



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**06.10.2021 Bulletin 2021/40**

(51) Int Cl.:  
**G01N 21/15** (2006.01) **G01N 21/53** (2006.01)  
**G08B 17/10** (2006.01)

(21) Application number: **20382246.5**

(22) Date of filing: **30.03.2020**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

(72) Inventors:  
• **CORDOBA GALERA, Andrés**  
**Barcelona 08950 (ES)**  
• **RODRIGUEZ MOLPECERES, Sergio**  
**Barcelona 08950 (ES)**

(74) Representative: **Dehns**  
**St. Bride's House**  
**10 Salisbury Square**  
**London EC4Y 8JD (GB)**

(71) Applicant: **Carrier Corporation**  
**Palm Beach Gardens, FL 33418 (US)**

(54) **CLEANING SYSTEM FOR A SMOKE DETECTOR**

(57) An optical smoke detector 1 comprises an ultrasonic transducer 4 configured to cause oscillations in its housing 2 so as to dislodge accumulated particulate matter from the walls of a sensor chamber or a labyrinth of the smoke detector 1. Additionally or alternatively, the

ultrasonic transducer 4 may be configured to cause oscillations that dislodge accumulated particulate matter from a light source or a light receiver of the smoke detector 1.

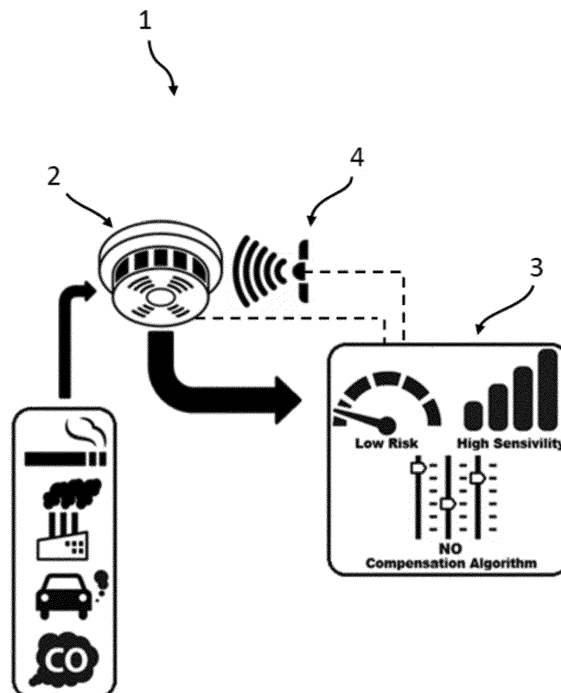


Fig. 1

## Description

**[0001]** The present disclosure relates to a cleaning system for a smoke detector, and particularly to a self-cleaning system for an optical smoke detector.

**[0002]** Optical smoke detectors (also known as photo-electric smoke detectors) commonly work using a light-scattering principle. The smoke detector contains a light source that emits a pulsed, infra-red light beam into a sensor chamber. A light detector is arranged so that it can detect light from the sensor chamber, but will not receive light directly from the light source. When smoke is present within the chamber, the beam is scattered by the smoke particles and the light detector can determine the quantity of smoke present within the sensor chamber.

**[0003]** An optical labyrinth connects the sensing chamber to an external environment such that ambient light cannot reach the sensor chamber, but air (and any smoke carried by the air) can enter the sensor chamber.

**[0004]** Typically, the internal walls of the sensor chamber will be black, so as to prevent light from the emitter being reflected by the walls to the detector. However, various contaminants in the air, such as dust, soot from combustion engines, and other pollutants will accumulate on the walls over time. These increase the amount of light reflected by the walls. Accumulated contaminants on the surfaces of the light source or detector can also decrease the amount of light transmitted or detected by these components.

**[0005]** Most optical smoke detectors are configured to compensate for this type of fouling using compensation software that automatically adjusts a sensitivity or other properties of the smoke detector. However, eventually, the smoke detector will reach a saturation limit requiring either replacement or manual disassembly and cleaning of the smoke detector.

**[0006]** A need therefore exists for an improved optical smoke detector.

**[0007]** Viewed from a first aspect, the present disclosure provides an optical smoke detector comprising an ultrasonic transducer configured to cause oscillations to dislodge accumulated particulate matter from at least one component of the smoke detector.

**[0008]** The smoke detector may comprise a housing, and walls of the housing may define a sensor chamber and a labyrinth. The ultrasonic transducer is preferably configured to cause oscillations in the walls of the housing. Thus, the ultrasonic transducer may dislodge accumulated particulate matter from one or more wall at least partially defining the sensor chamber or the labyrinth. By generating oscillations in the housing, particulate fouling accumulated on the walls of the sensor chamber and/or the walls of the labyrinth can be dislodged and carried out of the smoke detector in the air. By reducing accumulated fouling, reflected light within the sensor chamber can be reduced.

**[0009]** The smoke detector may be configured to periodically activate the ultrasonic transducer. That is to

say, the ultrasonic transducer may be automatically activated in response to expiry of a predetermined period of time since the last activation. Alternatively, or additionally, the smoke detector may be configured to activate the ultrasonic transducer in response to a detected or estimated degree of fouling exceeding a threshold value. The smoke detector may be configured to estimate a degree of fouling based on a level of light detected by the light detector when the sensor chamber does not contain smoke. This may be determined, for example, based on the levels of light detected by the light detector over a period of time.

**[0010]** The smoke detector preferably comprises a light source and a light detector. In one embodiment, the ultrasonic transducer may be configured to dislodge accumulated particulate matter from the light source and/or the light detector. For example, the ultrasonic transducer may be configured to directly cause oscillation of the light source and/or the light detector. Alternatively the ultrasonic transducer may be configured to cause oscillation of a housing, wherein the light source and/or the light detector is connected to the housing.

**[0011]** Preferably, the light source and light detector are configured such that the light source does not directly illuminate the light detector. For example, the housing may define a wall between the light source and the light detector. The light source is preferably configured to illuminate a gas within the sensor chamber. The light detector is preferably configured to detect scattered light from the sensor chamber, and particularly light from the light source that has been scattered by smoke within the sensor chamber.

**[0012]** The light source is preferably a light-emitting diode. The light source may be configured to emit infra-red, visible or ultraviolet light. Infra-red light is today the most commonly used, and the light source is preferably configured to emit infra-red light. The light source is preferably configured to emit pulsed light.

**[0013]** The light detector is preferably a photodiode receptor. The light detector is preferably configured to detect at least a frequency of light emitted by the light source.

**[0014]** The sensor chamber is preferably fluidly connected to an ambient environment outside of the smoke detector by the labyrinth. The labyrinth is preferably configured to permit flow of air into the sensor chamber. The labyrinth is preferably configured to block direct transmission of light from the ambient environment to the light detector and/or to the sensor chamber.

**[0015]** Viewed from a second aspect, the present disclosure provides a method of cleaning an optical smoke detector comprising generating oscillations using ultrasonic vibrations to dislodge accumulated particulate matter from at least one component of the smoke detector.

**[0016]** In one embodiment, the component may be at least one wall of a housing to the smoke detector that preferably defines part of a sensor chamber or a labyrinth of the smoke detector.

**[0017]** In another embodiment, the component may be a light source and/or a light detector of the smoke detector.

**[0018]** The method may comprise generating the oscillations periodically. Alternatively, or additionally, the method may comprise generating the oscillations in response to a detected or estimated degree of fouling exceeding a threshold value. The method may comprise estimating a degree of fouling based on a level of light detected by the light detector when the sensor chamber does not contain smoke.

**[0019]** The smoke detector may be a smoke detector as described above.

**[0020]** A preferred embodiment of the present disclosure will now be described in greater detail, by way of example only and with reference to the sole figure, which shows a smoke detector capable of performing automatic self-cleaning.

**[0021]** An optical smoke detector 1 is shown in Figure 1.

**[0022]** The smoke detector 1 comprises a housing 2 that defines a sensor chamber and a labyrinth. The housing 2 in this embodiment is formed from a plastic material in two parts that can be disassembled from one another. The labyrinth fluidly connects the sensor chamber to an ambient environment surrounding the smoke detector 1, so as to permit air to move freely between the sensor chamber and the ambient environment. However, the labyrinth is configured to prevent light from the external environment from entering the sensor chamber, i.e. such that there is no unimpeded straight-line path between the ambient environment and the sensor chamber.

**[0023]** The smoke detector 1 further comprises a controller 3, a light source and a light detector. The controller 3 may be an integrated within the housing 2, or may be external to the housing, for example as part of a centralised controller. The light source in this embodiment comprises an LED and is configured to emit light in the infrared spectrum (wavelengths of 700nm to 1mm). The light detector in this embodiment comprises a photodiode receptor sensitive to at least the light emitted by the light source.

**[0024]** The light source is configured to emit a beam of light into the sensor chamber, and the light detector is configured to detect light from the beam of light scattered within the sensor chamber. However, the light source and light detector are configured such that light from the light source cannot directly hit the light detector. For example, the housing 2 may comprise a wall between the light source and the light detector that blocks direct transmission of light between the light source and the light detector.

**[0025]** The internal walls of the sensor chamber are either formed from or coated with a black material, so as to minimise reflection of light by the walls from the emitter to the detector.

**[0026]** The controller 3 is configured to cause the light source to emit a pulsed, light beam into the sensor cham-

ber and to detect how much light is received by the light detector. When no smoke is present within the sensor chamber, the light beam is absorbed by the black material. When smoke is present within the chamber, the beam is scattered by the smoke particles. The degree of scattering is proportional to the quantity of smoke within the sensor chamber. Thus, the controller 3 can measure the quantity of smoke present within the sensor chamber.

**[0027]** Over time, various contaminants in the air, such as dust, soot from combustion engines, and other pollutants will accumulate on the walls of the labyrinth and the sensor chamber. These increase the amount of light reflected by the walls, which means that external light may reflect into the chamber via the walls of the labyrinth or that light from the light source may reflect off of the walls of the sensor chamber. Thus light may be detected by the light detector, even when no smoke is present within the sensor chamber.

**[0028]** The controller 3 of the smoke detector 1 comprises a compensation algorithm that automatically compensates for this type of fouling. The compensation algorithm may monitor base levels of light over an extended period of time, and determine a degree of fouling based on this level. The compensation algorithm may alter a sensitivity of the smoke detector 1 based on the degree of fouling.

**[0029]** The smoke detector 1 is further provided with an ultrasonic transducer 4. The ultrasonic transducer is configured to cause oscillations in the housing 2, and particularly in the walls of the sensor chamber and/or the labyrinth. The purpose of these oscillations is to dislodge accumulated particles fouling these walls.

**[0030]** The ultrasonic transducer 4 is activated by the controller 3 of the smoke detector 1. It may be actuated periodically. For example, the transducer 4 may be activated monthly, weekly, daily, or based upon any other periodic cycle. Alternatively, or additionally, it may be actuated based on an estimated or detected degree of fouling, such as determined by the compensation algorithm.

**[0031]** By automatically cleaning the smoke detector 1, manual maintenance can be reduced as the smoke detector 1 can remove a degree of fouling automatically. Indeed, in some embodiments, the compensation algorithm may no longer be required and thus may be omitted. By using ultrasonic vibrations, the cleaning of the smoke detector 1 will not disturb nearby people.

**[0032]** Whilst it is primarily envisaged that the ultrasonic transducer 4 will be used to dislodge accumulated particulate matter from the walls of the housing 2, in other embodiments the ultrasonic transducer 4 may be used to dislodge accumulated particulate matter from any component within the smoke detector 1 that requires cleaning. For example, the ultrasonic transducer 4 may be configured to generate oscillations to dislodge accumulated particulate matter from the light sensor and/or the light detector.

**[0033]** Whilst the ultrasonic transducer 4 has been described within the context of an optical smoke detector 1

having a housing, the principles discussed herein may be applied to a chamberless optical smoke detector. Chamberless optical smoke detectors operate on the same light-scattering principle as the described smoke detector 1, but have no sensor chamber and instead include additional sensors to automatically compensate for the presence of ambient light. In the context of a chamberless optical smoke detector, the ultrasonic transducer 4 may be arranged to dislodge accumulated particulate matter from the light sensor and/or light emitter, which are particularly prone to fouling due to the absence of a housing.

**[0034]** Furthermore, whilst the ultrasonic transducer 4 has been described within the context of a light-scattering optical smoke detector 1, it may also be employed for cleaning other types of optical smoke detectors, such as an optical beam smoke detector, which operates based on a principle of light obscuration (either by absorption or scattering of the light). In yet further examples, ultrasonic transducers may be used as described above to clean other types of smoke detector.

#### Claims

1. An optical smoke detector comprising an ultrasonic transducer configured to cause oscillations to dislodge accumulated particulate matter from at least one component of the smoke detector. 30
2. An optical smoke detector according to claim 1, comprising a housing having walls that define a sensor chamber and a labyrinth, wherein the at least one component of the smoke detector includes one or more of the walls that at least partially defining the sensor chamber or the labyrinth. 35
3. An optical smoke detector according to any preceding claim, wherein the smoke detector is configured to periodically activate the ultrasonic transducer. 40
4. An optical smoke detector according to any preceding claim, wherein the smoke detector is configured to activate the ultrasonic transducer in response to a detected or estimated degree of fouling exceeding a threshold value. 45
5. An optical smoke detector according to claim 4, wherein the degree of fouling is estimated based on a level of light detected when the sensor chamber does not contain smoke. 50
6. An optical smoke detector according to any preceding claim, comprising a light source configured to illuminate a gas within the sensor chamber, and a light detector configured to detect light from the light source that has been scattered by smoke within the sensor chamber. 55
7. An optical smoke detector according to claim 6, wherein the light source is a light-emitting diode.
8. An optical smoke detector according to claim 6 or 7, wherein the at least one component includes one or both of the light source and the light detector. 5
9. A method of cleaning an optical smoke detector comprising generating oscillations using ultrasonic vibrations to dislodge accumulated particulate matter from at least one component of the smoke detector. 10
10. A method according to claim 9, wherein the at least one component includes at least one wall of a housing of the smoke detector that defines part of a sensor chamber or a labyrinth of the smoke detector. 15
11. A method according to claim 9 or 10, wherein the component includes one or both of a light source and a light detector of the smoke detector. 20
12. A method according to any of claims 9 to 11, comprising generating the oscillations periodically.
13. A method according to any of claims 9 to 12, comprising generating the oscillations in response to a detected or estimated degree of fouling exceeding a threshold value. 25

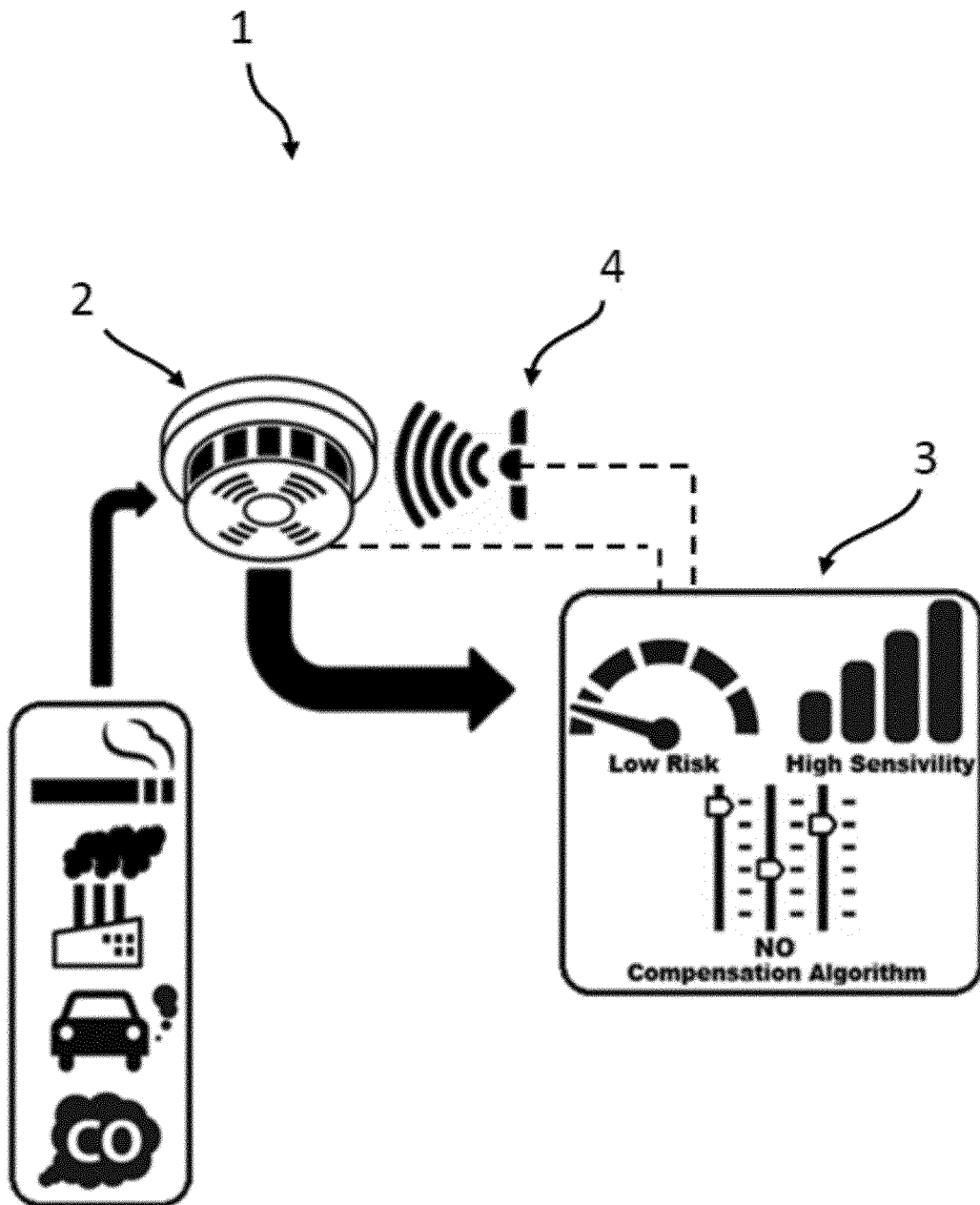


Fig. 1



## EUROPEAN SEARCH REPORT

Application Number  
EP 20 38 2246

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2007/097366 A1 (LEBOEUF STEVEN F [US] ET AL) 3 May 2007 (2007-05-03)	1,4-7,9,13	INV. G01N21/15
Y	* paragraphs [0002], [0023], [0025] - [0027] *	2,3,8,10-12	G01N21/53
Y	EP 1 777 670 A2 (IMOS GUBELA GMBH [DE]) 25 April 2007 (2007-04-25) * paragraphs [0004], [0008], [0010]; claim 11 *	1-13	ADD. G08B17/10
Y	GB 2 477 763 A (THORN SECURITY [GB]) 17 August 2011 (2011-08-17) * page 9, lines 2-3 * * page 11, line 33 - page 12, line 12 * * page 17, line 13 - page 18, line 13 * * page 22, lines 17-18 *	1-13	
Y	US 9 925 570 B2 (NEC LAB AMERICA INC [US]; NEC CORP [JP]) 27 March 2018 (2018-03-27) * abstract; figure 2 *	1-13	
Y	GB 2 281 619 A (HOCHIKI CO [JP]) 8 March 1995 (1995-03-08) * figures 1,2 *	2,10	TECHNICAL FIELDS SEARCHED (IPC) G01N G08B
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>5 August 2020</b>	Examiner <b>Meacher, David</b>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 38 2246

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-08-2020

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007097366 A1	03-05-2007	NONE	
EP 1777670 A2	25-04-2007	AT 421742 T DE 102005050451 A1 EP 1777670 A2	15-02-2009 03-05-2007 25-04-2007
GB 2477763 A	17-08-2011	EP 2534648 A1 GB 2477763 A US 2013031957 A1 WO 2011098773 A1	19-12-2012 17-08-2011 07-02-2013 18-08-2011
US 9925570 B2	27-03-2018	DE 112015005303 T5 JP 2017538934 A US 2016146721 A1 WO 2016085999 A1	07-09-2017 28-12-2017 26-05-2016 02-06-2016
GB 2281619 A	08-03-1995	CH 690940 A5 DE 4431889 A1 GB 2281619 A US 5587790 A	28-02-2001 06-04-1995 08-03-1995 24-12-1996