(12) PATENT (11) Application No. AU 200189464 B2
(19) AUSTRALIAN PATENT OFFICE (10) Patent No. 772018

(54) Title
Optoacoustic measuring arrangement and use thereof

(51)[6] International Patent Classification(s)
G01N 021/17

(21) Application No: 200189464 (22) Application Date: 2001.10.01

(87) WIPO No: WO02/31475

(30) Priority Data

(31) Number	(32) Date	(33) Country
00121937	2000.10.09	EP
896/01	2001.05.15	CH

(43) Publication Date : 2002.04.22
(43) Publication Journal Date : 2002.06.27
(44) Accepted Journal Date : 2004.04.08

(71) Applicant(s)
Siemens Building Technologies AG

(72) Inventor(s)
Martin Forster; Peter Nebiker

(74) Agent/Attorney
Griffith Hack,GPO Box 1285K,MELBOURNE VIC 3001

(56) Related Art
EP 855592
US 4688942

AU 200189464

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
18. April 2002 (18.04.2002)

PCT

(10) Internationale Veröffentlichungsnummer
WO 02/31475 A1

(51) Internationale Patentklassifikation[7]: G01N 21/17

(21) Internationales Aktenzeichen: PCT/CH01/00588

(22) Internationales Anmeldedatum: 1. Oktober 2001 (01.10.2001)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
00121937.7 9. Oktober 2000 (09.10.2000) EP
896/01 15. Mai 2001 (15.05.2001) CH

(71) Anmelder *(für alle Bestimmungsstaaten mit Ausnahme von US)*: **SIEMENS BUILDING TECHNOLOGIES AG** [CH/CH]; Bellerivestrasse 36, CH-8034 Zürich (CH).

(72) Erfinder; und
(75) Erfinder/Anmelder *(nur für US)*: **FORSTER, Martin** [CH/CH]; Sonnenbergstrasse 16, CH-8625 Jona (CH). **NEBIKER, Peter** [CH/CH]; Loorenrank 32, CH-8053 Zürich (CH).

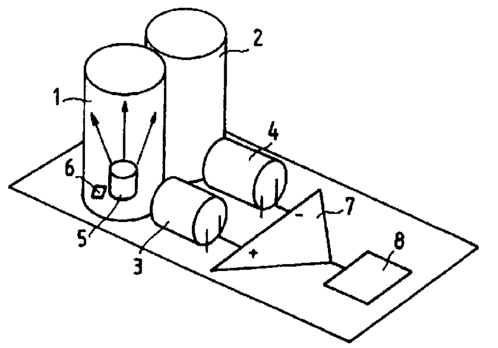
(74) Gemeinsamer Vertreter: **SIEMENS BUILDING TECHNOLOGIES AG**; Fire & Security Products, Alte Landstrasse 411, CH-8708 Männedorf (CH).

(81) Bestimmungsstaaten *(national)*: AU, CA, CN, CZ, HU, IN, JP, KR, NO, PL, SG, US.

[Fortsetzung auf der nächsten Seite]

(54) Title: OPTOACOUSTIC MEASURING ARRANGEMENT AND USE THEREOF

(54) Bezeichnung: OPTOAKUSTISCHE MESSANORDNUNG UND DEREN VERWENDUNG



(57) Abstract: The measuring arrangement contains a measuring cell and a reference cell (9, 10) to which microphones (11 or 12) are allocated, an evaluating electronics unit (7, 8) being connected to said microphones. In said evaluating electronics unit, the signals of the microphones (11 or 12) are subtracted. The inventive arrangement also comprises a source of radiation (5) which acts on the measuring cell (9) in a modulated manner. The modulation frequency of the radiation source (5) corresponds to the resonance frequency of the measuring cell (9), and the measuring cell and reference cells (9 to 10) are open on at least one side in relation to the gas and/or aerosol to be detected. The measuring arrangement is used as a smoke detector, gas detector, fire risk detector or a combined smoke and gas detector. The measuring cell (9) is subjected to radiation of a wavelength at which a relevant substance to be detected is absorbed and an optoacoustic effect is produced as a result.

(57) Zusammenfassung: Die Messanordnung enthält je eine Mess- und Referenzzelle (9, 10) und diesen zugeordnete Mikrofone (11 bzw. 12), an welche eine Auswerteelektronik (7, 8) angeschlossen ist, in welcher eine Subtraktion der Signale der Mikrofone (11 bzw. 12) erfolgt, sowie eine Strahlungsquelle (5) zur modulierten Beaufschlagung der Messzelle (9). Die Modulationsfrequenz der Strahlungsquelle (5) stimmt mit der Resonanzfrequenz der Messzelle (9) überein, und die Mess- und die Referenzzelle (9 bzw. 10) sind gegenüber dem nachzuweisenden Gas und/oder Aerosol mindestens einseitig offen. Die Messanordnung wird als Rauchmelder, Gasmelder, Brandgefahrenmelder oder als kombinierter Rauch- und Gasmelder verwendet, wobei jeweils die Messzelle (9) von einer Strahlung einer Wellenlänge beaufschlagt ist, bei welcher eine betreffende nachzuweisende Substanz absorbiert und dadurch ein optoakustischer Effekt erzeugt wird.

WO 02/31475 A1

(84) **Bestimmungsstaaten** *(regional)*: europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Erklärungen gemäß Regel 4.17:

— *hinsichtlich der Berechtigung des Anmelders, ein Patent zu beantragen und zu erhalten (Regel 4.17 Ziffer ii) für die folgenden Bestimmungsstaaten AU, CA, CN, CZ, HU, IN, JP, KR, NO, PL, SG, europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR)*

— *Erfindererklärung (Regel 4.17 Ziffer iv) nur für US*

Veröffentlicht:

— *mit internationalem Recherchenbericht*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

Opto-acoustic measuring arrangement and its application

Description

The present invention concerns an opto-acoustic measuring arrangement for the detection of gases and/or aerosols, having a measuring cell and a reference cell, respectively, and microphones assigned to these cells, to which microphones an electronic evaluation circuit is connected, in which a subtraction of the signals of the microphones takes place, and having a radiation source for applying a modulated signal to the measuring cell, wherein the modulation frequency of the radiation source coincides with the resonant frequency of the measuring cell.

With the opto-acoustic or photo-acoustic effect, an acoustic pressure wave, whose magnitude is directly proportional to the concentration of the relevant gas, is produced by the irradiation by modulated light of a gas to be detected. The acoustic pressure wave is produced because the gas absorbs the light radiation and heats up as a result. This results in a thermal expansion and a periodic pressure fluctuation in accordance with the modulation of the light radiation. The two cells are usually termed the measuring cell and the reference cell, and the measuring arrangement is constructed so that the cells are either separated from each other and the radiation passes through both cells (C. F. Dewey, Jr.: Opto-acoustic Spectroscopy and Detection, [Y. H. Pao, ed.], Academic Press, New York, 1977, 47-77) or the cells are interconnected and the radiation passes only through the measuring cell (G. Busse and D. Herboeck: Differential Helmholz resonator as an opto-acoustic detector, Applied Optics, Vol 18, No. 23, 3959).

With the detection of aerosols the behaviour is similar, as these also absorb the modulated radiation, whereby modulated heat and from this modulated pressure are produced as a result. Previously described opto-acoustic sensors for the measurement of aerosols are mostly mono-sensors with only one measuring cell. If, for the aerosol measurement, sensors with two cells, so-called dual sensors having one measuring cell and one reference cell are proposed, then these are constructed so that the reference cell is screened against aerosol. The latter is achieved by filtering the air before it reaches the reference cell. Reference is also made to the severe temperature-dependence of the resonant frequency, which requires correction of the signal magnitude.

When the dual principle is employed, the detection sensitivity of opto-acoustic sensors for gases or aerosols is in the region of that of optical smoke alarms. Since the opto-acoustic signals are produced by absorption and not by radiation, both large and even the smallest aerosols were able to be detected to below the µ range with the opto-acoustic principle, and light and dark types of smoke were able to be measured to a more or less equal degree. Nevertheless, the opto-acoustic principle is not being used up to now for smoke detection, which is chiefly due to the additional outlay necessitated by the air filtering and the correction of the signal magnitude.

An opto-acoustic measuring arrangement of the type stated at the outset, whose costs are competitive with those of a scattered-light detector, shall now be specified by the invention.

This problem is solved according to the invention in that the measuring cell and the reference cell are open at at least one end to the gas and/or aerosol to be detected.

Since in the opto-acoustic measuring arrangement according to the invention both cells are open to the gas and/or aerosol to be detected, filtering of the gas/aerosol to be investigated is not necessary. Normally the sensor signal is zero, and a signal which requires only a relatively simple electronic circuit for its processing is produced in the measuring cell only in the presence of aerosol or a combustible gas which absorbs the radiation emitted by the radiation source.

A first preferred embodiment of the measuring arrangement according to the invention is characterised in that the electronic evaluation circuit contains a differential amplifier and a phase-sensitive rectifier.

A second preferred embodiment of the measuring arrangement according to the invention is characterised in that the wavelength of the radiation emitted by the radiation source is chosen so that it is absorbed by the gas to be detected. A first photocell for monitoring the intensity of the radiation emitted by the radiation source is preferably disposed within the range of the radiation source.

A third preferred embodiment of the measuring arrangement according to the invention is characterised in that in addition to the measuring cell, a second photocell is disposed which, in the presence of an aerosol, is exposed to the scattered radiation of the radiation source caused by this aerosol.

A measuring arrangement constructed in this manner can detect both an aerosol, that is to say smoke, and a gas, and is therefore eminently suitable for use as a so-called dual-criteria alarm for smoke and gas. In practice it behaves in such a way that a specific aerosol is absorbed in a specific wavelength range, the type of aerosol depending on the combustible material. However, since the smoke from a fire nearly always contains mixtures of organic substances, such as wood, for example, which are very absorbent in the entire infrared range and still sufficiently absorbent in the visible light range, the choice of wavelength for optimum aerosol detection is not critical.

If only smoke is to be detected, the second photocell is not required because in this case a wavelength can be selected, at which no combustible gases are absorbent. In the detection of smoke and gas, the lateral photocell is always required when a gas whose absorption range is that of aerosol, is to be detected.

A fourth preferred embodiment of the measuring arrangement according to the invention is characterised in that the measuring cell is radiated by two radiation sources which are operated at different frequencies. This arrangement is suitable for the detection of smoke and two gases.

A further preferred embodiment of the measuring arrangement according to the invention is characterised in that two pairs of measuring cells and reference cells, open at both ends, are provided, each of which has a different length and thus different resonant frequencies, that a microphone is assigned to each reference cell pair and to each measuring cell pair, and that each measuring cell is exposed to a radiation source.

The measuring arrangement with the two pairs of measuring cells and reference cells is suitable for the detection of smoke and two gases. By adding a further pair with a measuring cell and a reference cell, the detection range of the measuring arrangement can be extended to a third gas.

The invention further concerns an application of said measuring arrangement as a smoke alarm. This application is characterised in that the measuring arrangement has a measuring cell which is exposed to a radiation of a wavelength at which the aerosol to be detected is absorbent and an opto-acoustic effect is produced as a result.

The invention further concerns an application of said measuring arrangement as a fire hazard alarm. This application is characterised in that the measuring arrangement has a measuring cell which is exposed to a radiation of a wavelength at which a combustible or explosive substance to be detected is absorbent and an opto-acoustic effect is produced as a result.

The invention further concerns an application of said measuring arrangement as a combined smoke and gas alarm. This application is characterised in that the measuring arrangement has a measuring cell which is exposed to a radiation of a wavelength at which a combustible or explosive substance to be detected is absorbent and an opto-acoustic effect is produced as a result, and that in addition to the measuring cell, a photocell is disposed so that it is exposed to scattered light of the radiation, caused by an aerosol.

The invention further concerns an application of said measuring arrangement as a combined fire alarm and fire hazard alarm. This application is characterised in that the measuring arrangement has two measuring cells, of which one is exposed to radiation of a wavelength at which the aerosol or a combustible gas to be detected is absorbent, and of which the other is exposed to radiation of a wavelength at which a combustible or explosive substance to be detected is absorbent and an opto-acoustic effect is produced as a result.

The invention is explained in further detail below with the aid of exemplary embodiments and the drawings, in which:

Fig. 1 shows a schematic representation of a resonant, opto-acoustic dual sensor, open at one end for smoke and gas;

Fig. 2 shows a schematic representation of a resonant, opto-acoustic dual sensor, open at both ends for smoke and gas; and

Fig. 3 shows a development of the dual sensor of Fig. 2.

The opto-acoustic measuring arrangement illustrated in Fig. 1 is a resonant, dual sensor, open at one end, with a tubular measuring cell 1 and a tubular reference cell 2 to each of which a microphone 3 and 4, respectively, is assigned. Furthermore, a radiation source 5, for example an LED, is provided, which exposes the inner space of the measuring cell 1 with radiation of a specific wavelength. In addition to the radiation source 5, a first photocell 6 is disposed for monitoring the intensity of the radiation emitted by the radiation source 5. The outputs of the two microphones 3 and 4 are fed to a differential amplifier 7 in which the microphone signals are subtracted from each other. The output signal of the differential amplifier 7 is fed to a phase-sensitive rectifier (lock-in) 8.

Tubes open at one end, with a length l have a resonant frequency v_k, which is given by

$$\upsilon k = \frac{2k+1}{4l} c ,$$

(k = 0,1,2,3,...; c = velocity of sound in air)

With a length l of 2 cm, this gives a resonant frequency v_0

= 4.1 kHz; with a tube open at both ends this resonant frequency is doubled. Standing waves therefore occur in the tube, wherein in the case of the tube open at one end, a pressure antinode (= motion node) occurs at the closed end and a pressure node (= motion antinode) occurs at the open end. In the tube open at both ends, the pressure antinode is located at the centre of the tube and a motion antinode at each open end.

The radiation source 5 emits modulated radiation into the measuring cell 1, the modulation frequency of the radiation source 5 coinciding with the resonant frequency of the measuring cell. If the measuring cell 1 contains an aerosol, then this absorbs the modulated radiation, thereby producing modulated heat. The modulated heat produces modulated pressure and thus sound at the frequency of the resonant frequency of the measuring cell 1, as a result of which the air column in the measuring cell is excited into oscillation. The same applies in the presence of a gas in the measuring cell 1. The microphone 3, which is located at the position of a pressure antinode of the standing wave, measures the oscillations (= sound) in the tube. As soon as the microphone 3 measures a sound which coincides with the resonant frequency of the measuring cell 1, there is an aerosol and/or a gas in the measuring cell 1.

In contrast to a scattered-light smoke alarm, the illustrated measuring arrangement responds equally well to dark and light aerosols: dark aerosols produce a large signal because when the radiation of the radiation source 5 initially strikes a particle much radiation power is absorbed. And light aerosols likewise produce a large signal, since the radiation at the light particles is reflected many times and in total is absorbed to a great extent. Moreover, the opto-acoustic sensor responds both to large aerosols and to very small ones below the µ range, since the opto-acoustic signals are generated by absorption and not by scattering.

The microphone 3 measures not only the resonant oscillations in the measuring cell 1, but also all noises in the room, which can lead to interference. This interference is eliminated by the reference cell 2 and the microphone 4. Since the reference cell 2 is not exposed to the radiation of a radiation source, the microphone 4 also cannot measure any oscillations produced by a radiation source, but exclusively measures the noise in the room. The signals of the reference microphone 4 are subtracted in the differential amplifier 8 from the signals of the measuring microphone 3, thus eliminating the room noise. Vibrations, which have an equal effect on both microphones, are likewise eliminated. The two cells, measuring cell and reference cell, can also be open at both ends.

Such an arrangement with a measuring cell 9, open at both ends, a reference cell 10, open at both ends, a measuring microphone 11 and a reference microphone 12, is illustrated in Fig. 2. A second photocell 13, which is disposed in the region between the radiation source 5 and the measuring cell 1, is also shown in Fig. 2. The position of the second photocell 13 is chosen so that in the presence of particles in the area between radiation source 5 and measuring cell 1, a portion of the scattered light of the radiation of the radiation source 5 produced by these particles falls on the photocell 13. The second photocell 13 enables a distinction to be made between aerosol and gas. If both the measuring cell 1 and the second photocell 13 deliver a signal, then an aerosol is present. If only the measuring cell 1 delivers a signal, then either a gas or a very small and therefore non-scattering aerosol is present.

If the suppression of room noise and vibrations can be dispensed with, in principle a measuring arrangement without reference cell 2 and the microphone 4 assigned to the former could be adequate. If in such an arrangement the wavelength of the radiation source 5 is placed on the CO_2 line, then the measuring arrangement will measure very sensitively the concentration of the combustion gas CO_2 on the one hand and the concentration of aerosol on the other.

The measuring arrangement illustrated in Figs. 1 and 2 can be designed as a gas alarm, smoke (aerosol) alarm, as a combined gas and smoke alarm and it can be used in these various forms as a fire alarm or as a fire hazard alarm. A fire alarm detects smoke and/or combustion gases, or generally, substances which characterise a fire. A fire hazard alarm detects, on the one hand, an existing fire by detecting an aerosol or substances occurring in a fire. On the other hand it detects toxic substances occurring in a fire and it recognises the danger of a possible fire or a possible explosion by detecting the presence of combustible substance in the air.

Substances which characterise a fire are, in particular, the following: CO_2, CO, NO, NO_2, SO_2, NH_3, HCl, HF, HCN, amine and amide, compounds containing hydrocarbons, C, O and H; aerosols. Combustible substances are generally hydrocarbons, particularly CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_2H_2, C_2H_4, as well as general solvents, alcohol, ether, ketone, aldehyde, amine and amide, in particular methanol, ethanol, n-propanol, diethylether, acetone. Other combustible substances which a fire hazard alarm should detect are compounds containing C, O and H, and carboxylic acids. Toxic substance are CO_2, CO, NO, NO_2, SO_2, NH_3, HCl, HF, HCN, H_2S, nitriles, phosphoric ester, mercaptans, halogenated compounds.

Since the velocity of sound in air is temperature-dependent and can vary by up to 30% in the temperature range of a fire alarm from -20°C to +70°C, the resonant frequency can also change accordingly. Water vapour also influences the velocity of sound and thus the resonant frequency. In order to eliminate these influences, the rough range of the resonant frequency and the possible additional expansion of the frequency range by varying water vapour content in the air, can be calculated with a temperature measurement and the modulation frequency of the radiation source varied (swept) in this range.

A further possible disturbance consists in frequencies in the room, which coincide with the resonant frequency. Such frequencies excite both cells into oscillation, but cannot be completely subtracted to zero by the differential circuit, because, due to the distance from the centre of the measuring cell 1, 9 to the centre of the reference cell 2, 10, they strike the cells with a time shift and excite these cells into oscillation which has a small phase shift. This phase shift can be minimised by a lowest possible resonant frequency, because the interfering audio frequencies then have a large acoustic wavelength and the phase shift becomes small. Or, the signal of the reference cell 2, 10 can be measured separately and when a signal, which in fact can be generated only from outside, impinges upon the reference cell, the alarm threshold of the measuring arrangement can be increased.

Further potential disturbance variables are different lengths of the cells. These disturbance variables can be eliminated by measuring the resonant frequency of one of the two cells and mechanically varying the length of the other cell accordingly. The resonant frequency of the reference cell can also be measured and the radiation source 5 positioned so that its position influences the resonant frequency of the measuring cell and brings it into coincidence with the reference cell.

As a further check, monitoring of the microphone sensitivity by means of the zero signals produced by the radiation source in the wall of the measuring cell 1, 9, which occur under all environmental conditions, is recommended.

The arrangement illustrated in Figs. 1 and 2 for the measurement/detection of smoke and one gas can be expanded by an additional pair of cells for the measurement/detection of a further gas. According to Fig. 3, an additional measuring cell 14, an additional reference cell 15 and an additional radiation source 16 are provided, where the measuring cell 9 measures aerosol and a first gas and the measuring cell 14 measures a second gas, for example. The two measuring cells 9 and 14 and, correspondingly, also the two reference cells 10 and 15 have different lengths and therefore also different resonant frequencies, and the two measuring cells are exposed to radiation from the radiation sources 5 and 16, respectively, at different wavelengths. The two different resonant frequencies can be measured with just one measuring microphone 11. Likewise, only one reference microphone 12 and only one single photocell 6 are required for monitoring the emission of both radiation sources 5 and 16.

The measuring cells and reference cells can have the following dimensions, for example:
Measuring cell 9, reference cell 10: length each 2 cm, resonant frequency each 8.2 kHz
Measuring cell 14, reference cell 15:length each 2.2 cm, resonant frequency each 7.6 kHz

Accordingly, the modulation frequency of the radiation source 5 is 8.2 kHz and that of the radiation source 16 is 7.6 kHz. LEDs are used as radiation sources.

The additional outlay for the detection of a second gas is thus only the costs of the second cell pair and for the second radiation source. It is quite obvious that an extension for the detection of a third gas requires only a further cell pair and a further radiation source.

Instead of two pairs of measuring and reference cells (9, 10; 14, 15), of different length, which are simultaneously irradiated by two radiation sources 5 and 16, in the arrangement of Fig. 2 the measuring cell 9 of one cell pair can be simultaneously irradiated by two radiation sources 5 and 16 and these can be operated at difference frequencies; for example, the radiation source 5 at the fundamental frequency and the radiation source 16 at the first harmonic. Consequently, compared to the arrangement of Fig. 3, only half the number of cells and microphones are needed and corresponding costs are saved.

Apart from the resonant opto-acoustic dual sensors, open at one end or both ends, non-resonant, closed dual sensors are also known (see for example EP-A-0 855 592), which can likewise be constructed so that the detection of aerosols and gases is possible with them. As can be seen in EP-A-0 855 592, these opto-acoustic dual sensors contain a measuring cell and a reference cell, each of which is sealed against the environment by a diaphragm, and a radiation source. Gas can permeate the cell through the diaphragm. A measuring microphone and a reference microphone are provided, the reference microphone being screened against opto-acoustic signals of the gas/aerosol to be detected. So that aerosol particles can permeate the cells, the pore size of the diaphragms is increased accordingly.

But as a result, the diaphragms for frequencies below 500 Hz are acoustically soft, pressure build-up in the cell is no longer possible and the sensitivity is seriously reduced. By increasing the modulation frequency to a few kilohertz, the diaphragms again become acoustically hard and the sensitivity no longer decreases. Any jamming of the diaphragms can be monitored by measuring the reference signal separately, which gives a base noise level, and the sensitivity corrected with the aid of this base level. If the wavelength of the radiation sources is positioned on the CO_2 line, for example, then the measuring arrangement will measure very sensitively the concentration of the CO_2 combustion gas. On the other hand, however, the concentration of aerosol is very sensitively measured because cellulose and carbonised cellulose particles are strongly absorbent in the entire infrared range. The volume per cell is approximately 2 times 2 times 2 cm^3.

It is to be understood that the prior art publications referred to herein, do not constitute an admission that that the publication forms a part of the common general knowledge in the art, in Australia or in any other country.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Opto-acoustic measuring arrangement for the detection of gases and/or aerosols, having a measuring cell and a reference cell , respectively, and microphones assigned to these cells, to which microphones an electronic evaluation circuit is connected, in which a subtraction of the signals of the microphones takes place, and having a radiation source for applying a modulated signal to the measuring cell , wherein the modulation frequency of the radiation source coincides with the resonant frequency of the measuring cell , characterised in that the measuring cell and the reference cell are open at at least one end to the gas and/or aerosol to be detected.

2. Measuring arrangement according to Claim 1, characterised in that the electronic evaluation circuit contains a differential amplifier and a phase-sensitive rectifier.

3. Measuring arrangement according to Claim 1 or 2, characterised in that the wavelength of radiation emitted by the radiation source is chosen so that it is absorbed by a gas to be detected.

4. Measuring arrangement according to Claim 3, characterised in that a first photocell for monitoring the intensity of the radiation emitted by the radiation source is disposed in the region of the radiation source.

5. Measuring arrangement according to Claim 3, characterised in that in addition to the measuring cell a second photocell is disposed, which, in the presence of an aerosol, is exposed to the scattered radiation of the radiation source caused by this aerosol.

6. Measuring arrangement according to one of Claims 1 to 5, characterised in that the measuring cell is exposed to two radiation sources , which are operated at different frequencies.

7. Measuring arrangement according to Claim 6, characterised in that one of the radiation sources is operated at the fundamental frequency and the other is operated at the first harmonic.

8. Measuring arrangement according to Claim 4 or 5, characterised in that two pairs of measuring cells and reference cells , open at both ends, are provided, each of which has a different length and thus different resonant frequencies, that a microphone is assigned to each reference cell and to each measuring cell pair , and that each measuring cell is exposed to a radiation source .

9. Measuring arrangement according to one of Claims 1 to 8, characterised in that a sensor for measuring the ambient temperature is provided, and that an adjustment of the modulation frequency of the radiation source to a frequency range corresponding to the measured ambient temperature, and a time-shift of the modulation frequency within this frequency range, takes place.

10. Application of the measuring arrangement according to one of Claims 1 to 9 as a smoke alarm, characterised in that the measuring arrangement has a measuring cell , which is exposed to a radiation of a wavelength at which the aerosol to be detected is absorbent, and an opto-acoustic effect is produced as a result.

11. Application of the measuring arrangement according to one of Claims 1 to 9 as a fire hazard alarm, characterised in that the measuring arrangement has a measuring cell , which is exposed to a radiation of a wavelength at which a combustible or explosive substance to be detected is absorbent and an opto-acoustic effect is produced as a result.

12. Application according to Claim 11, characterised in that the combustible or explosive substance to be detected is formed by one or more of the following substance: hydrocarbons, particularly CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_2H_2, C_2H_4, as well as general solvents, alcohol, ether, ketone, aldehyde, amine and amide, in particular methanol, ethanol, n-propanol, diethylether, acetone, compounds containing C, O and H, and carboxylic acids.

13. Application according to Claim 11, characterised in that the measuring arrangement has a measuring cell , which is exposed to a radiation of a wavelength at which a toxic substance to be detected is absorbent and an opto-acoustic effect is produced as a result.

14. Application according to Claim 13, characterised in that the toxic substance to be detected is formed by one or more of the following substances: CO_2, CO, NO, NO_2,

SO_2, NH_3, HCl, HF, HCN, H_2S, nitriles, phosphoric ester, mercaptan, halogenated compounds.

15. Application of the measuring arrangement according to one of Claims 1 to 9, as a combined smoke and gas alarm, characterised in that the measuring arrangement has a measuring cell , which is exposed to a radiation of a wavelength at which a combustible or explosive substance to be detected is absorbent and an opto-acoustic effect is produced as a result, and that in addition to the measuring cell , a photocell is disposed so that it is exposed to scattered light of the radiation, caused by an aerosol.

Dated this 1st day of October 2003
SIEMENS BUILDING TECHNOLOGIES AG
By their Patent Attorneys
GRIFFITH HACK
Fellows Institute of Patent and
Trade Mark Attorneys of Australia

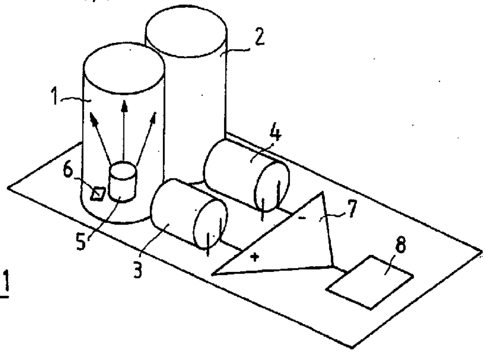


FIG. 1

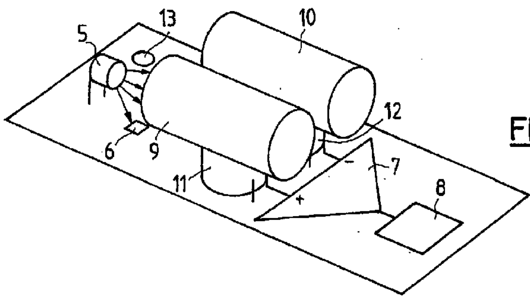


FIG. 2

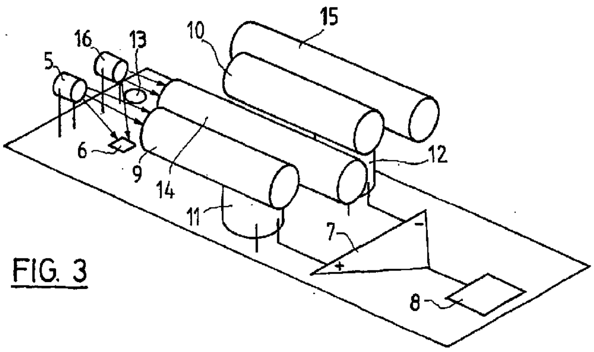


FIG. 3