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(71) Applicant *(for all designated States except US)*: **VAISALA OYJ** [FI/FI]; P.O. Box 26, FI-00421 Helsinki (FI).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **STORMBOM, Lars** [FI/FI]; Laajavuorentie 3 as 27, FI-01620 Vantaa (FI).

(74) Agent: **SEPPO LAINE OY**; Itämerenkatu 3 B, FI-00180 Helsinki (FI).

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(54) Title: METHOD FOR CALIBRATION OF A CO2 CONCENTRATION SENSOR AND A MEASURING DEVICE

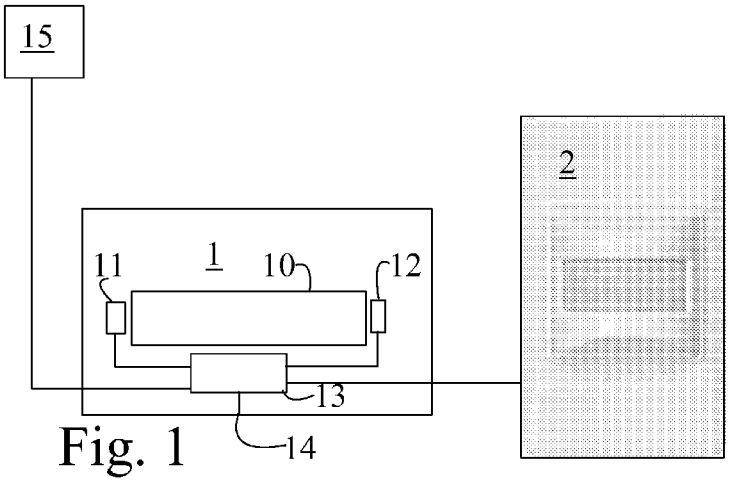

Fig. 1

(57) Abstract: This publication discloses a method for calibrating a CO2 concentration measuring device, in which method gas concentration is measured in a room. In accordance with the invention presence of persons is continuously determined in the room, and the measurement results are corrected based on the presence information.

Method for calibration of a CO_2 concentration sensor and a measuring device

The present invention relates to a calibration method according to the preamble of Claim 1.

The invention also relates to a measuring device.

WO2005015175 and **WO9604607** show how drift of a CO_2 sensor used for demand controlled ventilation can be compensated by recording the measured values of the sensor over a longer time and assuming that the concentration of CO_2 in the space approaches the outdoor background concentration of approximately 400ppm when the space is not occupied. The method described in **WO2005015175** is here called also as ABC-method.

While this method works well in i.e. office buildings some other buildings - for example hospitals and railway stations - are often occupied most of the time. In such cases this drift compensation often has to be disabled because there is no guarantee that CO_2 content in the space approaches the outdoor background concentration (apr. 400ppm).

The invention is intended to eliminate at least some defects of the state of the art disclosed above and for this purpose create an entirely new type of method for calibration of a CO_2 sensor and a measuring device.

The invention is based on combining CO_2 sensor with a movement sensor.

In such a sensor the signal from the movement sensor can be used to indicate when background (350 - 450 ppm) CO_2 concentration can be assumed. For instance >2 ... 4 h without detected movement can indicate that background concentration can be assumed. This means that a low-cost IR CO_2-sensor without reference channel can be used.

Advantageously this movement sensor is e.g. an ultrasonic or passive infrared movement sensor so that ventilation can be started immediately when movement is detected.

More specifically, the method according to the invention is characterized by what is stated in the characterizing portion of Claim 1.

The apparatus according to the invention is, in turn, characterized by what is stated in the characterizing portion of Claim 12.

Considerable advantages are gained with the aid of the invention.

Te invention allows the use of a simple low-cost CO_2 sensor, for instance a sensor without reference channel. Therefore the total cost with a movement sensor can be reduced.

The invention provides more reliable operation than the prior art methods. In addition the invention is easy to use and install.

The invention improves also the accuracy of more advanced CO_2 sensors after several years of operation.

In the following, the invention is examined with the aid of examples and with reference to the accompanying drawings.

Figure 1 shows a block diagram of one system according to the invention.

Figure 2 shows graphically CO_2 concentration in a typical object for implementing the invention.

In accordance with the invention the measurement device typically contains the actual measurement instrument 1 and a movement detector 2 connected to it. The measurement instrument further includes typically a measurement chamber 10, a light source 11 situated in one end of the measurement chamber 10 and a light detector 12 at the other end of the measurement chamber 10. Further, the measurement device 1 comprises a

control unit 13 for controlling the light source 11 and the detector 12 and has an input from the motion detector 2. The measurement chamber 10 is in gas connection to the ambient air and the content of desired gas like CO_2 is determined from the absorption of the light passing the measurement chamber 10. Typically the light arriving to the detector 12 is band-pass filtered such that it is sensitive to a characteristic wavelength of the gas to be measured. This can be done by a fixed filter or a electrically adjustable filter, e.g. a Fabry Perot filter (not shown). Typically NDIR–tehchnology (Nondispersive Infrared Sensor) is used for this purpose. This optical gas concentration measurement is known for the man skilled in the art.

The light source 11 and the detector 12 are connected to a control unit 13 for computing the gas concentration of the desired gas in the chamber 10. In accordance with the invention also a motion detector 2 is connected to the device 1, preferably to the control unit 13 of the device. The control unit 13 is typically a microprocessor. The connection from the sensor 2 to the unit 13 does not need to be direct, the control unit 13 needs only the information of the movement or presence sensor 2. Also a short delay for the presence information from the sensor 2 to control unit 13 (from milliseconds to minutes) is acceptable in connection with the invention because the changes in the CO_2 content are in practice rather slow. The measurement results are presented with a suitable display at the output 14 of the control unit 13.

In use of the measurement system e. g. in connection with a ventilation system, data from movement/presence sensor 2 is used to detect when it would be safe to assume that the room has been unoccupied long enough to assume that background (400 ppm) CO_2 level has been reached. The measurement system 1 can store values measured from the CO_2 sensor when the presence or movement sensor 2 has indicated no movement for a time longer than a threshold time (for instance 2-4h).

In order to reduce too fast changes these low values may be stored for a longer period, say a month, and the moving average of these low values to indicate the necessary correction to the CO_2 measurement. Then, minimum of measured CO_2 during the day is recorded. Then, the output is corrected using an average minimum values recorded

during the day, assuming that the concentration is at background (400 ppm) at such times. This background concentration can be e.g. a baseline corrected by a prior art ABC Logic of **WO2005015175**. This procedure might not be in buildings were there may be occupants at any time of the day, such as hospitals, hotels, train station etc. For such applications a prior art function often has to be switched off so as not to do false corrections.

In other words, in accordance with figure 2 CO_2 concentration of.an office building is presented as a function of time. Line 6 represents long term drift of the measuring device 1. As can be seen from the figure during working days 3 (days number 1-5 and 8-12) there are two peaks of CO_2 concentration each day. On Saturdays 5 (days number 6 and 13) the concentration drops and on Sundays 4 (days number 7 and 14) the concentration is practically on background level 7. This happens also in the night time during other days. By the presence or movement sensor 2 the calibration can be made based on time of absence independently from the working cycles. This means that that the calibration can be repeated more frequently than in the prior art.

In accordance with one advantageous embodiment of the invention CO_2 measurement is corrected such that the average of a set of measurements obtained over several days when no movement signal has been detected for a time longer than a set minimum time equals the background concentration 7.

In addition to the calibration method, the movement sensor 2 can be used to start airflow at once on a low flow level when rooms are occupied, not waiting for CO_2 levels to increase. In other words, the control unit 13 of figure 1 may instruct the ventilation system of a room to start air flow once persons are detected in the room.

In large metropolises the background level might be higher than standard level and therefore in these situations it is advantageous to measure the actual background level. This could be implemented by the present invention by measuring the background content by another sensor 15 situated e.g., outside the building or in a pipe inlet of the ventilation system. This another sensor 15 would tell the exact background level into

which the inside sensor should be adjusted, when there are no persons in the actual room where the measurement takes place.

In other words the presence sensor 2 would be used for determining the correct calibration time and the second sensor 15 for determining the background level to which the room CO_2 sensor should be adjusted. For telecommunications between the second sensor 15 and the room measuring device 1 could be used, e.g., field bus like BACnet.

The most advantageous alternative solution would be to put the additional sensor 15 into the inlet duct leading to the part of the building where the CO_2 sensors are. If the additional sensor 15 is placed after the mixed air dampers the influence of recirculated air to the CO_2 concentration in the gas flowing into the room is taken into account. Using recirculated air is done in order to save energy especially when the building unoccupied. In this case the unoccupied room where the measurement device 1 is situated does not represent real outdoor background value and therefore either a fixed background value or inlet duct sensor 15 should be used to correct the situation.

Claims:

1. A calibration method for a CO_2 concentration measuring device, in which method

- CO_2 concentration is measured in a room,

characterized in that

- presence of persons is continuously detected in the room, and
- the measurement results are corrected based on the presence information.

2. A method in accordance with claim 1, **characterized** in that if no persons are detected within a predetermined time the output (14) of the device (1) is set to background value (7) of CO_2 concentration.

3. A method in accordance with claim 1 or 2, **characterized** in that as a background level (7) is used concentration of 300 - 500 ppm.

4. A method in accordance with any claim 1-3, **characterized** in that background level (7) is determined by another CO_2 sensor (15) positioned in a place representing real background level (7).

5. A method in accordance with any claim 1-4, **characterized** in that the second sensor (15) is positioned outside the building where the measurement room is situated.

6. A method in accordance with any claim 1-4, **characterized** in that the second sensor (15) is positioned in an inlet duct supplying air to the building or part of the building where the measurement room is situated.

7. A method in accordance with any claim 1-6, **characterized** in that NDIR–tehcnology is used in the measuring device (1).

8. A method in accordance with any claim 1-7, **characterized** in that as a presence or movement sensor (2) is used ultrasonic sensor or passive infrared (PIR) sensor.

9. A method in accordance with any claim 1-7, **characterized** in that the measurement is corrected to the background value (7) when the no movement has been detected for several hours, preferably not within more than 2 hours, most preferably not within more than 4 hours.

10. A method in accordance with any claim 1-9, **characterized** in that the CO_2 measurement is corrected such that the average of a set of measurements obtained over several days when no movement signal has been detected for a time longer than a set minimum time equals the background concentration (7).

11. A method in accordance with any claim 1-10, **characterized** in that presence or movement sensor (2) is used for the switching on ventilation in a room to be measured when a person is detected.

12. A measurement device (1) including

- means for CO_2 concentration measurement (10, 11, 12),
- control means (13) for defining a gas concentration,
- **characterized** in that
- the device (2) includes also a presence of movement detector (2) connected to the control means (13).

13. A device in accordance with claim 12, **characterized** in that it includes means for setting the output (14) of the device (1) to background value (7) of CO_2 concentration. if no persons are detected within a predetermined time.

14. A device in accordance with claim 12 or 13, **characterized** in that as a background level (7) is used concentration of 300 - 500 ppm.

15. A device in accordance with any claim 12-14, **characterized** in that it includes another CO_2 sensor (15) for determining the background level (7) positioned in a place representing real background level (7).

16. A device in accordance with any claim 12-15, **characterized** in that the second sensor (15) is positioned outside the building where the measurement room is situated.

17. A device in accordance with any claim 12-15, **characterized** in that the second sensor (15) is positioned in an inlet duct supplying air to the building or part of the building where the measurement room is situated.

18. A device in accordance with any claim 12-17, **characterized** in that the measuring device (1) is implemented by NDIR–technology.

19. A device in accordance with any claim 12-18, **characterized** in that as a presence or movement sensor (2) is used ultrasonic sensor or passive infrared (PIR) sensor.

20. A device in accordance with any claim 12-19, **characterized** in that it includes means (13) for correcting the measurement to the background value (7) when the no movement has been detected for several hours, preferably not within more than 2 hours, most preferably not within more than 4 hours.

21. A device in accordance with any claim 12-20, **characterized** in that includes means (13) for correcting CO_2 measurement such that the average of a set of measurements obtained over several days when no movement signal has been detected for a time longer than a set minimum time equals the background concentration (7).

22. A device in accordance with any claim 12-21, **characterized** in that it includes means for using presence or movement sensor (2) for the switching on ventilation in a room to be measured when a person is detected.

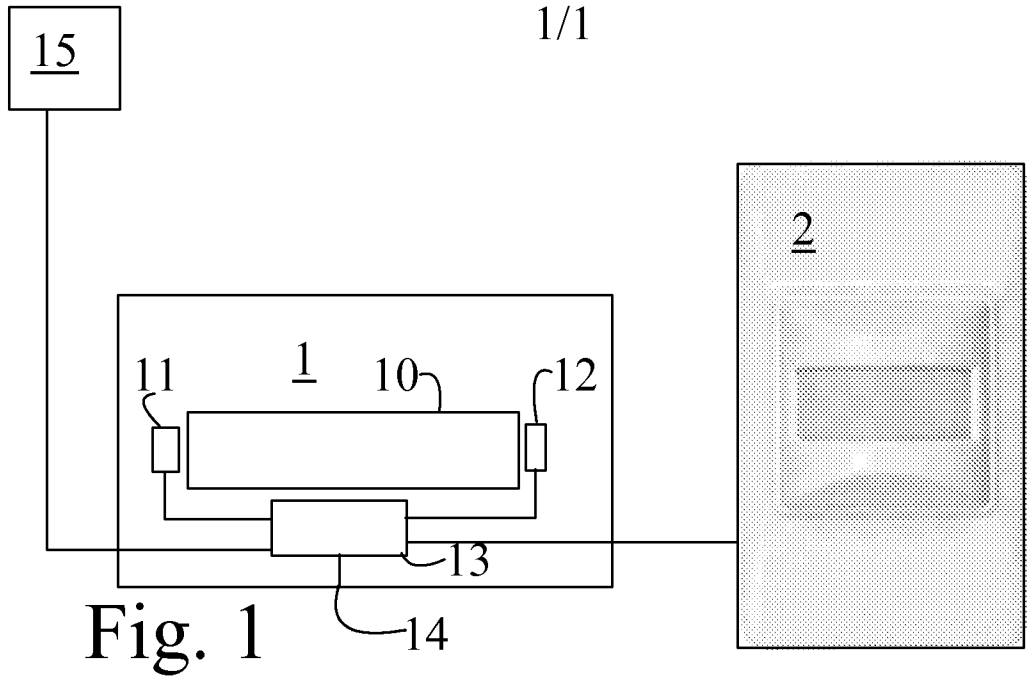
15
2
11
1
10
12
13
14

Fig. 1

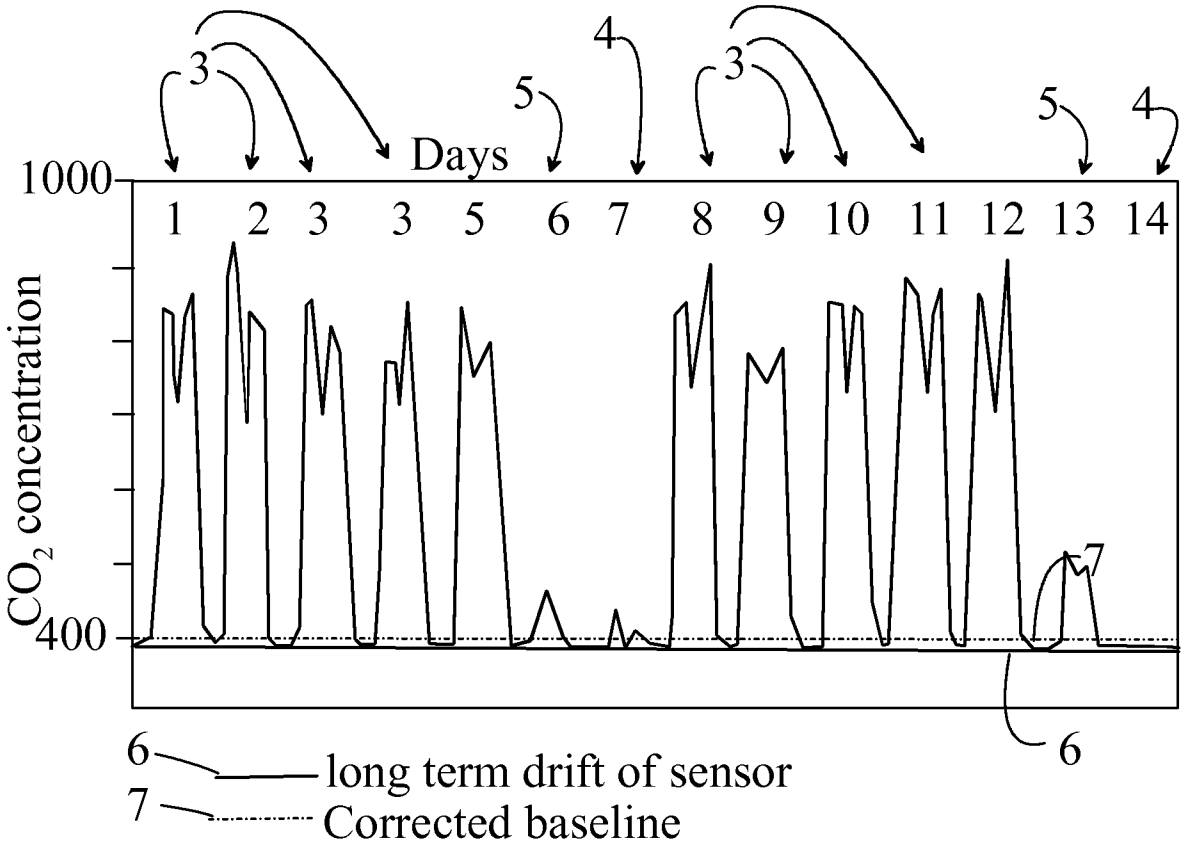
3
4
3
5
5
4
Days
1000
400
1 2 3 3 5 6 7 8 9 10 11 12 13 14
CO_2 concentration
7
6
6 long term drift of sensor
7 Corrected baseline

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2010/050110

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G01N, G01D, F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, TXTE, INSPEC, XPAIP, XPIEE, XPESP, XPRD, XPI3E, XPIOP, TXTWOT, TXTJPT, TXTJPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5800360 A (KISNER ROGER A et al.) 01 September 1998 (01.09.1998) entire document.	12, 19
X	US 2008076346 A1 (AHMED OSMAN) 27 March 2008 (27.03.2008) paragraphs [0008] - [0011], [0018] - [0084]; figs. 4-6.	12, 14-19, 22
X	US 2006107670 A1 (THOMLE ADRIENNE G et al.) 25 May 2006 (25.05.2006) paragraphs [0010] - [0019], [0029] - [0052]; figs.	12, 14-19, 22
A	US 2008283753 A1 (JENSEN JENS MOELLER et al.) 20 November 2008 (20.11.2008) paragraphs [0002], [0010] - [0048].	1-22
A	WO 2005015175 A1 (SENSEAIR AB et al.) 17 February 2005 (17.02.2005) entire document; cited in the application.	1-22

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Tuomo Ritari
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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PCT/FI2010/050110

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US 2009143915 A1	04/06/2009	None	

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