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(54) **Suspended particle detector.**

(57) A suspended particle detector includes a housing (1,2) containing a radiation source (3) which shines radiation across the interior of the housing (1,2), a first radiation sensor (5) arranged to receive radiation scattered from the wall (1) of the housing (1,2) and radiation scattered from particles suspended in the housing (1,2) and to produce a first signal indicative of the total intensity of radiation incident on it. A second sensor (4) is arranged to produce a second signal indicative of the intensity of the radiation source (3). The detector also includes a signal combining circuit arranged to combine the two signals in opposition to produce a composite signal and the detector is constructed so that the composite signal has a first polarity when the density of suspended particles in the housing is less than a predetermined pressure or value and the opposite polarity when the said density is greater than the threshold value. A logic unit is arranged to detect when the polarity of the composite signal reverses and then to produce an alarm signal.

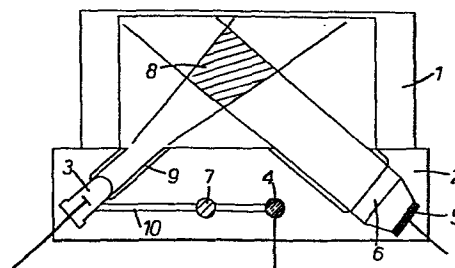


Fig. 1.

SUSPENDED PARTICLE DETECTOR

The present invention relates to suspended particle detectors, in particular smoke detectors, and is concerned with that type of detector including a housing, a radiation source arranged to shine a beam of radiation, typically visible light or infrared, across the housing and a sensor responsive to radiation scattered by the particles within the housing and connected to an evaluation circuit arranged to provide an alarm when the density of suspended particles reaches a predetermined value.

The simplest type of such detector utilises only a single sensor and an alarm is indicated when the signal produced by this sensor exceeds a predetermined value. However, such sensors have proved to be very unreliable in practice because the characteristics of the electrical components, particularly those of the radiation source, the sensor and the evaluation circuit, which commonly includes an amplifier and a comparator, vary with time and because the sensor receives not only particle-scattered radiation but also radiation reflected from the walls of the housing (referred to as background radiation) the reflectivity of which varies with time. A further source of unreliability is that if the intensity of the radiation source should suddenly increase, for instance as a result of a voltage surge, an alarm may be indicated even though an alarm condition is not actually present.

For these reasons a more complex detector has been proposed including two sensors, one of which is responsive to particle-scattered radiation and of

- necessity background radiation also whilst the other is responsive only to background radiation. The two sensors are coupled in opposition so that their net output is indicative of only the intensity of the particle scattered radiation and an alarm is indicated when this net output reaches a predetermined value. Whilst this construction solves certain of the problems of the simpler construction it is found that in practice the output signal is not truly indicative of the intensity of the particle-scattered radiation because the two sensors are generally directed at different portions of the housing wall whose reflectivity may differ, and this difference may increase with the passage of time. In addition, by virtue of the fact that the outputs of the two sensors are different at the alarm density of suspended particles, a variation in the intensity of the radiation source or a change in sensitivity of the sensors, even if this is the same for the two sensors, or a change in the characteristics of the amplifier or comparator will result in a variation in the particle density at which an alarm is indicated. This variation can be reduced by using higher quality components but this naturally substantially increases the cost of the detector.
- Accordingly it is an object of the present invention to provide a suspended particle detector in which the disadvantages referred to above are eliminated or substantially reduced and in particular a detector in which the particle density at which an alarm is indicated remains substantially constant but can

nevertheless be made up from mass-produced cheap components.

- According to the present invention a suspended particle detector includes a housing containing a
5. radiation source arranged to shine radiation across the interior of the housing, a first radiation sensor arranged to receive radiation scattered from the wall of the housing and radiation scattered from particles suspended in the housing and to produce a first signal
10. indicative of the total intensity of radiation incident on it and a second radiation detector arranged to produce a second signal indicative of the intensity of the radiation source, the detector also including signal combining means arranged to combine the two
15. signals in opposition to produce a composite signal, the detector being constructed and arranged so that the composite signal has a first polarity when the density of suspended particles in the housing is less than a predetermined threshold value and the opposite
20. polarity when the said density is greater than the threshold value and evaluation means arranged to detect when the polarity of the composite signal reverses and to produce an alarm signal.

- Thus the sensor of the present invention operates
25. in a very different manner to the known construction referred to above since there is no attempt to make the composite output signal independent of background radiation intensity as previously but on the other hand the threshold particle density at which an
30. alarm is indicated is genuinely independent of the

- intensity of the radiation source since at this threshold density, though at no other density, the output of the two sensors is the same and thus affected equally by any change in this intensity. In addition, the
5. detector of the present invention need only detect a change in polarity of the composite signal rather than an absolute value of this signal which is inherently more simple and reliable. This latter feature means that the electrical components used in the detector
10. can be of lower quality and thus very much cheaper than has previously been possible since variations in the characteristics of those components will cancel out at the threshold particle density.

- On the other hand, the particle density at which
15. an alarm is indicated will be dependent on the intensity of the background light. This is naturally taken account of when initially calibrating the detector but, in stark contrast to previous constructions, it is preferred that the internal surface of the wall of the housing
20. be relatively highly reflective so that the effect of any change in reflectivity due, for instance, to dust deposits, will be proportionally reduced.

- The second sensor may be positioned to detect the intensity of the background radiation in the manner
25. similar to that used in the known construction since this intensity is of course proportional to that of the radiation source itself. However, the intensity of the background radiation is relatively low and this would necessitate the use of a relatively sensitive
30. and thus expensive sensor. Thus it is preferred that

the second sensor is arranged to be directly subject to the radiation from the radiation source which makes possible the use of a relatively insensitive and thus cheap sensor.

5. It is preferred that the two sensors rely on a similar sensing principle so that any change of sensitivity resulting from ageing or temperature changes will be similar for the two sensors. Preferably these are both silicon junction photodiodes and the second sensor may
10. be a low cost, glass encapsulated silicon rectifier diode.

- The housing preferably includes a block of non-translucent material in which there is a first passage in which the radiation source is situated and a
15. second passage communicating with the first passage in which the second sensor is situated. This is found to be a simple manner of ensuring that radiation from the source, e.g. visible light or infrared, impinges directly
20. on the second sensor which is shielded from both background and particle-scattered radiation.

- The detector preferably includes adjustment means arranged to vary the magnitude of the second signal at a given density of suspended particles. The adjustment means may be electrical but are preferably mechanical
25. and arranged to attenuate the radiation incident on the second sensor and in one embodiment comprises a screw arranged to obstruct a desired proportion of the area of the second passage.

- Thus the detector may be calibrated by introducing
30. particles into the chamber at the desired threshold

density and then adjusting the adjustment means until the composite signal at that density is zero whereas in the known constructions adjustment of the threshold density can only be effected electrically by varying the gain of the amplifier or the detection level of the comparator and there is no clear-cut relationship between the settings of these components and the threshold density of suspended particles.

In the preferred embodiment the evaluation means includes an amplifier to the input of which the signal combining means is connected and to the output of which a logic unit is connected, the amplifier being so arranged that if there is no input the output is of the said opposite polarity so that an alarm signal is produced. This means that if the radiation source should fail an alarm is indicated which represents a substantial advantage over the known detector which can not indicate an alarm if the radiation source has failed which may well not be noticed since the source is within the lightproof housing.

Further features and details of the present invention will be apparent from the following description of one specific embodiment which is given by way of example only with reference to the accompanying drawings in which:-

Figure 1 is a diagrammatic cross sectional elevation of a detector chamber of a smoke detector in accordance with the present invention;

Figure 2 is a block diagram of the detector circuitry; and

Figure 3 is a graph showing the magnitude of the various signals at different points in the circuitry.

- The detector chamber shown in Figure 1 comprises a base 2 of non-translucent material connected to
5. which is a cover 1 which together define a space into which no light can enter but into which air and any suspended smoke particles can enter through a tortuous passageway (not shown). Set in a passage 9 in the base is a pulsed radiation source 3, in this case
10. an infrared light emitting diode, which is arranged to radiate a substantially collimated pulsed infrared beam through the passage 9 and then across the interior of the chamber. Also situated in the base is a first or smoke scattered radiation sensor 5, in this case
15. a photodiode, in front of which is an assembly 6 comprising a lens and an optical filter. The sensor 5 has a field of view which extends across the interior of the chamber and intersects the path of the pulsed beam from the light-emitting diode 3 over a volume 8.
20. Communicating with the passage 9 is a further passage 10 in the base 2 within which is a second or reference sensor 4 comprising a further photodiode. Situated between the radiation source 3 and the reference sensor 4 is an adjustable radiation attenuator 7 comprising a
25. conical tipped grubscrew received in a threaded hole in the base and accessible from the exterior of the chamber to permit a variation in the intensity of the radiation incident on the reference sensor.

- In use, the light emitting diode 3 is pulsed and
30. the reference sensor 4 receives radiation whose intensity

is dependent only on the position of the screw 7 and the intensity of the diode 3 and at any particular setting of the screw 7 its output signal is therefore indicative only of the intensity of the radiation from the diode 3.

5. The sensor 5 receives two components of radiation, the first being background radiation, that is to say radiation scattered from the wall of the chamber, and the second being smoke-scattered radiation, that is to say radiation scattered by the smoke particles, if any, in the volume 8 and its output signal is thus indicative of the sum of the intensities of the background radiation and the smoke-scattered radiation.

- The circuitry shown in Figure 2 comprises a pulse generator 21 connected to the light emitting diode 3 arranged to radiate pulses of infrared 150 microseconds in duration into the chamber. The two sensors 4 and 5 are connected to a signal combining circuit 22 comprising a direct inverse parallel connection which is connected so that its output, i.e. the difference between the outputs of the sensors 4 and 5, constitutes the input of an amplifier 23. The amplifier is a discrete component operational amplifier operating from a zener diode regulated 5 volt supply (not shown) and its output is connected to a logic unit 24 arranged to detect when the polarity of the output of the amplifier changes. The quiescent output of the amplifier is set close to and slightly above the logic threshold of the unit 24. The gain of the amplifier is such that the amplitude of the output pulses is large compared to uncertainties in the logic threshold and large compared to the difference between the quiescent output and the logic threshold

and amplified signal pulse excursions are limited by the available output of the amplifier.

5. The logic unit consists of a CMOS counter which is clocked by an auxiliary output from the pulse generator 21 and connected to "reset" each time the amplifier output presents a logic "low" level during the positive transition of the clock signal and to "count" each time the amplifier presents a logic "high" level during the positive transition of the clock
10. signal. When three successive "counts" have occurred since the last "reset" an output signal is produced which fires an output switch 25. This causes current to flow from the output connection 26 to the negative supply connection 27 thus allowing the actuation of an
15. alarm and in this case a light emitting diode indicator 28 and a similar repeat remote indicator 29 which is present also in this embodiment.

The pulse generator 21 is a complementary astable oscillator operating from a current source of about
20. 80 microamperes derived from the output terminal 26. Every 2 seconds it produces a current pulse of 1.2 amperes peak value and 150 microseconds duration into the infrared light emitting diode 3.

The amplifier integrates and amplifies the composite
25. signal over the duration of the radiation pulse to produce an appropriate input for the logic unit when the positive clock transition occurs at the end of each radiation pulse.

The graph of Figure 3 shows the magnitude of
30. the various signals against time, all the signals

pulsing in synchronism with the radiation source with the same duration, i.e. 150 microseconds. The x axis, indicated by 30, represents the logic threshold level of the logic unit whilst the line 31 which is slightly positive with respect to it represents the amplifier output quiescent level. 32 represents the output of the photodiode 4 when no smoke is present in the housing, i.e. as a result of only background radiation whilst 33 represents the output of this diode when smoke is present in the housing, i.e. as a result of both background and smoke-scattered radiation. 34 represents the output of the reference sensor 5 and this is exactly the same for every pulse since the intensity of radiation does not vary. 35 and 36 represent the composite signal when no smoke is present in the housing and smoke of greater than threshold density is present in the housing respectively.

Thus, in use, the reference sensor 4 always produces an output represented by curve 34 at each radiation pulse whilst when no smoke is present the sensor 4 produces an output represented by curve 32 and the composite signal represented by curve 35 is negative, that is to say less than the logic threshold and no alarm is indicated. As the smoke density in the housing increases the output of the sensor 4 increases to that represented by value 33 and the composite signal rises towards the curve represented by the curve 36 which is both positive and above the logic threshold. After the composite signal has been above the logic threshold for three pulses an alarm

- is indicated, though it will be appreciated that three is an arbitrary number chosen substantially to exclude the possibility of transient signals or variations in the logic threshold resulting in an alarm being
5. incorrectly indicated.

12.

CLAIMS

1. A suspended particle detector including a housing (1, 2) containing a radiation source (3) arranged to shine radiation across the interior of the housing, a first radiation sensor (5) arranged to receive radiation scattered from the wall (1) of the housing and radiation scattered from particles suspended in the housing and to produce a first signal indicative of the total intensity of radiation incident on it and a second radiation detector (4) arranged to produce a second signal indicative of the intensity of the radiation source, the detector also including signal combining means (22) arranged to combine the two signals in opposition to produce a composite signal, characterised in that the detector is constructed and arranged so that the composite signal has a first polarity when the density of suspended particles in the housing is less than a predetermined threshold value and the opposite polarity when the said density is greater than the threshold value and that evaluation means (23, 24, 25) are arranged to detect when the polarity of the composite signal reverses and to produce an alarm signal.
2. A detector as claimed in Claim 1 characterised in that the second sensor (4) is arranged to be directly subject to radiation from the radiation source.

13.

3. A detector included in Claim 2 characterised in that the housing (1, 2) includes a block (2) of non-translucent material in which there is a first passage (9) in which the radiation source (3) is situated and a second passage (10) communicating with the first passage (9) in which the second sensor (4) is situated.
10. 4. A detector as claimed in any one of the preceding claims characterised by adjustment means (7) arranged to vary the magnitude of the second signal at a given density of suspended particles.
15. 5. A detector as claimed in Claims 3 and 4 characterised in that the adjustment means comprises a screw (7) arranged to obstruct a desired proportion of the area of the second passage (10).
20. 6. A detector as claimed in any one of the preceding claims characterised in that the evaluation means (23, 24, 25) includes an amplifier (23) to the input of which the signal combining means (22) is connected and to the output of which a logic unit (24) is connected, the amplifier (23) being so arranged that if there is no input the output is of the said opposite polarity so that an alarm signal is produced.
- 25.

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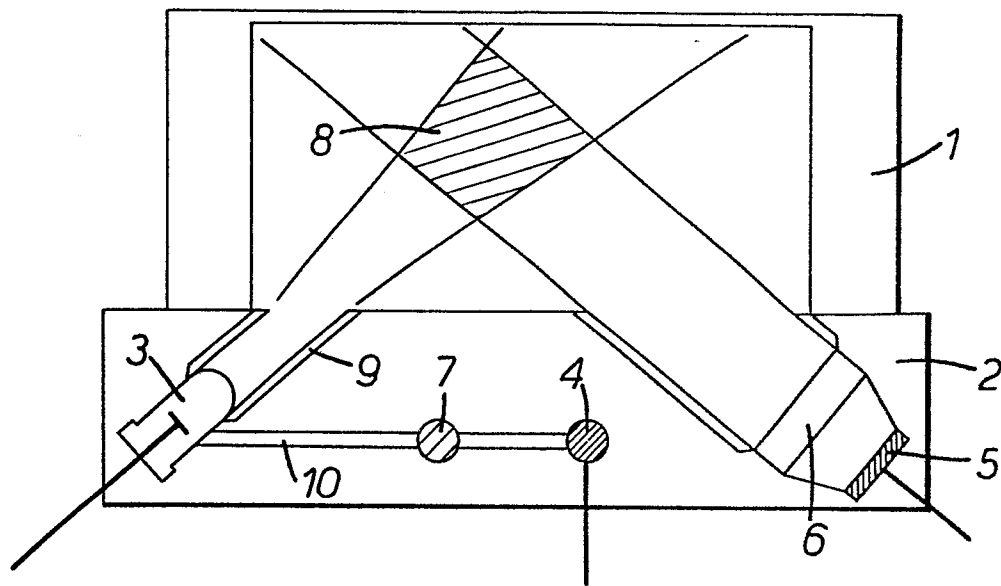


FIG. 1.

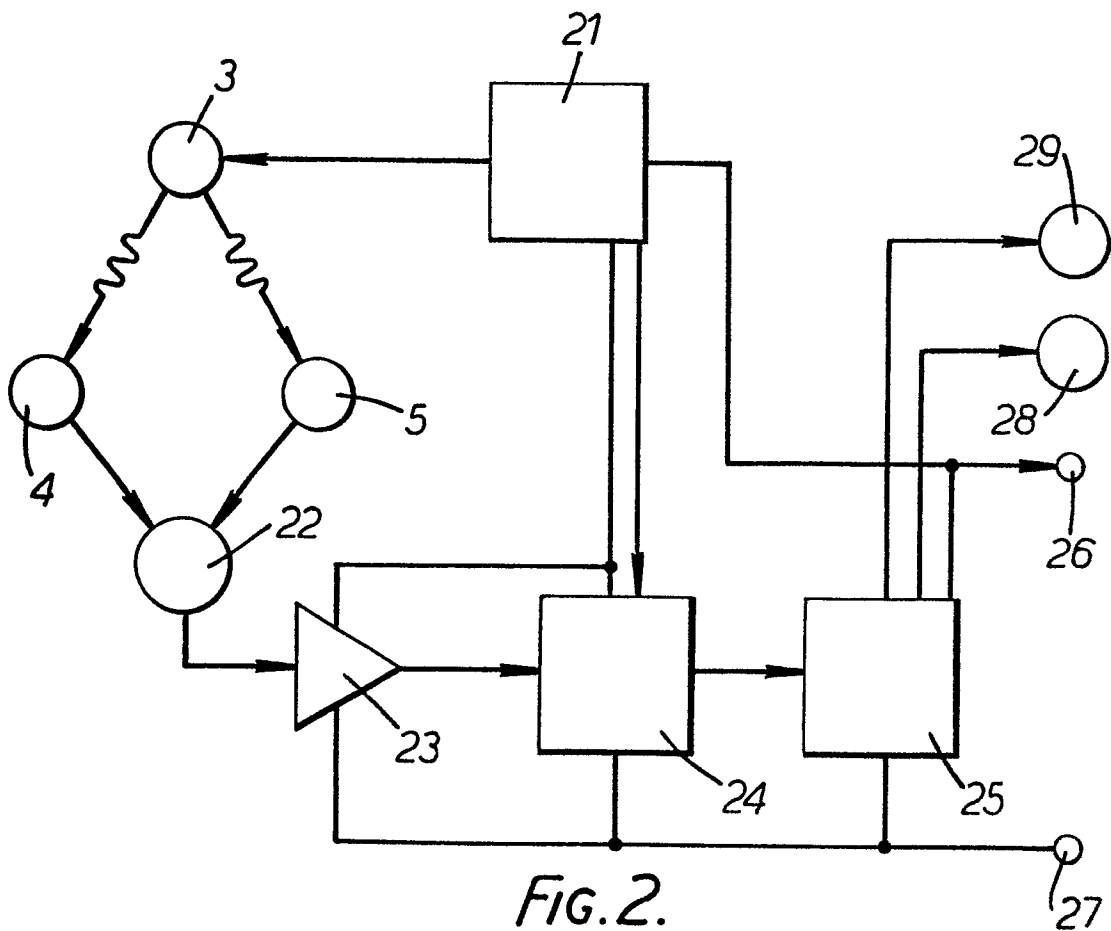


FIG. 2.

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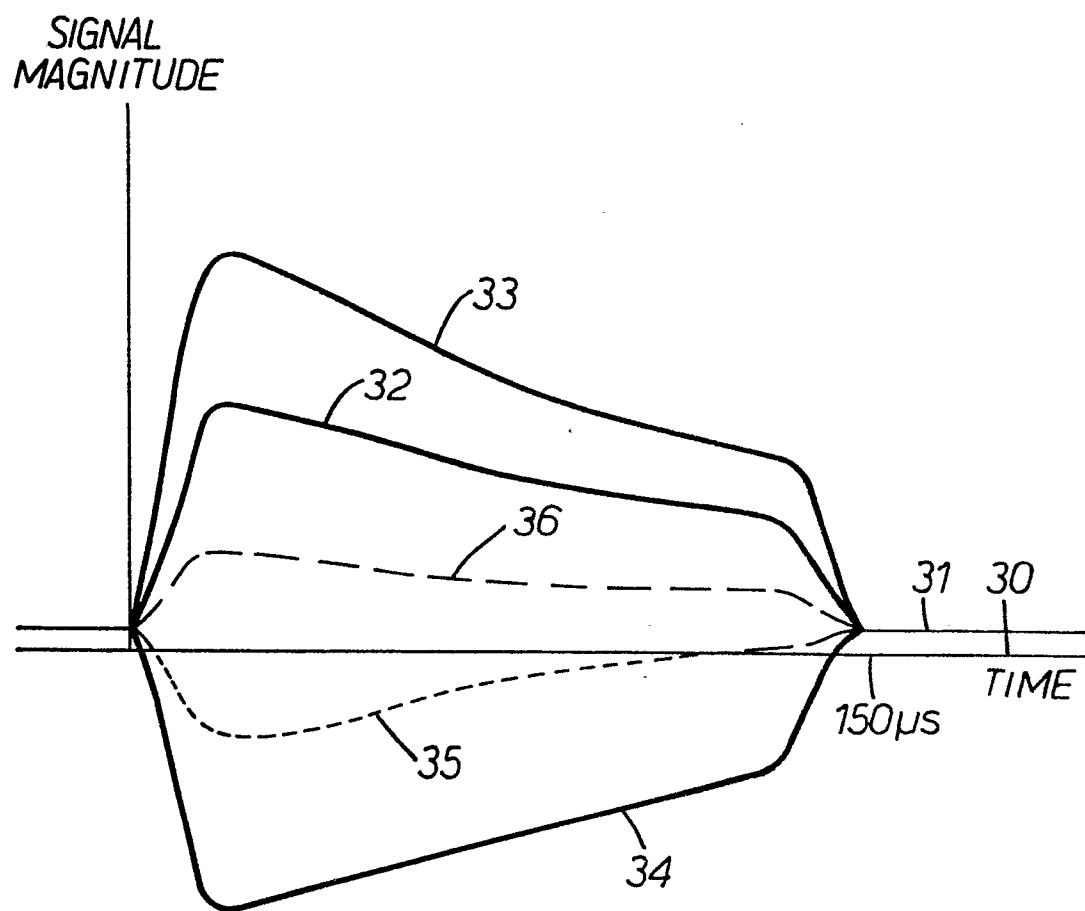


FIG. 3.



European Patent
Office

EUROPEAN SEARCH REPORT

0099729

Application number

EP 83 30 4076

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y, X	US-A-3 723 747 (D.F. STEELE) * Whole document *	1, 2-5 6	G 08 B 17/10
Y	DE-B-2 856 259 (CERBERUS AG) * Figures 1b, 6; column 4, line 31 - column 5, line 9, column 8, lines 1-43 *	1, 6	
A	EP-A-0 015 007 (HEKATRON GMBH) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
			G 08 B 17/00
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 19-09-1983	BEYER F Examiner
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