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[Continued on next page]

(54) Title: GAS SENSOR WITH VORTEX

(57) Abstract: The invention relates to a gas sensor comprising a gas measurement region such designed that the flow of gas in the region intrinsically serves to keep specific internal surfaces free of residues, e.g. soot particles. To this purpose means are introduced ensuring a non-direct path of the gas in its flow from one end of the measurement region to the other, such as by transferring it into a vortex letting the gas whirl from one end of the measurement chamber to the other, by forming a turbulent flow of the gas, etc..

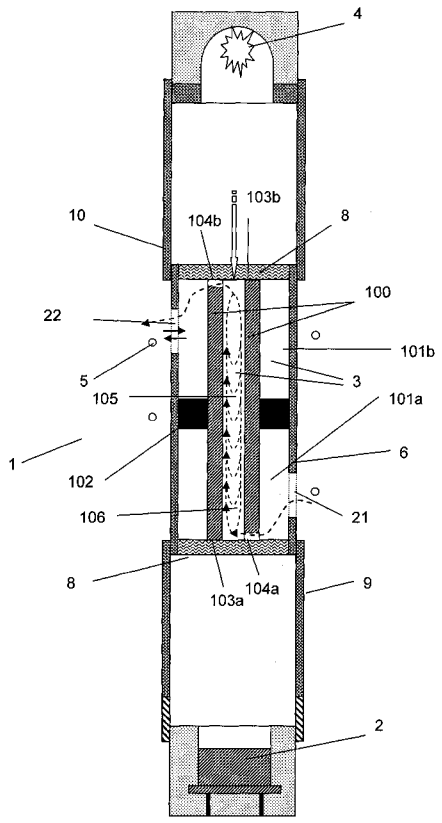

Fig. 1

WO 2012/126469 A1

CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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GAS SENSOR WITH VORTEX

The invention relates to a gas sensor comprising a gas measurement region such designed that the flow of gas in the region intrinsically serves to keep specific internal surfaces free of residues, e.g. soot particles. To this purpose means are introduced ensuring a non-direct path of the gas in its flow from one end of the measurement region to the other, such as by transferring it into a vortex letting the gas whirl from one end of the measurement chamber to the other, by forming a turbulent flow of the gas, etc..

BACKGROUND

Gas sensors configured to measure as a gas bases on absorption bands of bands of radiation characteristic to the gas of interest is widely known, for example as disclosed in WO10118748A describing a sensor having a filter arrangement, downstream of which there is arranged a detector arrangement, and an evaluating device which is connected to the detector arrangement, the filter arrangement has at least a first filter, the suspect filter, which is configured as a band pass filter allowing the passage of a first predetermined band, the suspect band, at least one second filter, the reference filter(s), which is configured as a band pass filter allowing the passage of a second predetermined band(s), the reference band(s), and where the detector arrangement has at least one detector associated with at least one of the filters. The band passes reference filters are distributed above and below the band pass of the suspect filter. The sensor with advantage could be utilized within the IR band, and could advantageously be used to detect CO.

A second document WO10118749A discloses a related sensor relating to the fact that particles or substances in general are present in the environment where the sensor operates, and that these over time gets into contact with more delicate parts of the sensor, decreasing the time of operation of the sensor, before maintenances or even exchange is needed. It is therefore often desired to keep the more delicate parts of the sensor physically separated from the media or environment containing the substances or species being

measured by the sensor. The present invention solves this problem by introducing sight glasses positioned at least in front of the delicate parts of the sensor, the sight glasses in general being formed with coating(s) chosen according to the environment wherein the sight glasses are to be used.

The present invention in the preferred, but not exclusive, embodiment relates to sensors of the same kind as described in the documents WO10118749A and WO10118748A, where it especially relates to a sensor as in WO10118749A including a system of sight glasses to protect the delicate parts of the sensor, but where an alternative, or additional, method is introduced to keep the sight glasses clean, alternative or additional to form special and often expensive sight glasses with special coatings or surfaces.

SUMMARY OF THE INVENTION

The object is solved by introducing:

A gas sensor adapted to measure the concentration of a gas in a measurement region by the absorption of spectral band characteristic to the gas, the sensor therefore comprising;

- a light source emitting light in a range at least comprising the absorption band, and
- a detector adapted to measure the light at least in the range of the absorption band,

where the gas sensor is configured such that the gas within the measurement region will follow a non-direct path from a first end to a second end of the measurement region.

In an especially preferred embodiment the gas whirls as it flows from a first end to a second end of the measurement region.

To ensure the detector is sealed from the gas, an embodiment further introduces at least one sight glass positioned in a manner the detector sealed from the measurement region, and it is especially suited that the sight glass is

fixed to the first sight tube in a manner where an gas tight internal enclosure of the first sight tube is defined separating the detector from the measurement region.

To ensure no signal is absorbed within the sight glass(es), a second sight glass is fixed to the first sight tube in a manner where a gas tight internal enclosure of the first sight tube is defined separating the detector from the measurement region. Then the internal enclosure is filled with a gas inert to the gas to be measured.

In the same manner a second sight tube constructed as the first sight tube may be connected to the light source sealing it from the measurement region.

To form the whirling gas it is led through a hollow tube with an internal volume being the measurement region, where the gas enters and leaves the internal volume through bores having a curvature, or being arch shaped, relative to the radial direction of the hollow tube.

The hollow tube may with advantage be the porous structure, the bores or recesses being the inlet and outlet openings

It is especially advantageous that the bores are formed as recesses in the two end-surfaces and of the hollow tube, and that the sight glasses in contact with the gas in the measurement region are encircled by the end-surfaces. Hereby the whirling gas will be in contact to this / these sight glass(es) thus helping to keep them clean.

To force the gas through the hollow tube, it with advantage is positioned inside the internal of the porous structure, where the volume of the internal being external to the hollow tube, are divided into two sub-chambers and by a gas tight wall.

To form a protection for the sensor, and at the same time ensure means to transfer gas through the measurement region, it with advantage may be

positioned within the internal of a sensor container, and where the sensor container is equipped with;

- a gas inlet externally connected to the environment comprising the gas to be measured, thus forming a gas communication from this environment to the internal of the sensor container, and

- a gas outlet forming a connection from its inside to any environment where the gas that has been measured are to be fed, such as e.g. to the externals, or more preferable back into the environment containing the gas.

Further the gas inlet of the sensor container is connected to the inlet opening if the gas sensor and an gas outlet is connected to the outlet opening of the gas sensor.

Especially, but not exclusive, the embodiment where the gas sensor is inserted into a sensor container a flow of gas in the measuring region may induced by means of vacuum or pumping by means also positioned within or at least attached to the sensor container..

FIGURES

Fig. 1	Illustration of a gas sensor introducing a hollow tube according to an embodiment of the present invention.
Fig. 2	Illustration of an end-surface of a hollow tube according to an embodiment of the present invention, illustrating the recesses.
Fig. 3	Illustration of the gas sensor positioned in a sensor container according to an embodiment of the present invention.

DETAILED DESCRIPTION

Fig. 1 shows a diagrammatic view of a gas sensor (1) for determining for example the CO_2 content (carbon dioxide content) in a measurement region (3), where the sensor (1) comprises a detection part (2) and an light source (4) emitting light (illustrated by the arrow) within a desired span of wavelengths defined by the specific gas, or gasses, to be measured, frequently within the such span of IR frequencies.

In the example, a large number of CO_2 molecules are present in the measurement region (2), the CO_2 molecules being represented herein by small circles. The gas molecules (5) absorb IR rays in a specific spectral range, as represented by the arrows. The greater the concentration of CO_2 the lower the energy in a specific spectral range that can be detected in the gas sensor (1).

The measurement region (3) may be defined as the internal a porous structure (6), such that the sensor device (2) is fixed at first end of the porous structure (6) and the light source (4) is fixed at a second end. The porous structure (6) may be formed such that gas (5) may enter and leave its internal hollow, the measurement region (3), through openings (21) and (22) in its wall. However, in an alternative version, it is gas tight the gas to be measured being filled into the internal.

In one preferred embodiment of the present invention, sight glasses (8) are introduced to form a gas tight separation of the light source (4) and the detector (2) from the measurement region (2), but still ensuring optic communication from the light source (4) to the detector device (2).

Further it is preferred that the porous structure (6) is such that it forms a stable alignment of the detector (2) to the light source (4), despite changes in the ambient conditions such as the humidity, temperature, vibrations etc.

A first (9) and / or second (10) sight tube may be connected to the porous structure (6) and detector (2) and / or light source (4). The sight tube is hollow and may be forming an internal being gas tight sealed from the externals and the measurement region (3), still maintaining the optic communication from the light source (4) to the detector device (2).

The sensor (1) of the present system preferable is made in a manner where each of the parts, sensor (2), light source (4), separation structures (9) and (10), and porous structure (6) are individually easily exchangeable. Each of the parts may be connected to other parts in any manner as known in the art, such as by equipping the parts with windings so that they may comprise windings, or by the use of suitable fittings.

Further it is preferred that the porous structure (6) is such that it forms a stable alignment of the detector (2) to the light source (4), despite changes in the ambient conditions such as the humidity, temperature, vibrations etc.

A first (9) and / or second (10) sight tube may be connected to the porous structure (6) and detector (2) and / or light source (4). The sight tube is hollow and may be forming an internal being gas tight sealed from the externals and the measurement region (3), still maintaining the optic communication from the light source (4) to the detector device (2). The internal(s) of the sight tube(s) may be filled with a gas inert to the wavelengths of the system. This helps to ensure no absorption occurs in the sight tubes (9) and (10) affecting the signal.

In an embodiment, one or both of the sight tubes (9) and (10) comprises sight glasses (8) attached either at one or both ends of the sight tube(s), where they may be attached in a manner, where they form the gas tight internal(s) of the sight tube(s).

The first (9) and second (10) sight tubes may optionally be mounted in a way such that they defines hermetically sealed volumes, where one or both of these in a preferred embodiment is filled with and gas inactive to the radiation frequency span of the light source (4) or at least to the frequencies of interest for measurements. This may help to get rid of any cross-correlations, and the

volume(s) may additionally be filled with a gas of high concentration in order to filter specific wavelengths out. The volume may be filled with any gas, as long as the concentrations are stable over time meaning that the volume is adequately sealed for the purpose..

In order to keep internal surfaces to the gas sensor (1), especially the sight glasses (8). free from residues such as impurities and / or moist within mixed with the gas from, where this would affect the measurements, the present invention introduces a mechanism within the porous structure (6), and thus the measurement region (3), that forms the gas flow into a vortex, or whirlpool. This is illustrated if Fig. 1. This is the example of the present invention, however it may also be formed into a turbulent flow etc.

The structure of the illustrated embodiment is a hollow tube (100) inserted in a manner, where a first end-surface (103a) encircles one sight glass (8), and the opposite end-surface (103b) encircles another sight glass (8). . Further, the part of the internal of the porous structure (6) being external (101) to the hollow tube, are equipped with a separating wall (102) of any kind, separating it in two sub-chambers (101a) and (101b) being sealed from each other in a gas tight manner.

In this embodiment the two end-surfaces (103a) and (103b) of the hollow tube (100) are equipped with recesses (104a, b) forming communications from the respective sub-chambers (101a) and (101b) to the internal (105) of the hollow tube (100).

When a flow of gas is induced through the gas sensor (1) it enters one of the two sub-chambers (101a) or (101b) by an inlet opening (21). It then continues through the recesses (104a) or (104b) of the corresponding end-surface (103a) or (103b), into and along the internal (105) of the hollow tube (100), until it leaves to other sub-chamber (101b) or (101a) by the opposite of the recesses (104b) or (104a). Finally the gas leaves the sensor through outlet opening(s) (22).

The recesses (104a) and (104b) preferable is formed having a curvature, or being e.g. arch shaped, relative to the radial direction of the hollow tube (100), as illustrated in Fig. 2, where the radial direction is illustrated by the arrow.., By designing the recesses (104a) and (104b) correctly, a vortex of the gas flow in the internal (105) of the hollow structure (100) if formed, as illustrated by the dotted circles (106) in Fig. 1. How to design this is well established in the art. A simplified example is shown below.

The recesses (104a) and (104b) in the preferred but not exclusive embodiment is formed in the end-surfaces (103a) and (103b), but may be formed as bores in the walls of the hollow tube (100).

It has been found that when the gas flow in the internal (105) of the hollow tube (100) in this manner whirl from the one set of recesses (104a) or (104b) to the other (104b) or (104a), the residues / impurities and moist are swung out of the hollow tube (100) with the gas, without settling onto the sight glasses (8). Further, the whirling gas, including whatever impurities and moist it may contain, will actually further help clean the sight glasses (8) should there anyway be a settlement of particles onto the sight glasses (8).

The sensor (1) in one embodiment is positioned within the internal of a sensor container (200), as seen in Fig. 3, where the sensor container (200) is equipped with a gas inlet (210) externally connected to the environment comprising the gas to be measured, thus forming a gas communication from this environment to the internal of the sensor container (200). The communication may be by a tube connected to the gas inlet (210). Further the sensor container (200) has a gas outlet (211) forming a connection from its inside to any environment where the gas that has been measured are to be fed, such as e.g. to the externals, or more preferable back into the environment containing the gas.

The gas inlet (210) of the sensor container (200) is connected to the inlet opening (21) of the gas sensor (1) and an gas outlet (211) connected to the outlet opening (22) of the gas sensor (1).

A flow of gas in the internal of the sensor container (200) may then be induced by vacuum or pumping means of any kind as known in the arts. When the sensor (1) is inserted into the internal of the sensor container (200), the gas will then flow in and out through the openings (21) and (22) of the porous structure (6) and thus in and out of the measurement region (2), preferable at a constant flow rate.

A gas communication tube (23) may be connected to the sensor container (200) to form the gas flow connection from the first gas inlet (21) in the sensor stack (201) to the environment comprising the gas to be measured, and / or a gas communication tube (24) to form the gas flow connection from the last gas outlet (22) of the sensor stack (201) to where the gas is to be expelled. The tubes may comprise any needed connection means for fixing them to needed structures.

The materials of the sight tubes (9) and (10) preferable is such that they at least has the same heat transfer characteristics as the other parts of the gas sensor (1) (but not the cooling device (11)), since this would ensure the different connected parts react to the temperature in the same manner.

CLAIMS

1. A gas sensor (1) adapted to measure the concentration of a gas in a measurement region (3) by the absorption of spectral band characteristic to the gas, the sensor (1) therefore comprising;

- a light source (4) emitting light in a range at least comprising the absorption band, and

- a detector (2) adapted to measure the light at least in the range of the absorption band,

where the gas sensor (1) is configured such that the gas within the measurement region (3) in a non-direct path from a first end to a second end of the measurement region (3).

2 A gas sensor (1) according to claim (1) where the gas whirls as it flows from a first end to a second end of the measurement region (3).

3. A gas sensor (1) according to claim 1 or 2, wherein a first sight tube (9) is connected to the detector (2) separating it from the measurement region (3), and wherein a cooling device (11) is connected in a heat transfer manner to the sight tube (9).

4. A gas sensor (1) according to one of claims 1 to 3, where at least one sight glass (8) is positioned in a manner the detector (2) sealed from the measurement region (3).

5. A gas sensor (1) according to claim 4, where the sight glass (8) is fixed to the first sight tube (9) in a manner where an gas tight internal enclosure of the first sight tube (9) is defined separating the detector (2) from the measurement region (3).

6. A gas sensor (1) according to claim 4, where second sight glass (8) is fixed to the first sight tube (9) in a manner where a gas tight internal enclosure of the

first sight tube (9) is defined separating the detector (2) from the measurement region (3).

7. A gas sensor (1) as in one of claims 5 or 6, wherein the internal enclosure is filled with a gas inert to the gas to be measured.

8. A gas sensor (1) according to one of claims 2-7, wherein a second sight tube (10) is constructed as the first sight tube (9) is connected to the light source (4) sealing it from the measurement region (3).

9. A gas sensor (1) according to any of the previous claims, where the whirling gas are formed by letting the gas through a hollow tube (100) with an internal volume (105) being the measurement region (3), where the gas enters and leaves the internal volume (105) through bores (104a) and (104b).

10. A gas sensor (1) according to claim 9, wherein the bores (104a) and (104b) have a curvature relative to the radial direction of the hollow tube (100).

11. A gas sensor (1) according to claim 9 or 10, wherein the bores (104a) and (104b) are formed as recesses in the two end-surfaces (103a) and (103b) of the hollow tube (100).

12. A gas sensor (1) according to claim 11, wherein the end-surfaces (103a) and / or (103b) encircles sight glasses (8).

13. A gas sensor (1) according to one of claims 8 to 12, wherein the hollow tube (100) is the porous structure (6), and the bores or recesses (104a) and (104b) are the inlet (21) and outlet (22) openings.

14. A gas sensor (1) according to one of claims 8 to 12, wherein the hollow tube (100) is positioned inside the internal (101) of the porous structure (6), where the volume of the internal (101) being external to the hollow tube (100) are divided into two sub-chambers (101a) and (101b) by a gas tight wall (102).

15. A gas sensor (1) according to any previously claim, where the sensor (1) is positioned within the internal of a sensor container (200), and where the sensor container (200) is equipped with;

- a gas inlet (210) externally connected to the environment comprising the gas to be measured, thus forming a gas communication from this environment to the internal of the sensor container (200), and

- a gas outlet (211) forming a connection from its inside to any environment where the gas that has been measured are to be fed, such as e.g. to the externals, or more preferable back into the environment containing the gas.

16. A gas sensor (1) according to claim 15, wherein the gas inlet (210) of the sensor container (200) is connected to the inlet opening (21) if the gas sensor (1) and the gas outlet (211) of the sensor container is connected to the outlet opening (22) of the gas sensor (1).

17. A gas sensor (1) according to any of the previous claims, where a flow of gas in the measuring region (3) is induced by means of vacuum or pumping.

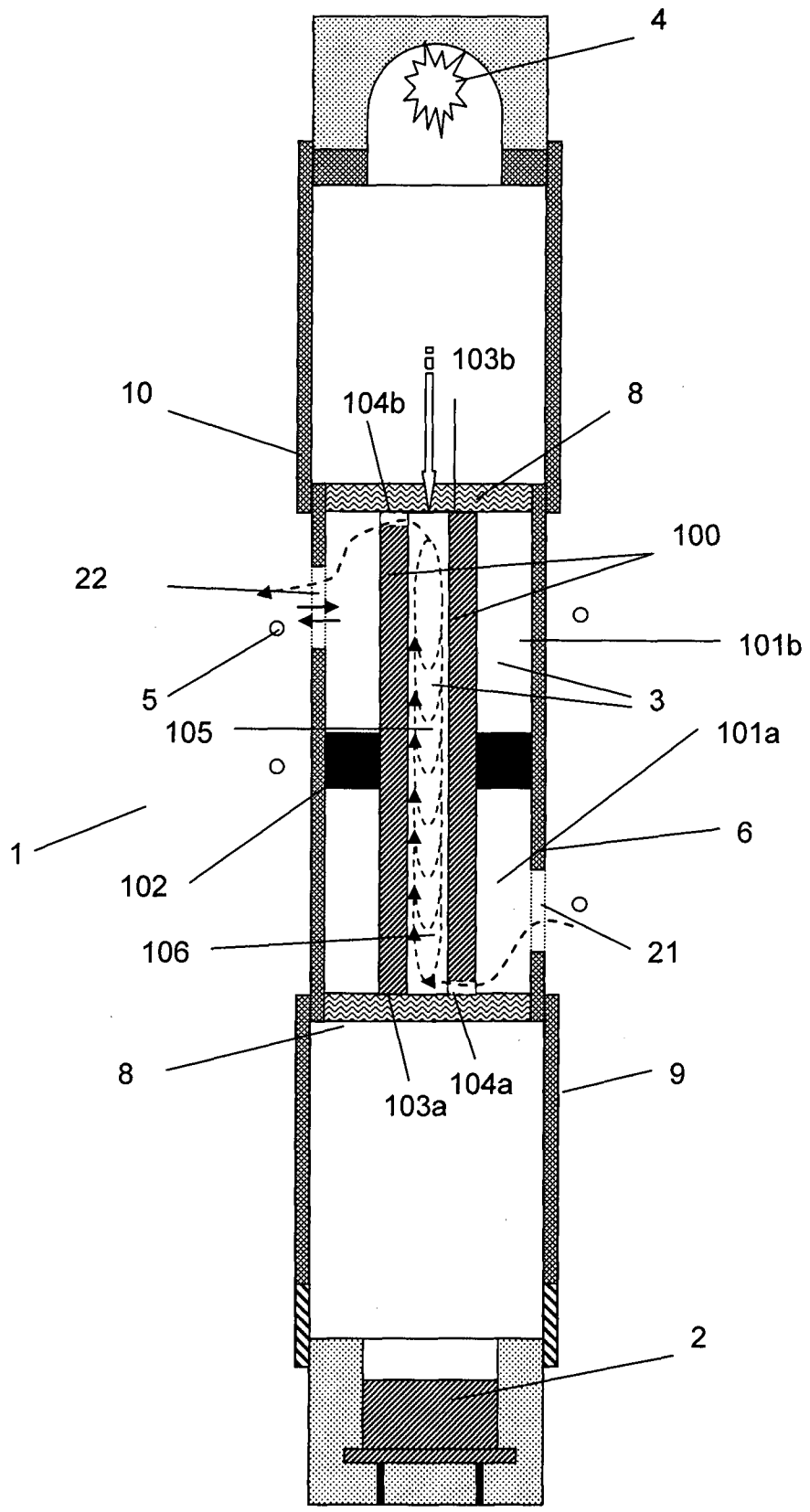
4
103b
10
104b
8
100
22
101b
5
3
105
101a
1
6
102
106
21
8
9
103a
104a
2

Fig. 1

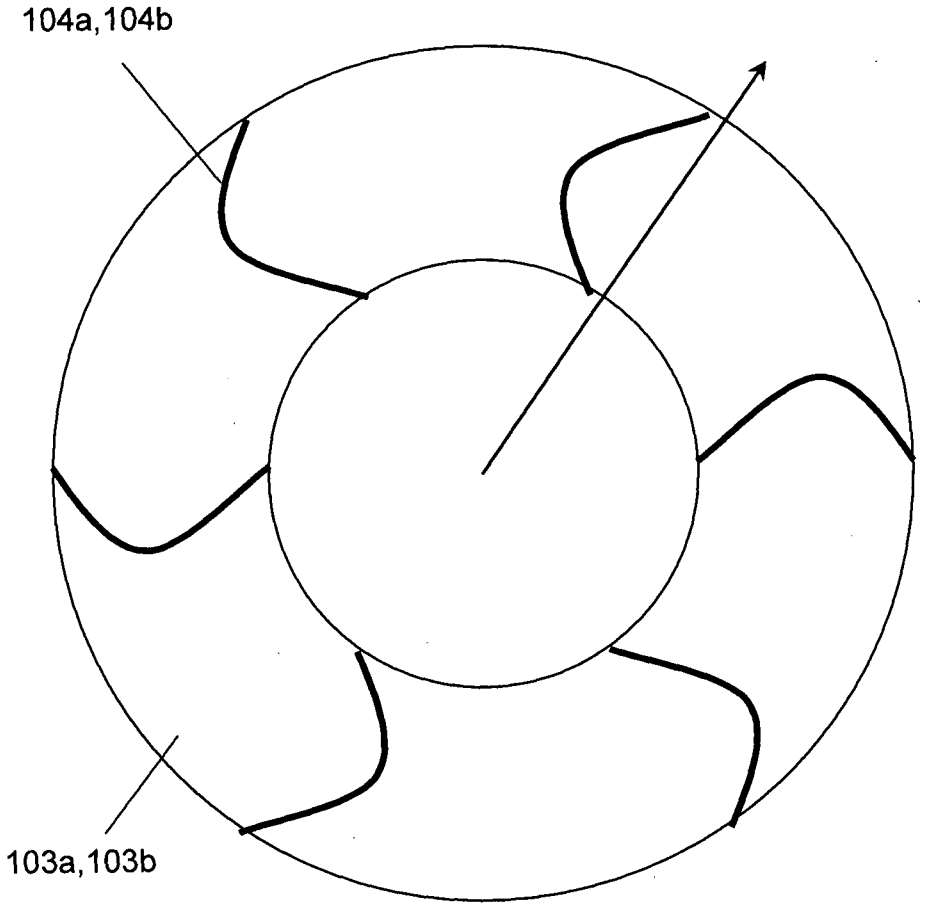

Fig. 2

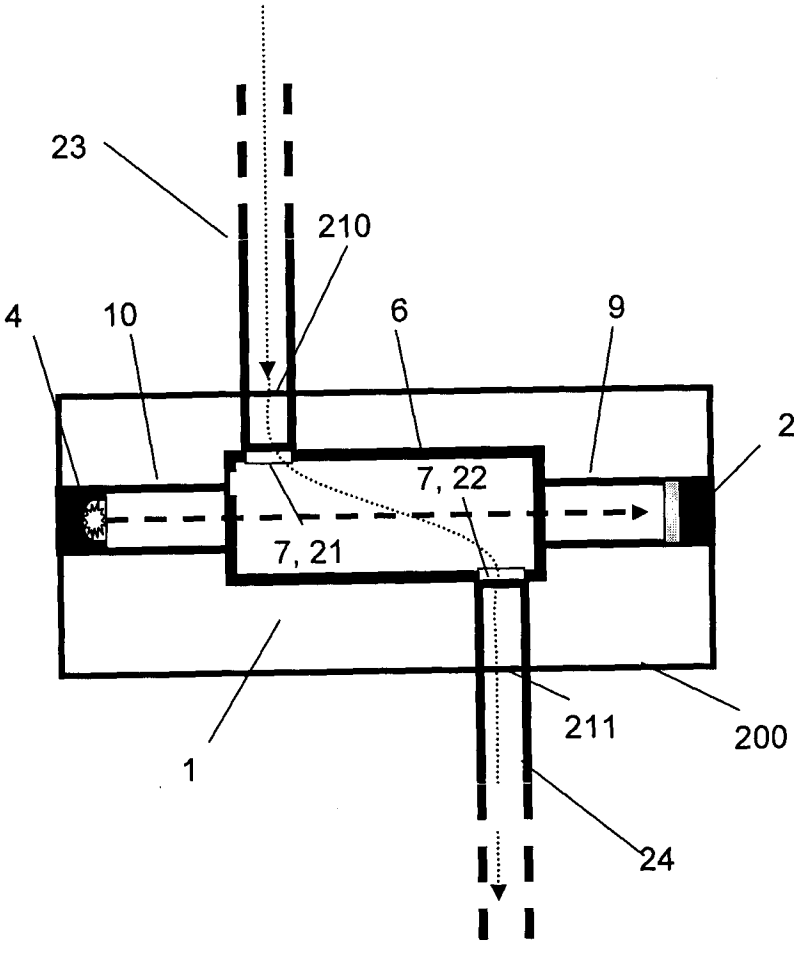

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2012/000026

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N21/15 G01N21/35 G01N21/03 G01N21/05
ADD.

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)
G01N G01J

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 196 01 873 A1 (HORIBA LTD [JP]) 5 September 1996 (1996-09-05)	1,2,9, 13,15-17
Y	column 1, line 1 - line 26 column 7, line 7 - line 26 column 7, line 27 - line 51; figure 1	10-14

Y	US 4 779 970 A (IRISH MARK R [US] ET AL) 25 October 1988 (1988-10-25)	11-13
A	column 1, line 52 - column 2, line 9 column 5, line 47 - column 6, line 42; figures 5,6	2,9,10

Y	US 4 443 072 A (BALLARD EVAN O [US]) 17 April 1984 (1984-04-17)	10
A	column 1, line 62 - column 2, line 20 column 2, line 6 - column 2, line 49 column 3, line 52 - column 4, line 12; figures 1,2	2,9

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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
21 June 2012	21/08/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Stadlmeyer, R

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK2012/000026

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1, 2, 9-17

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2012/000026

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 10 2009 029949 B3 (SIEMENS AG [DE]) 5 January 2011 (2011-01-05) paragraph [0006]; figure 1 paragraph [0014] - paragraph [0015]	14
A	EP 0 733 897 A2 (VAISALA OY [FI] VAISALA OYJ [FI]) 25 September 1996 (1996-09-25) paragraph [0011]	17
A	WO 89/02069 A1 (ROSEMOUNT INC [US]) 9 March 1989 (1989-03-09) page 6, line 18 - page 8, line 32 page 10, line 1 - line 27	2,9,11
A	US 2005/173635 A1 (SMITH PATRICK G [US]) 11 August 2005 (2005-08-11) figures 2-4 paragraph [0067] paragraph [0059] paragraph [0062] paragraph [0065]	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/DK2012/000026

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2, 9-17

   Gas sensor with turbulent gas flow

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2. claims: 3-8

   Gas sensor for high temperature measurements
