(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 404 633 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.11.2018 Bulletin 2018/47

(51) Int Cl.:
G08B 29/16 *(2006.01)* ***G08B 17/10*** *(2006.01)*
G08B 19/00 *(2006.01)*

(21) Application number: **18172793.4**

(22) Date of filing: **17.05.2018**

(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

(30) Priority: **17.05.2017 IT 201700053602**

(71) Applicant: **Pruneri, Marco**
39044 Egna (Bolzano) (IT)

(72) Inventor: **Pruneri, Marco**
39044 Egna (Bolzano) (IT)

(74) Representative: **Forattini, Amelia**
INTERNAZIONALE BREVETTI
INGG. ZINI, MARANESI & C. S.R.L.
Piazza Castello 1
20121 MILANO (IT)

(54) APPARATUS FOR MONITORING ATMOSPHERIC CHARACTERISTICS AND DETECTING FIRES

(57) An apparatus for monitoring atmospheric characteristics and detecting fires, including an electronic unit provided with a means for detecting the presence of smoke in an environment to be protected, a means for detecting the quantity of carbon monoxide, and a means for detecting the temperature. The particularity of the apparatus resides in that the electronic unit furthermore includes a partial or complete combination of means for detecting the quantity of oxygen, means for detecting the relative humidity, means for detecting the differential pressure, means for detecting the carbon dioxide and means for detecting the quantity of volatile organic compounds (VOCs) present in the environment; the electronic unit, with all the related detection means, is operatively connectable to a remote central control unit and can be supplied by means of a power source.

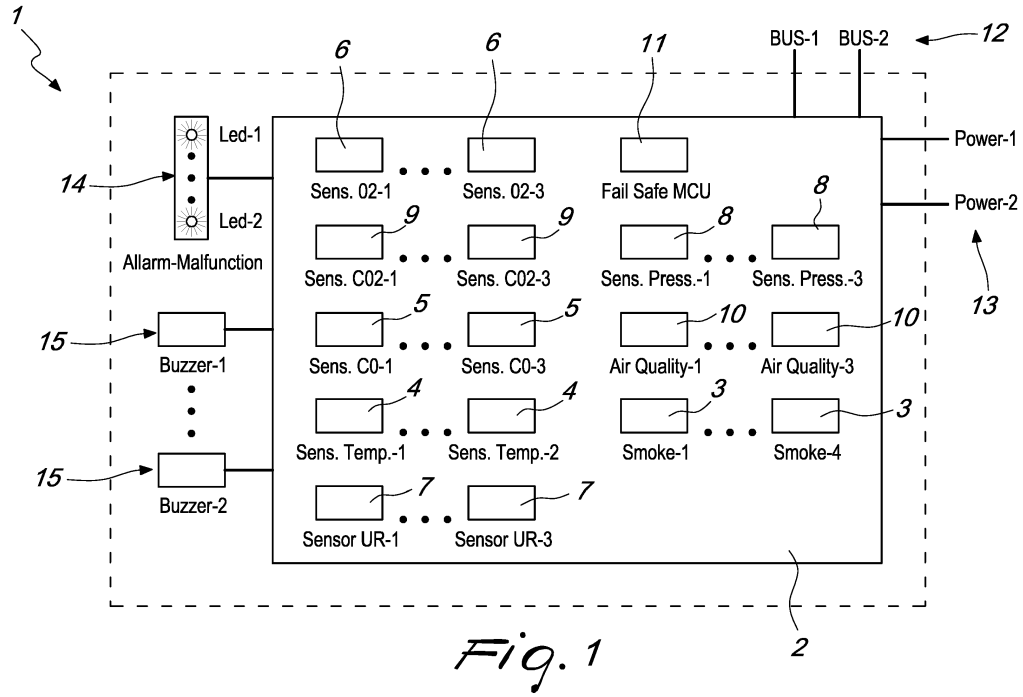

Fig. 1

EP 3 404 633 A1

Description

[0001] The present invention relates to an apparatus for monitoring atmospheric characteristics and for the simultaneous detection of fires.

[0002] Currently, in the field of fire prevention, the state of the art of smoke sensors is represented by so-called "multiple spot sensors", i.e., apparatuses that have a combination of some or all of a smoke sensor, a carbon monoxide sensor and a temperature sensor.

[0003] Those multiple spot sensors have the advantage of a better detection because of the combined assessment of any presence of smoke, of the temperature variation and, in some cases (fire from materials which also generate carbon monoxide), also the variation of the level of carbon monoxide in the atmosphere proximate to the fire.

[0004] The combined analysis of these values in fact is able to better discriminate false alarms, for example caused by the lighting of a cigarette and/or a cigar, and to identify earlier the outbreak of a fire.

[0005] It is also known that a new sector of fire prevention, based on the creation of hypo-oxygenated normobaric environments, exists and is becoming increasingly important. In said environments the risk of fire is completely eliminated simply by lowering the level of oxygen below the ignition threshold of the material to be protected.

[0006] Currently, international European standards (Austrian ONORM and British BAS), as well as the state of the art, provide for the installation of oxygen sensors and smoke sensors for controlling said environments. Said sensors are distributed appropriately inside the environment to be monitored, so as to be able to monitor and control both the conditions of the environment to be preserved safely, i.e., the level of the oxygen that must be kept below the ignition level of the material to be preserved in the room, and the "failure" condition of the protection system.

[0007] A failure of the oxygen control system might in fact lead to the need to temporarily place out of service the oxygen reduction system, consequently eliminating its protective prevention effect; obviously, in this case any outbreak of fire, which in this situation of temporary halting of the active protection system potentially might occur, must be detectable by means of the smoke sensors.

[0008] The systems briefly described above, despite being increasingly widespread in the field of fire prevention, are not free from drawbacks, which include the fact that the oxygen sensors and the smoke sensors are not integrated within the same apparatus and therefore require separate installation and maintenance.

[0009] Moreover, those sensors do not talk to each other and do not work is synergy.

[0010] It should also be noted that the apparatuses used in fire prevention systems of the known type do not consider the quality of the air inside the protected rooms or other atmospheric parameters such as, for example, relative humidity and/or carbon dioxide, which are instead important atmospheric parameters within sealed environments in which humans stay and which in any case can, upon detection, contribute to improve the quality of the detection of an outbreak of a fire.

[0011] One should consider, moreover, that no commercially available fire prevention apparatus, despite being related to safety systems, uses functional security logic criteria, which would ensure its correct operation even in the presence of failures of the individual sensors.

[0012] Commercially available apparatuses and sensors, despite being safety devices, in fact are not redundant, which poses the serious problem that if a sensor or a measurement apparatus arranged inside a room fail, they are no longer capable of detecting and providing information on the state of safety of the monitored point/region and the room being controlled, in order to assess its own state of safety, must temporarily (until the sensor is replaced and/or repaired) rely only on the information that arrives from the other sensors, which however are far from the region being considered.

[0013] It goes without saying that this might be a severe problem, since in case of a catastrophic event the inertia of the system in detecting the event would be increased considerably, with a corresponding increase in damage.

[0014] Regarding the various types of sensor used, and in particular oxygen sensors, it is noted that the state of the art is currently represented by zirconium oxide sensors or sensors of the electrochemical type.

[0015] Zirconium oxide sensors are not particularly suitable to work in low-temperature environments, such as subzero storage areas, their electrical consumption is remarkable and they reach high temperatures during their operation, consequently requiring the use of mechanical solutions, insulations and particular distances from the rest of the sensors and of the control electronics to avoid influencing the behavior of parts of the system. Electrochemical sensors considerably drift over time, which forces frequent calibration of the measurement systems that use them, and have a relatively short life (2-5 years), which requires their replacement once they are depleted.

[0016] Also electrochemical sensors cannot be used in low-temperature environments, unless they are provided with thermostat-controlled heating elements.

[0017] US5486811 discloses an early fire detection and extinguishment system having a plurality of fire detection units, each associated with a localized portion of a protected space and including condition sensors specifically appropriate to the environment of that localized portion of a protected space by a selected combination of condition sensors. A fire alarm annunciator and a controlled fire extinguishment system portion, or a standalone fire extinguishment system, is provided for each fire detection unit. A central control unit includes a profile detector which evaluates outputs of one or more condition sensors over time to reduce false alarm rates while

increasing sensitivity to early stage fires. US5486811 does not address the problem of the air quality inside the protected rooms, in which humans stay and which contributes to improve the quality of the detection of a fire outbreak.

[0018] WO2009024774 discloses a gas sensor and a method of operating the gas sensor with reduced energy requirements.

[0019] The aim of the invention is therefore to solve the problems described above, providing an apparatus for monitoring atmospheric characteristics and for detecting fires that performs a complete analysis of the atmosphere of an environment to be preserved in safety.

[0020] Within the scope of this aim, a particular object of the invention is to provide an apparatus that is capable not only of detecting the oxygen level inside an environment but also allows better and more effective management/detection of the fire outbreaks with respect to the current state of the art, together with the management of the quality of the air inside these protected confined spaces.

[0021] Another object of the invention is to provide an apparatus wherein it is possible to choose the number and type of sensors to be installed.

[0022] Another object of the present invention is to provide oxygen sensors which are innovative with respect to the state of the art and are not affected by the problems mentioned above with respect to zirconium oxide and electrochemical sensors.

[0023] Another object of the invention is to provide an apparatus that is capable of implementing functional safety logic criteria, which allow the apparatus to ensure usability of the information and safety even in case of a partial failure of the apparatus.

[0024] Another object of the invention is to provide an apparatus that can have a "spot" or "suction" use.

[0025] This aim, these objects and others which will become better apparent hereinafter are achieved by an apparatus for monitoring atmospheric characteristics and detecting fires, including an electronic unit provided with a means for detecting the presence of smoke in an environment to be protected, a means for detecting the quantity of carbon monoxide present in the environment, and a means for detecting the temperature present in the environment; the apparatus being characterized in that the electronic unit furthermore includes a partial or complete combination of means for detecting the quantity of oxygen present in the environment, means for detecting the relative humidity present in the environment, means for detecting the differential pressure present in the environment, means for detecting the carbon dioxide present in the environment and means for detecting the quantity of volatile organic compounds present in the environment; the electronic unit being operatively connectable to a remote central control unit and being able to be supplied by means of a power source.

[0026] Further characteristics and advantages will become better apparent from the description of preferred but not exclusive embodiments of an apparatus according to the invention, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a schematic view of an apparatus according to the invention;

Figure 2 is schematic view of a further embodiment of the apparatus according to the invention.

[0027] With reference to the above figures, an apparatus for monitoring atmospheric characteristics and detecting fires is designated generally by the reference numeral 1.

[0028] The apparatus 1 has an electronic unit 2, which can consist for example of one or more printed circuit boards, having one or more, preferably one to four, smoke sensors 3, one or more, preferably one to three, temperature sensors 4 and one or more, preferably one to three, carbon monoxide sensors 5.

[0029] According to the present invention, the electronic unit 2 also comprises a partial or complete combination of one or more, preferably one to three, oxygen sensors 6, one or more, preferably one to three, relative humidity sensors 7, one or more, preferably one to three, differential pressures sensors 8, one or more, preferably one to three, carbon dioxide sensors 9, and one or more, preferably one to three, VOC sensors 10, which allow to monitor the quality of the air of the environment to be protected, detecting and measuring the percentage in the air of volatile organic compounds (VOCs).

[0030] The expression "partial or complete combination" in the present description and in the claims is meant to indicate that the apparatus 1 is designed so as to have a modular architecture, which allows to choose the number and type of sensors to be mounted on the electronic unit 2 that supports them.

[0031] It is pointed out that according to an innovative aspect of the present invention, the oxygen sensors 6 used in the apparatus 1 are preferably of the optical type.

[0032] This ensures in practice a reduction of the drift of the detected signal, a faster response time and at the same time ensures maximum accuracy of the measurements made.

[0033] It should also be considered that oxygen sensors 6 of the optical type have a very long life, which can be compared to that of zirconium oxide sensors, and do not require maintenance interventions.

[0034] According to a further aspect of the invention, the apparatus 1 also comprises an electronic control means 11 integrated in the electronic unit 2.

[0035] The electronic control means 11 can be constituted for example by a microcontroller or by a safety microprocessor, preferably compliant with the IEC 61508 and/or ISO 26262 standards for functional safety of electrical and electronic systems.

[0036] From an operating point of view, the electronic control means 11 processes the information, which is generally in the form of analog or digital electrical signals,

provided by the smoke sensors 3, by the temperature sensors 4, by the carbon monoxide sensors 5, and by the oxygen sensors 6, by the relative humidity sensors 7, by the differential pressure sensors 8, by the carbon dioxide sensors 9 and by the VOC sensors 10 that are optionally installed in the electronic unit 2.

[0037] The physical values converted by the respective sensors and processed by the electronic control means 11 are then sent, by means of an appropriate communication means 12 which is constituted preferably by two independent data transmission buses, to a central processing unit, which is not shown in the figures.

[0038] Advantageously, the electronic control means 11 is configured so as to increase the functional safety of the apparatus 1 in relation to the measurement and analysis of the various physical values detected by the multiple sensors that are present in the electronic unit 2.

[0039] The apparatus 1 has a plurality of substantially mutually equivalent sensors that measure a specific atmospheric parameter (quantity of oxygen, presence of smoke, quantity of carbon monoxide, temperature, relative humidity, differential pressure, quantity of carbon dioxide, air quality), therefore the electronic control means 11 acquires, in each instance, all the values related to a specific atmospheric parameter detected by the sensors of the same type (for example, carbon dioxide quantity) and then compares them with each other.

[0040] Following the comparison, the electronic control means 11 determines a final value for the atmospheric parameter being considered, if the values detected by the sensors substantially mutually agree with a predetermined tolerance; on the contrary, the electronic control means 11 determines a state of malfunction of the apparatus 1 if the values detected by the sensors disagree with the predetermined tolerance.

[0041] The final value determined by the electronic control means 11 for each atmospheric parameter is then sent to the central processing unit.

[0042] By way of example, assuming that in the apparatus 1 there are three mutually equivalent oxygen sensors 6, if one of the three sensors fails, by using the control policy implemented by the electronic control means 11, which confirms the oxygen measurement in case of agreement (within the preset tolerance) of at least two of the three oxygen sensors 6 that are present, the control means 11 has a correct measurement of the quantity of oxygen that is present in the environment to be protected despite the presence of a failed sensor.

[0043] Conveniently, the apparatus 1 is connected to an energy source, which is preferably redundant, not shown in the figures, by means of an appropriate electrical connection means 13, preferably constituted by one or two pairs (if the power supply is redundant) of electrical cables which can be connected to an electrical distribution grid.

[0044] Also, or alternatively, the apparatus 1 can be powered by an internal energy source, such as for example an electric battery.

[0045] It is important to point out that the approach of redundant duplication of the components in order to increase the reliability of the apparatus 1 does not relate only to the various sensors that are present but also affects the means of communication 12 and the electrical connection means 13, which can be redundant and constantly monitored by the electronic control means 11.

[0046] In fact, if one of the data transmission buses and/or one of the electric power supply cables that enter the apparatus 1 fails, the apparatus would in any case continue to operate, the electronic control means 11 would detect the anomaly and would send a report thereof to the central processing unit.

[0047] Advantageously, the apparatus 1 is also equipped with an optical signaling means 14, which can consist for example of a series of colored LEDs, and an acoustic signaling means 15, such as for example buzzers.

[0048] The optical signaling means 14 and the acoustic signaling means 15 are connected to the electronic control means 11 to provide respectively a visual and acoustic signal regarding the various states of operation of the apparatus 1 and/or to operate any alarms and/or report any malfunctions.

[0049] The apparatus 1 can be used substantially as a "spot sensor" arranged in the environment to be protected, as illustrated by way of example in Figure 1, or as a "suction sensor", and therefore arranged even outside the environment to be protected, as shown by way of example in Figure 2.

[0050] In this last case, the apparatus 1 is equipped also with a suction means 16 adapted to draw the air from the environment to be protected by means of ducts 17 and to cause this air to flow over the sensors with which the electronic unit 2 is equipped.

[0051] In the specific case of the example being considered, the extraction means 16 consists of a pair of fans which operate individually and/or in parallel.

[0052] Conveniently, the flow rate of each fan is modified automatically by the electronic control means 11 as a function of the differential pressure detected downstream of each fan by adapted detection devices 18.

[0053] It should be noted that even in the case of the suction means 16, a redundancy duplication approach is adopted in order to increase the functional safety of the apparatus 1.

[0054] It is evident from the above description that the apparatus 1 is in practice a complete instrument for atmospheric analysis, which is capable of detecting not only the level of oxygen inside an environment but, by means of the reading and comparative analysis of the values of the other parameters analyzed, also provides a better and more effective management/detection of the outbreaks of fire with respect to the current background art, together with the management of the quality of the air inside confined spaces to be protected.

[0055] The multiple equivalent sensors on the electronic unit 2 also make it possible to economically and

effectively increase the functional safety of the apparatus 1, significantly reducing the cost of the system with respect to an equivalent functional safety system composed of apparatuses equipped with individual sensors of a specific type.

[0056] As already noted, the redundancy duplication of the sensors that are present in the apparatus 1 combined with the control policy implemented by the electronic control means 11 allow to solve the problem related to the reliability of the values detected by the various types of sensors, with respect to possible failures of individual sensors.

[0057] Also by virtue of this solution, the apparatus according to the invention is able to provide safety during operation.

[0058] In practice, therefore, it has been found that the apparatus for monitoring atmospheric characteristics and detecting fires according to the invention fully achieves the intended aim and object.

[0059] The materials used, so long as they are compatible with the specific use, as well as the contingent shapes and dimensions, may of course vary according to the requirements and the state of the art.

Claims

1. An apparatus for monitoring atmospheric characteristics and detecting fires, comprising an electronic unit (2) provided with a means for detecting the presence of smoke in an environment to be protected, a means for detecting the quantity of carbon monoxide present in said environment, and a means for detecting the temperature present in said environment; said apparatus being **characterized in that** said electronic unit (2) also comprises a partial or complete combination of means (6) for detecting the quantity of oxygen present in said environment, means (7) for detecting the relative humidity present in said environment, means (8) for detecting the differential pressure present in said environment, means (5) for detecting the carbon dioxide present in said environment and means (10) for detecting the quantity of volatile organic compounds present in said environment; said electronic unit (2) being operatively connectable to a remote central control unit and being powered by a power source.

2. The apparatus according to the preceding claim, **characterized in that** said means for detecting the quantity of oxygen comprises one or more sensors of the optical type (6).

3. The apparatus according to one or more of the preceding claims, **characterized in that** said means for detecting relative humidity comprises one or more relative humidity sensors (7).

4. The apparatus according to one or more of the preceding claims, **characterized in that** said differential pressure detection means comprises one or more differential pressure sensors (8).

5. The apparatus according to one or more of the preceding claims, **characterized in that** said carbon dioxide detection means comprises one or more carbon dioxide sensors (5).

6. The apparatus according to one or more of the preceding claims, **characterized in that** said means for detecting the quantity of volatile organic compounds comprises one or more VOC sensors (10).

7. The apparatus according to one or more of the preceding claims, **characterized in that** said electronic unit (2) furthermore comprises electronic control means (11) adapted to process the data that arrive from said detection means (3, 4, 5, 6, 7, 8, 9, 10) and configured to:

   - acquire the values related to a specific parameter detected by a plurality of sensors (3, 4, 5, 6, 7, 8, 9, 10) of the same type;
   - comparing with each other the values detected by said sensors (3, 4, 5, 6, 7, 8, 9, 10);
   - determining a final value of said parameter if the values detected by said sensors (3, 4, 5, 6, 7, 8, 9, 10) substantially mutually agree with a predetermined tolerance, or determining a state of malfunction of said apparatus if said values detected by said sensors (3, 4, 5, 6, 7, 8, 9, 10) disagree with said predetermined tolerance.

8. The apparatus according to one or more of the preceding claims, characterizing that it comprises an optical and/or acoustic signaling means (14, 15) adapted to signal the various states of operation of said apparatus and/or any alarms and/or any malfunctions.

9. The apparatus according to one or more of the preceding claims, **characterized in that** it comprises a suction means (16) adapted to draw air from an environment to be protected and feed it to said sensors (3, 4, 5, 6, 7, 8, 9, 10).

10. The apparatus according to claim 9, **characterized in that** said suction means (16) comprises one or more fans which operate individually and/or in parallel; the flow rate of each fan being modified automatically by said electronic control means (11) as a function of the differential pressure detected downstream of said fan.

11. The apparatus according to one or more of the preceding claims, **characterized in that** it comprises a

means for communicating with said remote central control unit and a means for electrical connection to said remote power source.

12. The apparatus according to one or more of the preceding claims, **characterized in that** said detection means, said communication means and said electrical connection means are redundant and are constantly monitored by said electronic control means (11).

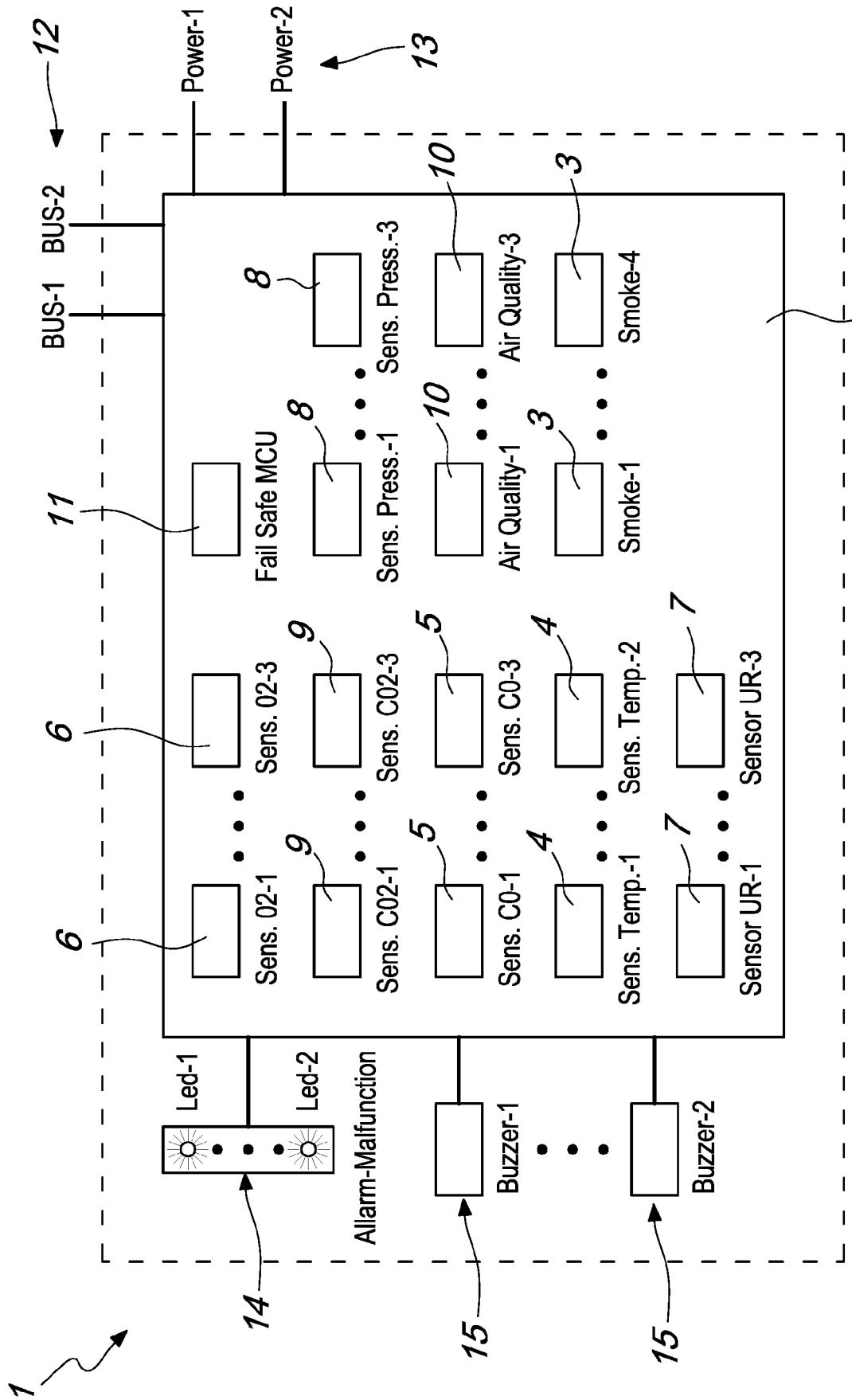
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Power-1
Power-2
BUS-1
BUS-2
Fail Safe MCU
Sens. 02-3
Sens. C02-3
Sens. C0-3
Sens. Temp.-2
Sensor UR-3
Sens. Press.-3
Air Quality-3
Smoke-4
Sens. 02-1
Sens. C02-1
Sens. C0-1
Sens. Temp.-1
Sensor UR-1
Sens. Press.-1
Air Quality-1
Smoke-1
Led-1
Led-2
Allarm-Malfunction
Buzzer-1
Buzzer-2

Fig. 1

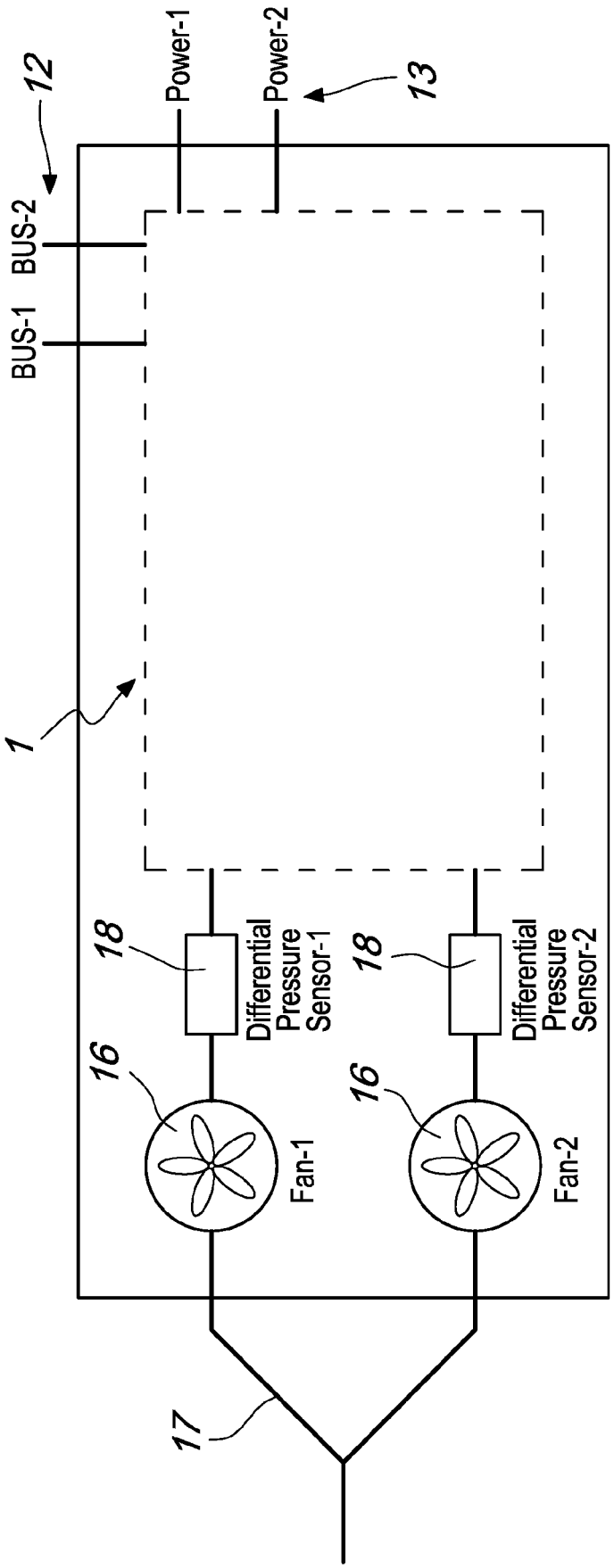
12
Power-1
Power-2
13
BUS-2
BUS-1
1
18
Differential Pressure Sensor-1
18
Differential Pressure Sensor-2
16
Fan-1
16
Fan-2
17

Fig. 2

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 17 2793

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 5 486 811 A (WEHRLE JOHN P [US] ET AL) 23 January 1996 (1996-01-23) * column 1, lines 14-47 * * column 4, line 11 - column 8, line 14; figures 1,2 *	1-4,8	INV. G08B29/16 G08B17/10 G08B19/00
X	WO 2009/024774 A1 (THORN SECURITY [GB]; SHAW JOHN E A [GB]) 26 February 2009 (2009-02-26)	1,2,5,6, 8,11,12	
Y	* page 6, lines 1-25 * * page 10, line 21 - page 11, line 6 * * page 17, lines 25-29 * * page 20, line 12 - page 21, line 11 * * page 22, line 25 - page 25, line 20 * * page 26, line 18 - page 27, line 12; figure 1 * * page 27, lines 26-29; figure 3 * * page 31, lines 8-20 * * page 33, line 29 - page 39, line 4; figure 11 *	7,9,10	
Y	WO 2012/012083 A2 (KNOWFLAME INC [US]) 26 January 2012 (2012-01-26) * page 1, lines 6-8 * * page 2, line 24 - page 4, line 6 * * page 6, lines 13-27 * * page 9, line 10 - page 10, line 7 *	7	TECHNICAL FIELDS SEARCHED (IPC) G08B
Y	EP 1 868 172 A2 (SIEMENS SCHWEIZ AG [CH]) 19 December 2007 (2007-12-19) * paragraph [0009] *	9,10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 September 2018	Russo, Michela

CATEGORY OF CITED DOCUMENTS

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

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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 17 2793

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.

07-09-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5486811 A	23-01-1996	NONE	
WO 2009024774 A1	26-02-2009	NONE	
WO 2012012083 A2	26-01-2012	AU 2011280059 A1	24-01-2013
		BR 112012033698 A2	06-12-2016
		CA 2804051 A1	26-01-2012
		CL 2012003731 A1	11-10-2013
		CN 103098106 A	08-05-2013
		EP 2589033 A2	08-05-2013
		IL 223847 A	29-12-2016
		JP 6061848 B2	18-01-2017
		JP 2013530474 A	25-07-2013
		KR 20130143545 A	31-12-2013
		US 2012001760 A1	05-01-2012
		WO 2012012083 A2	26-01-2012
EP 1868172 A2	19-12-2007	AU 2010200806 A1	25-03-2010
		CN 1871624 A	29-11-2006
		CN 101135627 A	05-03-2008
		CN 101135628 A	05-03-2008
		CN 101135629 A	05-03-2008
		CN 101135630 A	05-03-2008
		CN 101135631 A	05-03-2008
		EP 1868172 A2	19-12-2007
		EP 2112639 A2	28-10-2009
		ES 2597844 T3	23-01-2017
		ZA 200706464 B	25-09-2008
		ZA 200706468 B	25-09-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5486811 A **[0017]**
- WO 2009024774 A **[0018]**