EUROPEAN QUALIFYING EXAMINATION 1998

PAPER B
ELECTRICITY/MECHANICS

THIS PAPER COMPRISES:

Description of the Application

The present invention relates to a smoke detector for detecting smoke particles in ambient air, the smoke detector comprising a source of radiation which emits electromagnetic radiation into a detecting chamber open to the ambient air.

Smoke detectors of this kind are used in alarm installations for detecting fires or the presence of dangerous gases or vapours. The output signal of the smoke detector is transmitted to a centrally located evaluation device and can be employed as an alarm signal and/or as a signal for initiating protective or counter measures upon occurrence of the above undesired conditions.

Document I discloses a smoke detector according to the preamble of Claim 1. The smoke detector is connected to a central evaluation device by means of light guides. In a dark chamber of the smoke detector a beam of light leaves an incoming light guide and, when smoke is present in the dark chamber, the light scattered by the smoke particles is conducted to the central evaluation device where the alarm signal is generated. Although the smoke detector disclosed in Document I works very reliably in general, it nevertheless has a few disadvantages: it is necessary to detect the light scattered by the smoke particles and the intensity of this scattered light not only depends on the concentration of the smoke present in the detector, but also on the reflectivity of the smoke particles themselves. This means that the sensitivity of the detector for "grey" smoke is considerably higher than for "black" smoke, the particles of which are less light-reflective than those of grey smoke. In other words, black smoke must be present in a higher concentration than grey smoke in the dark chamber in order to cause generation of the alarm signal. In extreme cases this can lead to a fire being detected too late or - even worse - not being detected at all.

It is therefore an object of the present invention to provide a smoke detector which allows the detection of various kinds of smoke with a sensitivity that is independent of the optical reflectivity of the smoke particles.

According to the present invention, this object is achieved in the above defined smoke detector in that the source of radiation emits the electromagnetic radiation in the form of pulses, and in that the smoke detector is provided with an acoustic transducer for converting pressure waves, which are gen[…] the electromagnetic radiation pulses are absorbed by smoke particles, into a smoke detector outp[…] indicative of the presence of smoke in the detecting chamber.

In this way, the smoke detector according to the invention is capable of detecting smoke independently of its reflectivity and thus ensures very reliable smoke detection.

Preferred features of the invention are the subject of dependent claims.

The invention and its underlying principle will be better understood when consideration is given to the following detailed description thereof.

In the accompanying drawings:-

Fig. 1 is a schematic representation of a smoke detector according to the invention in vertical cross-section together with a central alarm unit;

Fig. 2 is a cross-sectional view of an embodiment of an acoustic transducer for use in the smoke detector of Fig. 1; and

Fig. 3 is a cross-sectional view of another embodiment of an acoustic transducer for use in the smoke detector of Fig. 1.

The smoke detector of Fig. 1 comprises a cylindrical housing 1 open to the ambient air by means of a labyrinth structure 2 which allows air to pass therethrough, but which blocks ambient light from entering a detecting chamber 3. In an upper wall of the housing 1, an incoming light guide 4 is mounted in such a way that it can emit light pulses into the detecting chamber 3. The light pulses are produced in a remote central alarm unit 5 by means of a light source 6, such as a light emitting diode or a laser diode which is controlled by a pulse generator 7.

When smoke enters the detecting chamber 3, smoke particles 8 absorb the emitted light pu[illegible] absorbing the pulses, each particle heats up and then cools down. This happens in synchronism with [illegible] light pulses. Acoustic pressure waves (i.e. sound) are thereby generated which reach an acoustic transducer 9. The latter is exposed to these pressure waves and has the task of converting them into an output signal which is sent to the central alarm unit 5. The occurrence of acoustic pressure waves is a clear and highly sensitive indication of the presence of smoke in the detecting chamber 3.

Next, the transducer 9 and its connection to the central alarm unit 5 will be explained in more detail. As can be seen in Fig. 2, the transducer 9 comprises a housing 10 which is closed in an air-tight manner by means of a membrane 11. The membrane 11 is mounted such that it can freely vibrate and a continuous light guide, which has portions 12, 13 and 14, is connected along its portion 13 to the membrane, e.g. by glueing. The portion 12 of the light guide is divided off from the light guide 4 at 15 and hence connected to the light source 6 (see Fig. 1). Acoustic pressure waves occurring in the detecting chamber 3 when smoke is present therein cause vibration of the membrane 11. This in turn causes vibration of the portion 13 of the light guide in contact with the membrane and, as a consequence of this vibration, the optical transmissibility of the portion 13 of the light guide is changed. Due to these changes of optical transmissibility, the intensity of the light pulses in the light guide portion 14 is different from the intensity of the light pulses in the light guide portion 12. Shortly it can be stated that the portion 14 of the light guide carries information as to whether or not smoke is present in the detecting chamber. When the light pulses in the portion 14 have the same intensity as the light pulses in the portion 12, this indicates that no smoke is present in the detecting chamber 3 (the membrane does not vibrate). When the light pulses in the portion 14 have a different intensity from that of the light pulses in the portion 12, this indicates that smoke is present in the detecting chamber 3 (the membrane vibrates).

Turning back to Fig. 1, the transducer output light pulses are conducted by the portion 14 of the light guide to the central alarm unit 5 where they are converted by means of an optical receiver 16 into an electrical signal. This signal is fed into a gate circuit 17 which is also supplied with the output signal from the pulse generator 7. The gate circuit 17 passes only that portion of the output signal from the optical receiver 16 which occurs during the light pulses. In this way, it is ensured that the signal generated by the transducer 9 is evaluated only during the duration of the light pulses.

The output signal of the gate circuit 17 is fed to an evaluation circuit 18 which evaluates variations in order to generate a fire alarm signal Al. Advantageous frequencies for the light p between 1 kHz and 20 kHz (1 000 and 20 000 pulses per second).

Fig. 3 shows another embodiment of an acoustic transducer for use in the smoke detector shown in Fig. 1. In its essential parts, the transducer shown in Fig. 3 corresponds to the transducer of Fig. 2 and the same parts carry the same reference numerals. The portions 12 and 14 of the light guide respectively lead into and leave the housing 10 of the transducer in an air tight manner. In contrast with the embodiment of Fig. 2, the light guide of the transducer shown in Fig. 3 is not continuous: portions 12 and 14 both terminate below the membrane 11 and face the latter in a tilted manner. On the side facing the light guide portions 12 and 14, the membrane 11 is provided with a reflective coating, so that the light emitted by the portion 12 is reflected into the portion 14. As the acoustic pressure waves cause vibrations of the membrane 11, the amount of light reflected by the vibrating membrane into the portion 14 of the light guide will vary. This variation of intensity of the light pulses can be evaluated in the central alarm unit in the same way as explained above.

The present invention has been described in its preferred form in which light guides are used to connect the smoke detector or detectors to the central alarm unit. This electrically passive detector is particularly advantageous for explosion-endangered environments. For applications in less dangerous environments, it is also possible to connect the smoke detectors electrically to the central alarm unit. In this case, the light source is located in the smoke detector and is supplied via a cable with voltage pulses from the central alarm unit. The acoustic transducer is then constituted by a simple and small microphone, the output signal of which will however have to be amplified in the smoke detector. This signal is then conducted to the central alarm unit where it is further evaluated.

The above described smoke detector ensures a highly reliable smoke detection which is entirely independent from the reflectivity of the smoke particles. It is possible to further increase the sensitivity of the smoke detector by combining the above detection principle with the scattered light principle that is described in Document I. It would in fact only be necessary to provide a further light guide for receiving scattered light from the smoke particles in the detecting chamber. This light guide conducts the scattered light from the detecting chamber to the central alarm unit which must be provided with separate evaluation circuitry therefor (see Document I). It is obvious that the fact that the light is pulsed does not h[...] undesired effect on the scattered light detection principle.

List of reference numerals

1 ....housing of smoke detector
2 ....labyrinth structure
3 ....detecting chamber
4 ....incoming light guide
5 ....central alarm unit
6 ....light source
7 ....pulse generator
8 ....smoke particles
9 ....acoustic transducer
10 ....housing of transducer
11 ....membrane
12, 13, 14 ......portions of light guide
15 ....division of light guide
16 ....optical receiver
17 ....gate circuit
18 .... evaluation circuit

Claims

1. A smoke detector for detecting smoke particles (8) in ambient air, the smoke detector compri a source of radiation which emits electromagnetic radiation into a detecting chamber (3) open to the ambient air, characterized in that the source of radiation emits the electromagnetic radiation in the form of pulses, and in that the smoke detector is provided with an acoustic transducer (9) for converting pressure waves, which are generated when electromagnetic radiation pulses are absorbed by smoke particles, into a smoke detector output signal indicative of the presence of smoke in the detecting chamber.

2. A smoke detector according to Claim 1, in which the electromagnetic radiation is light.

3. A smoke detector according to Claim 1 or 2, in which the pulses have a frequency between 1 kHz and 20 kHz.

4. A smoke detector according to Claim 2 or 3, in which the smoke detector is connected to a central alarm unit (5) by means of light guides (4, 12, 14).

DRAWINGS OF THE APPLICATION

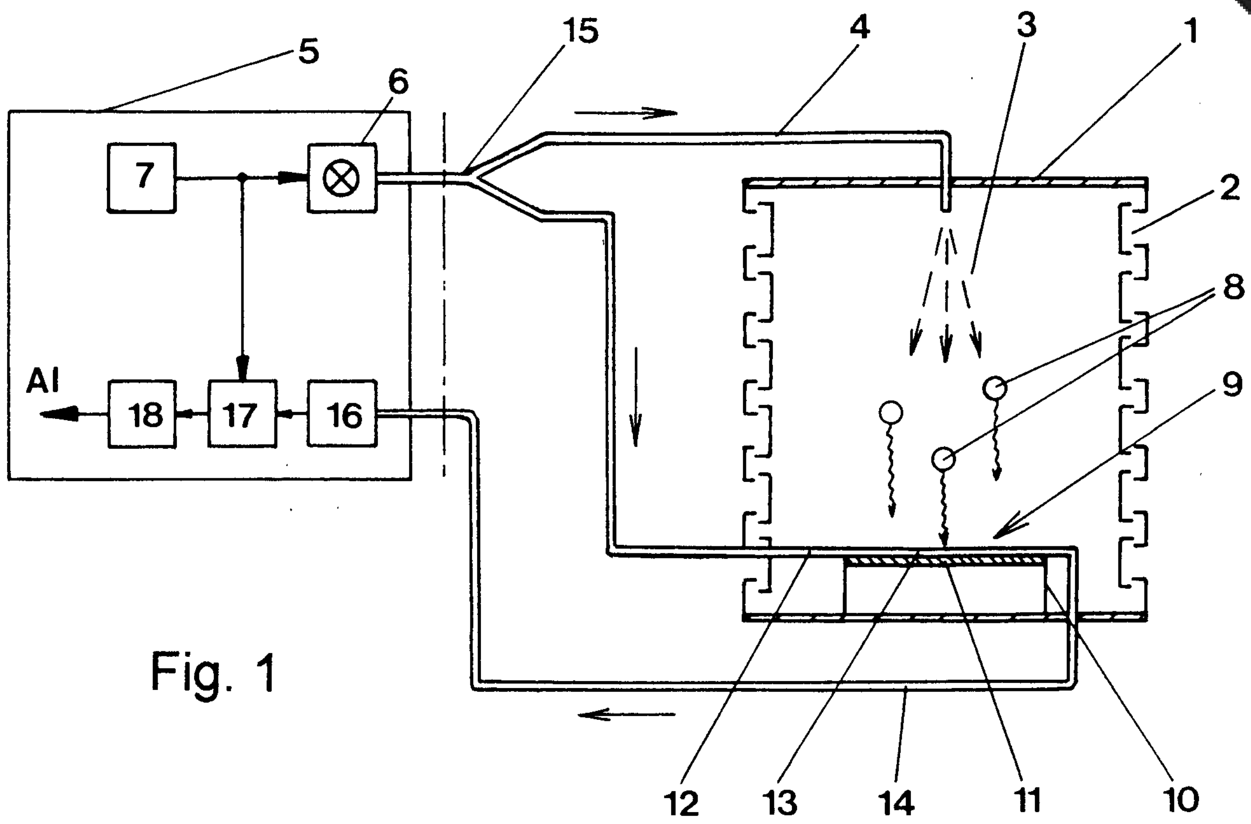

Fig. 1

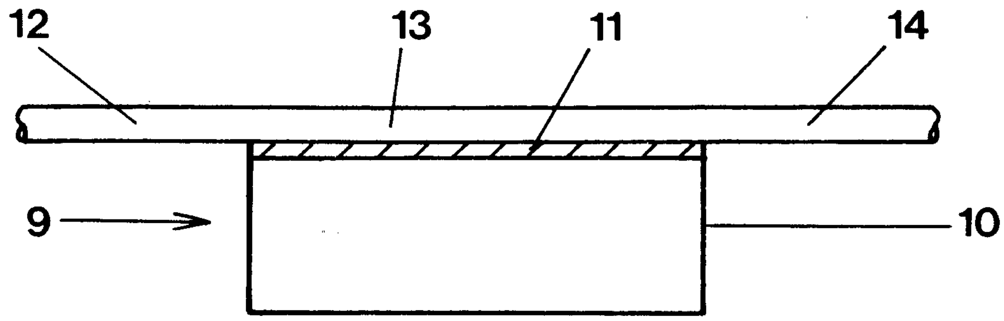

Fig. 2

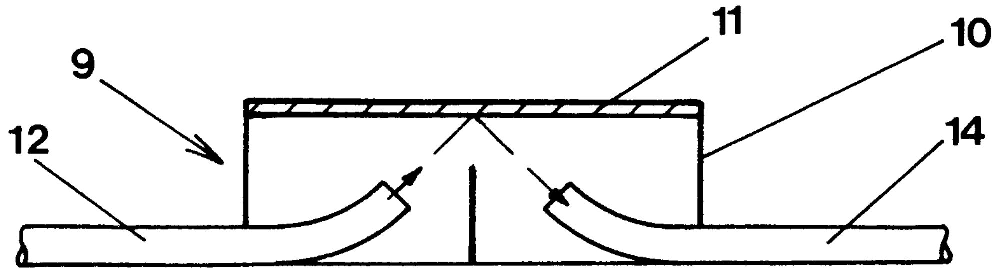

Fig. 3

Communication pursuant to Art. 96 (2) and Rule 51 (2) EPC

The examination is being carried out on the following application documents:

The application documents as originally filed.

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1. The following documents are referred to in this communication; the numbering will be adhered to for the rest of the procedure:

   Document I and
   Document II.

   Both documents were published before the filing date of the present application.

2. Claim 1 lacks novelty with respect to Document II.

   Using the terminology of Claim 1, Document II discloses (the reference numerals refer to Document II) a smoke detector for detecting smoke particles in ambient air, the smoke detector comprising a source of radiation (4) which emits electromagnetic radiation into a detecting chamber (1) open to the ambient air (inlet 2 and outlet 3), whereby the source of radiation emits the electromagnetic radiation in the form of pulses, and whereby the smoke detector is provided with an acoustic transducer (8) for converting pressure waves, which are generated when electromagnetic radiation pulses are absorbed by smoke particles, into a smoke detector output signal indicative of the presence of smoke in the detecting chamber.

   In view of the above, Claim 1 is not allowable having regard to Art. 52 (1) and 54 (1, 2) EPC.

3. The subject-matter of Claim 2 is also disclosed in Document II.

In view of the fact that Document II discloses a pulse frequency range of 5 kHz to 25 kHz (5 000 to 25 000 pulses per second), the frequency range set out in Claim 3 is nothing more than a slight variation of the prior art range, which the skilled person can adopt according to his/her needs.

It is known from Document I to connect a smoke detector to a central alarm unit by means of light guides (see the light guides 6 and 7 in Document I). The skilled person facing the problem of selecting appropriate connecting means for particular dangerous circumstances will therefore readily combine the use of light guides taught in Document I with the detector described in Document II and will thus arrive at the subject-matter of Claim 4.

In view of the above, Claim 2 lacks novelty and Claims 3 and 4 lack an inventive step. These claims are therefore not allowable in view of Art. 52 (1), 54 (1, 2) or 56 EPC respectively.

4. It is not at present apparent which part of the application could serve as a basis for a new, allowable main claim. Should the applicant nevertheless regard some particular matter as patentable, an independent claim including such matter should be filed. The applicant should also indicate in the letter of reply the difference of the subject-matter of the new claim vis-à-vis the state of the art and the significance thereof.

DOCUMENT I (State of the Art)

This invention relates to an alarm installation comprising a smoke sensor which is capable of detecting smoke by radiating light into a smoke detection area and detecting light scattered by smoke in the smoke detection area. When scattered light is detected, an output signal is generated which is processed in a central evaluation device which is adapted to generate an alarm signal when the sensor detects smoke in the detection area.

In known alarm installations of this kind, the energy supply from the evaluation device to the sensor arranged remotely therefrom and transmission of the sensor signal to the evaluation device is accomplished by means of electrical conductors. However, in such installations, electrical disturbances can arise, e.g. due to mains pulses, which can lead to spurious responses of the sensors and to faulty signal transmission. Moreover, due to voltage drop in long conductors, the supply voltage of the sensor may be too low, so that complicated stabilization devices in the sensors are needed, which make the latter expensive. In special fields of application, especially in explosion-endangered environments, further protective measures are required when the supply of voltage to the sensors and/or output of voltage from the sensors occurs by means of electrical conductors.

It is an object of the present invention to provide an alarm installation which does not suffer from the above disadvantages.

According to the invention, this object is achieved in that the sensor is connected to the central evaluation device by means of radiation-conducting elements, such as light guides. In view of the fact that the alarm installation according to the invention does not require any electrical connections between the sensor or sensors and the central evaluation device, it operates free of disturbances in a stable, accurate and voltage independent manner and it can be used in explosion-endangered environments.

The invention is described with reference to the accompanying drawings, in which:

Fig. 1 is a basic diagram of an alarm installation according to the invention; and

Fig. 2 is a partially cut-away view of a smoke sensor according to the invention.

Referring now to Fig. 1, a smoke sensor S is connected to a central evaluation device CED by means of an input line 6 and an output line 7. Both the input and the output lines are constituted by light guides. A light guide is a radiation-conducting element which is known per se and which is cap conducting light just like an electrical conductor conducts electrical current, so that a light guide analogous to an electrical cable.

Turning now to Fig. 2, a sensor casing 1 is fitted to a sensor base which is adapted to be fixed to a ceiling. An outer cover 3 having, at the periphery thereof, a plurality of smoke inlets 2, is mounted on a lower portion of the sensor casing 1. In the outer cover 3 there is provided an inner cover 4, such that the two covers constitute a labyrinth structure which prevents external light from entering through the inlets 2 and which allows the passage of smoke. The outer and inner covers 3 and 4 are fitted to the lower portion of the sensor casing 1 to form a dark chamber. A holder 5 is fitted to an inner wall of the dark chamber. One end of the light guide 6 is mounted on the right-hand side of the holder 5. The other end of the light guide 6 faces a light source L in the central evaluation device CED so that the light from the light source L is conducted into the dark chamber. In the dark chamber, the light leaves the light guide 6 and produces a light beam along the optical axis 9.

The holder 5 also carries one end of the output light guide 7. Both light guides 6 and 7 are so disposed that their optical axes 9 and 10 are directed slantingly downwardly so as to intersect at a smoke detection area 11 located at a central portion of the dark chamber. It is important to note that the construction is such that no light which is emitted from the light guide 6 can reach the light guide 7 directly.

When smoke enters the dark chamber, the light emitted by the light guide 6 is scattered by the smoke particles. This scattered light reaches the end of the light guide 7 and is conducted therethrough to the central evaluation device CED. An optical receiver R in the central evaluation device converts the incoming light into an electrical signal, which signal is further evaluated in an alarm circuit A. When the electrical signal from the optical receiver R exceeds a certain threshold value, the alarm circuit A generates a fire alarm signal. Of course, more than one sensor can be connected to a single central evaluation device.

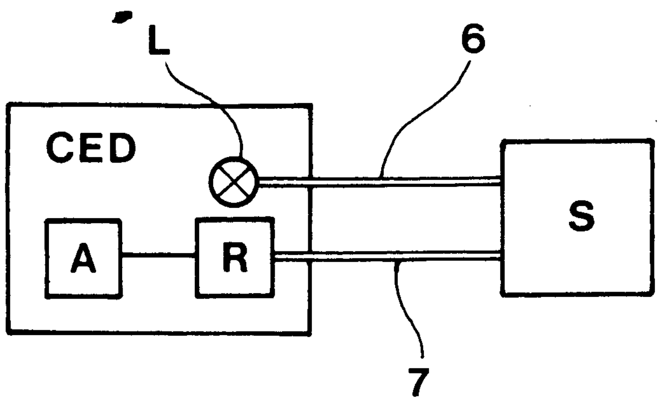


Fig. 1

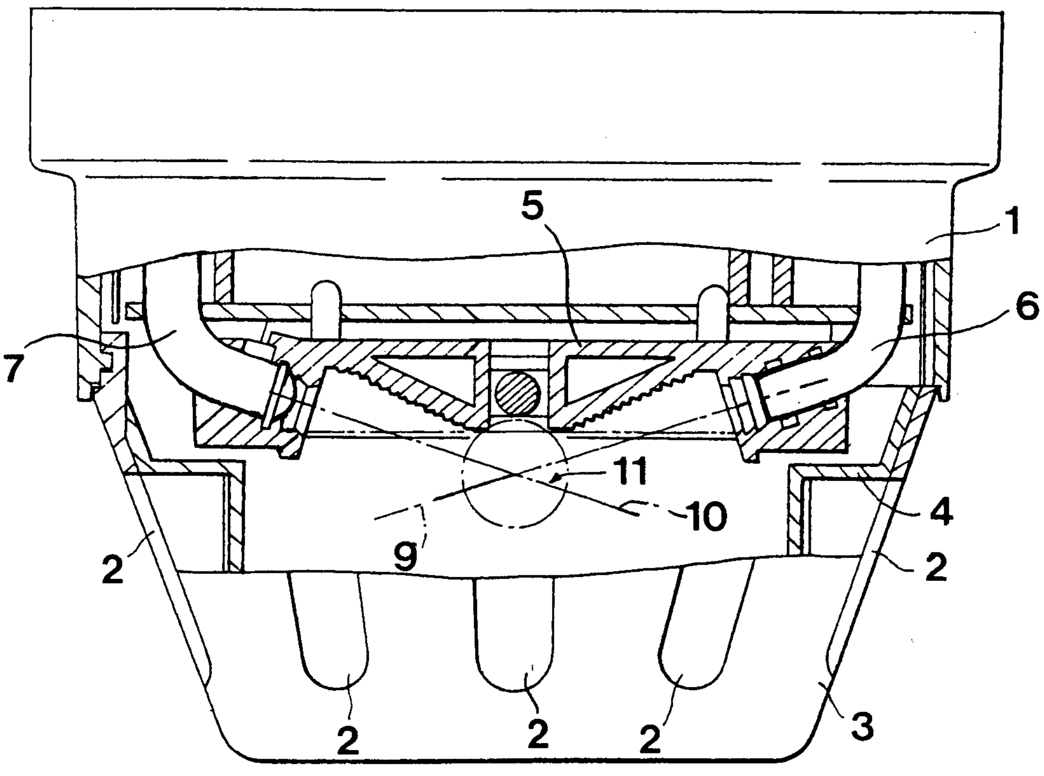


Fig. 2

DOCUMENT II (State of the Art)

"A NEW SMOKE DETECTION PRINCIPLE BASED ON THE GENERATION OF SOUND WAVES BY MEANS OF ELECTROMAGNETIC RADIATION"

Hans D. Rauch, James E. Smoke and Jean F. Fumée

ABSTRACT

A new principle for the detection of smoke particles in enclosed spaces relies on the production of sound waves which are generated when smoke particles are exposed to pulsed electromagnetic radiation. The experimental results indicate that the new principle is promising for use in smoke detectors.

INTRODUCTION

Optical detection principles for the presence of smoke known hitherto relied in general on the optical properties of the smoke particles which can, however, vary considerably depending on what particular material is combusted under what particular circumstances. With this paper the authors present a detection principle that is independent of the individual optical properties such as reflectivity of the smoke particles.

DESCRIPTION

The authors discovered that smoke particles absorb pulsed electromagnetic radiation by continuously heating up and cooling down. This results in repeated expansion and contraction of the particles which in this way produce sound waves which can be converted by means of an appropriate transducer into an electrical signal for further processing.

The attached drawing shows schematically the experimental arrangement. A smoke chamber 1 is provided with a smoke inlet 2 and a smoke outlet 3. Cylindrical portions 6a and 6b are provided in the smoke chamber in order to seal the latter against ambient light while allowing the desired flow of smoke particles through the smoke chamber as indicated by the curved arrows. On one end wall of the smoke chamber, an infra-red light emitting diode 4 is arranged which is supplied with voltage pulses from a voltage pulse generator 5. The pulse frequency was selected to be 10 kHz (10 000 pulses per second).

The opposite end wall of the chamber carries a funnel-shaped portion 7 for concentrating onto a microphone 8 the sound waves generated by smoke particles present in the smoke chamber and exposed to the infra-red light pulses. The output voltage of the microphone 8 is amplified in an amplifier 9 and is measured in a voltmeter 10. The measured voltage is indicative of the presence and intensity of smoke in the smoke chamber.

EXPERIMENTAL RESULTS

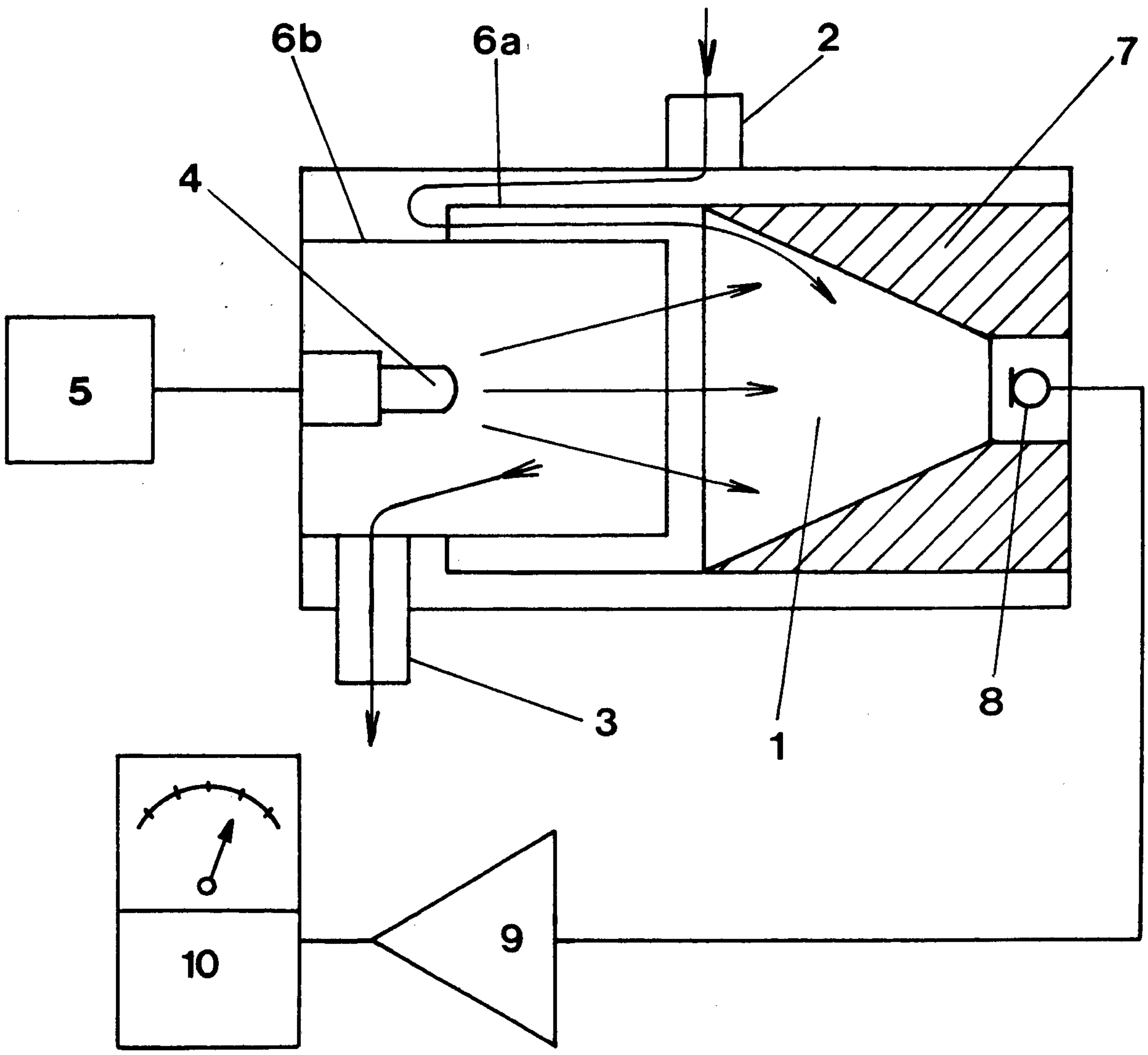
With the above arrangement, the amplified microphone output voltage was as high for grey smoke (obtained by burning a cotton wick, the smoke density had an extinction rate of 1.33% per 10 cm) as for black smoke (obtained by burning kerosine, the smoke density had an extinction rate of 3.33% per 10 cm). Smoke-indicative output voltages were obtained for extremely low smoke concentrations that could not be detected by commercial scattered light smoke detectors that were used for purposes of comparison.

The radiation pulse frequency was varied between 5 kHz and 25 kHz (5 000 and 25 000 pulses per second) and proved to have a negligible influence on the amplified microphone output voltage. However, the sensitivity of smoke detection could be significantly increased by selecting the wavelength of the electromagnetic radiation radiated into the smoke chamber to be in the range of the resonance radiation of carbon dioxide or carbon monoxide (one or both of these gases occur under practically all circumstances of fires). For this purpose, the infra-red light emitting diode can be replaced by a laser diode emitting laser light with a wavelength of 4.7 µm.

CONCLUSIONS

The new detecting principle described above appears to be appropriate for commercial use in smoke detectors. In fact, it is the subject of pending patent applications. In commercial applications, the amplified microphone output voltage must be processed in an evaluation circuit for generating an alarm signal. In order to avoid noise problems in such a commercial arrangement, it appears to be necessary to include a gating circuit that guarantees that the microphone output voltage is evaluated exclusively during radiation pulses. In this way, the evaluation circuit ignores any noise occurring between the individual pulses. It would even appear to be possible to use the above principle for smoke detectors which are connected by means of light guides to the evaluation circuit: the light pulses can be easily fed by means of a light guide to the smoke detector; the output voltage of the microphone would have to be amplified in the smoke detector and then be fed to a light source in the smoke detector which emits its light into a light guide leading from the smoke detector to the evaluation circuit. The amplifier in the smoke detector could be powered by means of a battery in the smoke detector.

DRAWING OF DOCUMENT II (State of the Art)



Client's Letter

Thank you for your letter forwarding a copy of the official communication from the European Pa Office as well as Document II.

We share the Examiner's view insofar as the basic smoke detection principle has obviously been described in the prior art. However, we firmly disagree with the Examiner's assertions with respect to the use of light guides. It might be an obvious measure simply to connect a smoke detector to a central alarm unit by means of light guides; however, we have the feeling that our invention includes more than a simple combination of Documents I and II. A good deal of inventive skill appears to be necessary to arrive at the smoke detectors as they are described in our application.

We would therefore like you to perform the necessary steps to ensure protection for the light guide embodiments. If this means that we cannot obtain protection for the "electrical embodiment" (at present covered by Claim 1), which is mentioned at the end of the description (second paragraph counted from the end) then so be it. Our firm is specialized in smoke detectors for explosion-endangered environments and the "electrical embodiment" is of no commercial interest to us.