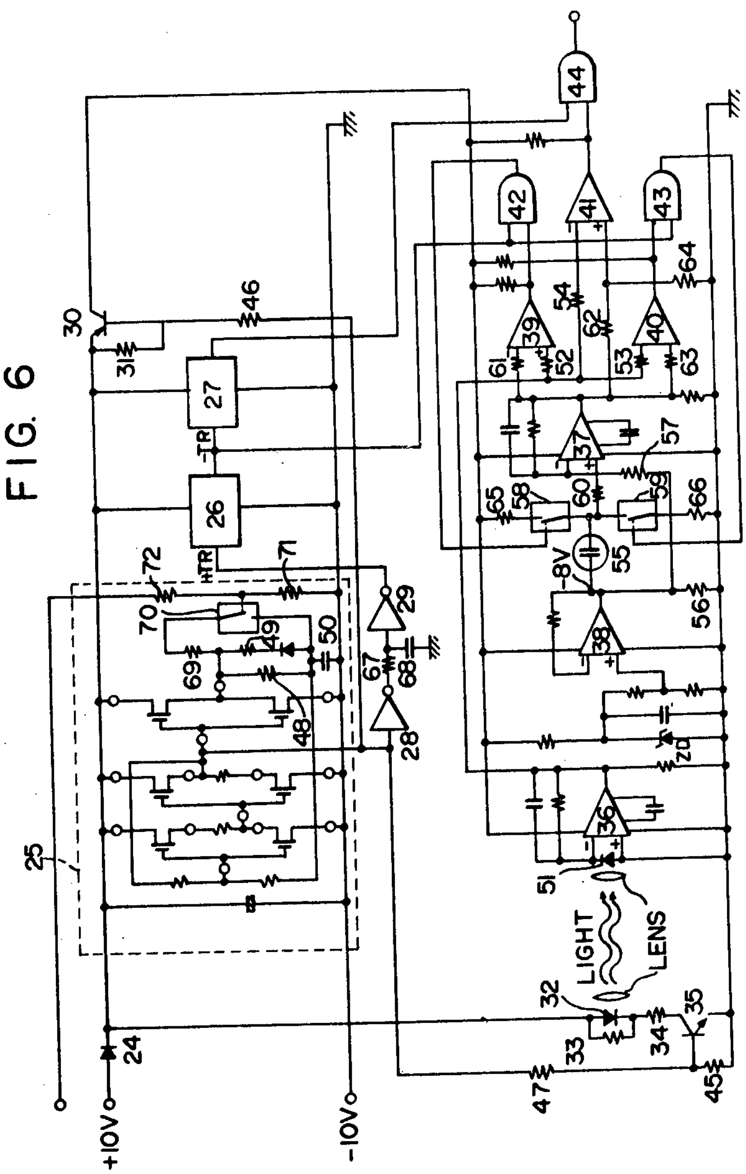
Sheet 3

FIG. 6



1583935 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 4

FIG. 7