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(71) Applicant: **Kjærulf Pedersen A/S**
2630 Taastrup (DK)

(72) Inventor: **Ehrhorn, Kristian**
5260, Odense S (DK)

(74) Representative: **Kitchen, Steven Richard**
Chas. Hude A/S
H.C. Andersens Boulevard 33
1780 Copenhagen V (DK)

(54) **Humidity sensoring system for storage rooms**

(57) Humidity sensoring system (1) for determining the humidity in a storage room. The system comprises a humidity sensor comprising a humidity sensor element (3) producing a relative humidity signal. Furthermore, the system comprises heating means (4) and timer means (5) for activating and deactivating the heating means (4).

A Method for drying up a humidity sensor element (3) in a humidity sensoring system (1) which comprise the steps of activating the heating means (4) in the system in order to raise the temperature above the dew point of the ambient air, and deactivating the heating means (4) by use of the timer means (5).

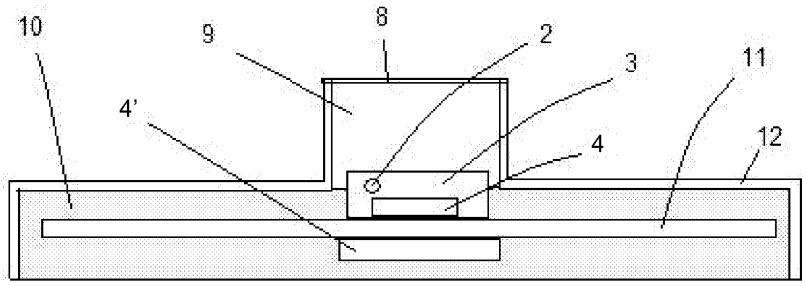

Fig. 3

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Description

Technical field

[0001] The present invention relates to a humidity sensoring system for determining the humidity in a storage room, the system comprising:

- a humidity sensor comprising a humidity sensor element producing a relative humidity.

Background art

[0002] Humidity sensors used in controlled atmosphere systems or similar environment found in reefer containers or storage environments may be exposed to condensing conditions, where the surface of the sensor and its near environment may be wet. In that case the humidity sensor measures 100% relative humidity (RH) as long as wet surfaces exist near the sensor's sensitive surface. The time it takes to dry a sensor by natural or forced ventilation may in some applications be unacceptably long. During the time the sensor is wet, it is unable to measure ambient RH correctly and may in some cases be considered defect. This issue exists mainly for humidity sensors of capacitive or resistive art, where water is absorbed in a polymer and changes the dielectric coefficient or the conductivity of this polymer as a function of RH.

[0003] Thus, an aspect of the invention is to provide a new and improved humidity sensoring system that overcomes the drawbacks of the prior art mentioned above.

[0004] According to the invention this aspect is obtained by a humidity sensoring system that comprises heating means and timer means for activating and deactivating the heating means.

[0005] The heat from the heating means will cause moist or water accumulated in the humidity sensor element to dissipate, whereby locally accumulated moist or water is dried up. The timer will cause the heating means to be turned off after a predetermined time. The temperature of the humidity sensor element is increased to a level above the dew point of the ambient air by the use of heat from the heating means. In this way, it is achieved that locally accumulated moist or water is dried up and thus the risk of inaccurate readings from the sensor caused by the locally accumulated moist or water is minimised.

[0006] In the situation where moist or water has accumulated around the humidity sensor element, such accumulation would cause the humidity sensor element to measure a value that is too high in relation to the humidity of the ambient surroundings.

[0007] According to another embodiment of the invention, the system may further comprise:

- at least one temperature sensor producing a temperature signal,
- data storage means for storing the temperature measured by the at least one temperature sensor, and
- processing means for processing the temperature signal and the humidity signal.

[0008] The processing means renders it possible to control the system with respect to activation of the heating means depending on different conditions, e.g. based on time or an ambient temperature. Furthermore, when the system comprises processing means it is possible to compensate the measurements from the humidity sensor element according to a local rise in temperature caused by the heating means. The data storage capabilities may e.g. supply the processing means with temperature data recorded just within the activation of the heating means such as to achieve a reference temperature. In this way it is possible to compensate the measured humidity from the humidity sensor element for the increase in temperature.

[0009] By storing the ambient temperature value, which may be considered equal to the temperature of the humidity sensor just before the heating means is turned on, and comparing that ambient temperature to the actual temperature of the sensor, the error due to heating may be calculated and corrected, presuming the ambient temperature is unchanged during that period.

[0010] The sensor temperature may be measured with an internal temperature sensor integrated in the humidity sensor. The ambient temperature may be measured with the same sensor as mentioned above or by a dedicated ambient temperature sensor in the air, where the humidity sensor is implemented.

[0011] According to an embodiment of the invention the humidity sensoring system may further comprises a temperature sensor in the ambient surroundings. In this way it is possible to continuously measure the ambient temperature in the ambient surroundings and thus it is possible to continuously compare the sensor temperature in the humidity sensor element with the ambient temperature in the ambient surroundings.

[0012] According to an embodiment of the invention, the heating means may be adapted for activation when the relative humidity measured by the humidity sensor element is higher or equal to a threshold value.

[0013] According to a further embodiment of the invention, the threshold value may be a relative humidity of 90% to 100%. If the threshold value is above 90%, the heating means should be activated in order to dry up the humidity sensor. In this way, it is avoided that the measuring of a relative humidity of more than 90% is just a local humidity inside the humidity sensor e.g. caused by condensation. If the humidity sensor, after having been dried by the heating means, is still measuring a relative humidity above 90%, it is most likely that the relative humidity in the storage room is in fact that high.

[0014] According to an embodiment of the invention, the humidity sensor element may be integrated in a sili-

con chip.

[0015] According to a further embodiment of the invention, the heating means may comprise a resistor. The resistor dissipates heat when a current is lead through it. In this way a simple and cheap way of providing heating means is provided.

[0016] According to a further embodiment of the invention, the heating means may be integrated in the silicon chip. In this way, it is achieved that a good thermal contact is obtained between the heating means and the sensor element.

[0017] Moreover, the humidity sensoring system may comprise a PTFE membrane. In this way, it is less possible for liquid water to get in contact with humidity sensor element.

[0018] Furthermore, the invention relates to a method for drying up a humidity sensor element in a humidity sensoring system wherein the method comprises the steps of:

- activating heating means in the system in order to raise the temperature above the dew point of the ambient air, and
- deactivating the heating means by use of the timer means.

[0019] According to a further embodiment, the invention relates to a method for drying up a humidity sensor element in a humidity sensoring system where the method may comprise the steps of:

- providing humidity signals from the humidity sensor element to the processing means,
- providing temperature signals by measuring the ambient temperature in the ambient surroundings,
- activating the heating means if the humidity signals is above a threshold value,
- measuring the sensor temperature in the humidity sensor and comparing it with the ambient temperature, and
- deactivating the heating means when the humidity measured by the humidity sensor element is lover than a threshold value.

[0020] In this way, it is achieved that a humidity sensor subjected to moist or water e.g. caused by condensation is dried out. If moist is accumulated in the humidity sensor, the humidity sensor is likely to measure a relative humidity which is incorrect. However, having the humidity sensor dried out to e.g. 90% RH before use it is possible to find out whether the measuring of a high humidity was caused by a local accumulation of moist or in fact the true RH of the storage room. Before activating the heating means the temperature of the humidity sensor element and the ambient temperature may be the same, and thus a temperature of the humidity sensor element stored just before activation of the heating means is the same as the ambient temperature. Thus, the stored temperature of the humidity sensor element may be used as reference temperature. In this way it is possible to determine the rise in temperature caused by the activation of the heating means.

[0021] According to yet a further embodiment, the invention relates to a method for drying up a humidity sensor element in a humidity sensoring system, and the method may further comprise the steps:

- measuring the temperature of the humidity sensor element and comparing it with the ambient temperature, and
- compensating the measured RH for difference in the temperature between the humidity sensor element and the ambient temperature due to the activation of the heating means.

[0022] When a humidity sensor is heated, the RH of the air inside the sensor is lower than the RH in the ambient air which is colder than the sensor. This RH measurement error, due to sensor heating, may be calculated by the processing means when the temperature difference to the ambient temperature is known. At an ambient temperature near 10°C, the measurement of RH is approximately 5% lower for each 1 °C the sensor is heated. Furthermore, the invention relates to the use of a humidity sensor system for measuring the humidity, wherein the humidity sensor system is placed in a storage room or reefer container.

[0023] Particularly during the start-up of reefer containers, it is often experienced that moist is accumulated locally around the humidity sensor. During the pre-check of the functionality of the reefer container, it is essential that it is possible to clarify whether the measurement of a high relative humidity is caused by locally accumulated moist, or whether the humidity sensor is malfunctioning. If the humidity sensoring system detects a relative humidity of nearly 100% it is necessary to leave the container to dry up until it has become obvious for the operator that the detection of a high relative humidity is caused by a malfunctioning humidity sensor or by locally accumulated moist inside the humidity sensor. Thus, a humidity sensoring system being able to automatically dry itself is highly advantageous. In this way, the time to control the container during pre-check may be minimised with reduced cost and reduced environmental impact as a result due to lowered energy consumption during the pre-check.

[0024] The ambient temperature is considered the temperature outside the humidity sensor. When the heating means has not been activated for a long period, the ambient temperature and the temperature inside the sensor, i.e. the sensor temperature, are approximately the same. A storage room could be any kind of storage room in which the humidity is to be controlled, e.g. a reefer container.

Brief description of the drawings

[0025] The invention will be described in more detail below, with reference to the accompanying drawings, which for the purpose of illustration only show non-limiting embodiments, in which

Fig. 1A schematically shows a humidity sensor system according to the invention,

Fig. 1B shows a timing diagram of the activation and deactivation of heating means,

Fig. 2 schematically shows another embodiment of a humidity sensor system according to the invention, and

Fig. 3 shows a sectional view of an embodiment of the humidity sensor accord- ing to the invention.

Description of preferred embodiments

[0026] In Fig. 1A, a humidity sensor system 1 according to the invention is shown schematically. The humidity sensor element 3 with integrated heating means 4 is controlled by a timer 5 which activates the heating means for a limited time after the power to the system is switched on.

[0027] Fig. 1B shows schematically that the heating means 4 is activated when the power to the humidity sensoring system is turned on. Furthermore, it is shown that the heating means 4 is deactivated after at period of time determined by the timer 5 (not shown).

[0028] Fig. 2 shows another embodiment of the humidity sensoring system 1, in which a humidity sensor element 3 according to the invention is shown with an integrated temperature sensor 2, which measures the temperature of the humidity sensor element 3. The heating means 4 is integrated with the humidity sensor element 3 and the temperature sensor 2. The heating means 3 dissipates heat to the humidity sensor and the humidity sensor element 3. Furthermore, a temperature sensor 2' for measurement of the ambient temperature, e.g. the temperature in a reefer container, is shown. The humidity sensor element 3, the temperature sensor 2 and the ambient temperature sensor 5 are connected to the processing means 6, e.g. a microcontroller. The processing means 6 measures and processes the relative humidity in the humidity sensor on basis of the humidity signals HS form the humidity sensor element 3. Furthermore, the humidity signals HS from the humidity sensor element 3 is sent to the processing means 6 and processed in order to determine whether a signal AS should be sent to the heating means 4 in order to activate or deactivate the heating means 4. A temperature signal TS is sent to the processing means 6 from the temperature sensor 2.

[0029] According to the invention, the output signal 7 is RH corrected with respect to the error resulting from the temperature increase near the humidity sensor element 3. The increase in temperature can be measured as the difference in temperature between the temperature sensor 2 and the ambient temperature sensor 5. In the embodiment using an ambient temperature sensor 2', an ambient temperature signal ATS is sent to the processing means 6. Typically, a rise in temperature inside the humidity sensor causes a reduction of the measured RH of about 5% RH per °C. As the rise in temperature is known from the measurements from the two temperature sensors 2, 2', the correct RH is determined. In one embodiment, the ambient temperature sensor 2' may be omitted and the ambient temperature measured with the temperature sensor 2 just before starting the heater 3. In order to still be able to calculate a difference, the measured temperature is stored in storage means in the microcontroller 6 and used in the subsequent calculations. Having stored the temperature before the heating means 4 is activated, the stored temperature is used as a reference temperature, i.e. the ambient temperature. When the heating means 4 is activated, the processing means 6 continuously receives the temperature signal TS from temperature sensor 3 for calculating the rise in temperature in relation to the stored temperature. The heating means 4 may be a resistor placed physically close to the humidity sensor in order to heat this to a higher temperature than the ambient temperature.

[0030] According to the invention, the temperature sensor 2 and the heating means 4 may be integrated into the same silicon chip, which comprises the components of the humidity sensor element 3. By such embodiment, a good thermal coupling between the humidity sensor element 3, the heating means 4 and the temperature sensor 2 is achieved.

[0031] Fig. 3 shows a sectional view of an embodiment of a humidity sensor according to the invention. The temperature sensor 2 and the heating means 4 are embedded in the humidity sensor element 3. On the other side of the printed circuit board (PCB) 11 a further auxiliary heating means 4' is placed. The sensor element 3 is placed inside a casing 12 which may be made of e.g. a plastic material or stainless steel. To protect the PCB 11 and the electronic circuit, the casing 12 may be filled with a filling material 10, e.g. polyurethane, silicone or similar filling material. A porous and hydrophobic PTFE membrane 8 is protecting the humidity sensor element in order to prevent liquid water from getting into the dead space 9. Water vapor can pass through the PTFE membrane 8 to the humidity sensor element 3. The dead space 9 is simply a small volume between the PTFE membrane and the sensor element 3.

[0032] Although the invention above has been described in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without deviating from the invention as defined by the following claims.

Claims

1. Humidity sensoring system (1) for determining the humidity in a storage room, the system comprising:

   - a humidity sensor comprising a humidity sensor element (3) producing a relative humidity signal, **characterised in that** the system comprises heating means (4) and that the system comprises timer means (5) for activating and deactivating the heating means (4).

2. Humidity sensoring system (1) according to claim 1, **wherein** the system further comprises:

   - at least one temperature sensor (2) producing a temperature signal,
   - data storage means for storing the temperature (TS) measured by the at least one temperature sensor, and
   - processing means (6) for processing the temperature signal (TS) and the humidity signal (HS).

3. Humidity sensoring system (1) according to claim 1 or 2, **wherein** the system further comprises a temperature sensor (2') in the ambient surroundings.

4. Humidity sensoring system (1) according to claim 1, 2 or 3, **wherein** the heating means (4) is adapted for activation when the relative humidity measured by the humidity sensor element is higher or equal to a threshold value.

5. Humidity sensoring system (1) according to claim 4, **wherein** the threshold value is a relative humidity of 90% to 100%.

6. Humidity sensoring system (1) according to claim 1-5, **wherein** the humidity sensor element (3) is integrated in a silicon chip.

7. Humidity sensoring system (1) according to claim 1-6, **wherein** the heating means (4) comprises a resistor.

8. Humidity sensoring system (1) according to claim 6 or 7, **wherein** the heating means (4) is integrated in the silicon chip.

9. Method for drying up a humidity sensor element (3) in a humidity sensoring system (1) according to any of the claims 1-8 wherein the method comprises the steps of:

   - activating the heating means (4) in the system in order to raise the temperature above the dew point of the ambient air, and
   - deactivating the heating means (4) by use of the timer means (5).

10. Method for drying up a humidity sensor element in a humidity sensoring system (1) according to any of the preceding claims, wherein the method further comprises the steps of:

    - providing humidity signals (HS) from the humidity sensor element to the processing means (6),
    - providing temperature signals (TS, ATS) by measuring the ambient temperature in the ambient surroundings,
    - activating the heating means (4) if the humidity signals (HS) is above a threshold value, and
    - deactivating the heating means (4) when the humidity measured by the humidity sensor element (3) is lover than a threshold value.

11. Method for drying up a humidity sensor element (3) in a humidity sensoring system (1) according to claim 10, wherein the method further comprises the steps:

    - measuring the temperature (TS) of the humidity sensor element (3) and comparing it with the ambient temperature (ATS), and
    - compensating the measured RH for difference in the temperature between the humidity sensor element (3) and the ambient temperature due to the activation of the heating means (4).

12. Use of a humidity sensor system (1) according claims 1-9 for measuring the humidity, wherein the humidity sensor system (1) is placed in a storage room or reefer container.

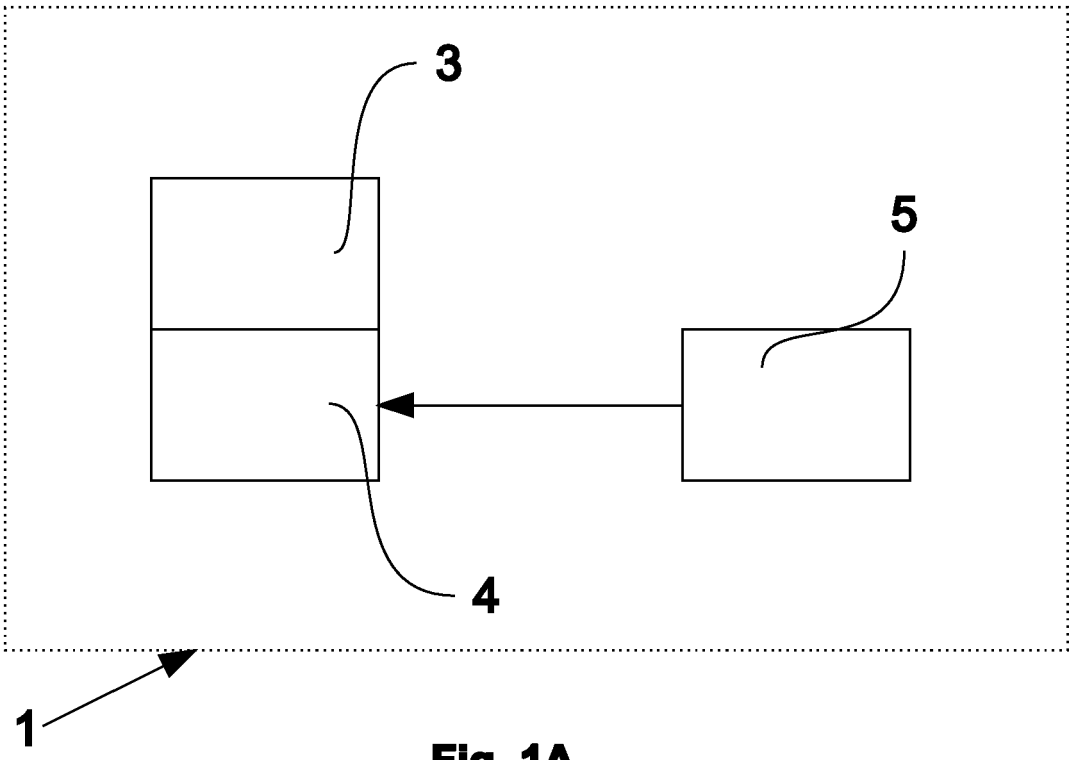

Fig. 1A

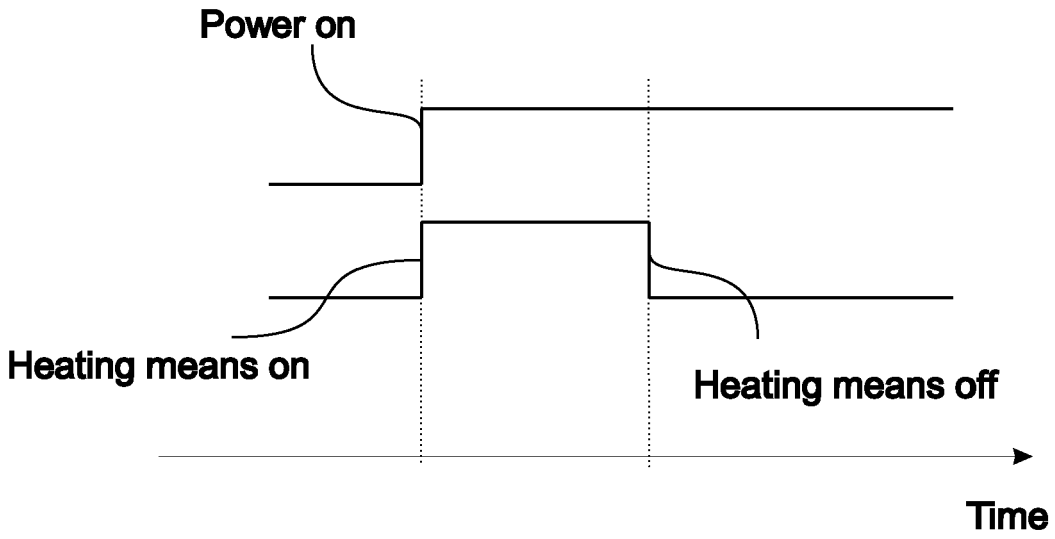

Fig. 1B

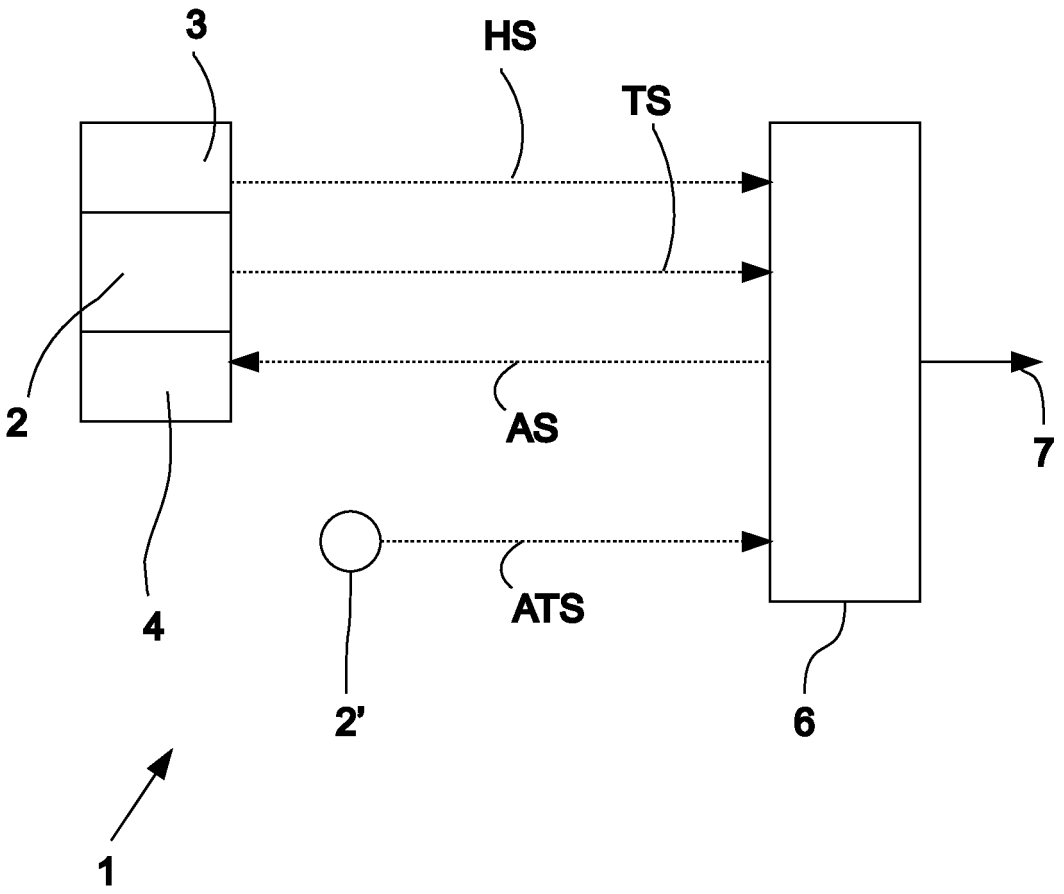

Fig. 2

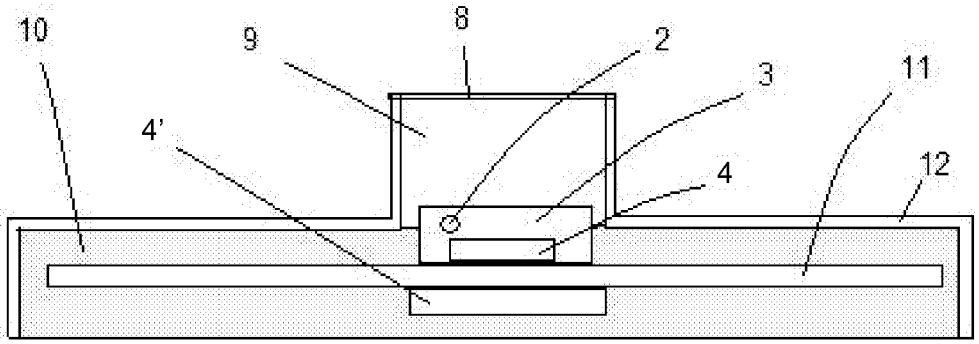

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 09 16 2502

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	JP 56 070449 A (RICOH KK) 12 June 1981 (1981-06-12) * abstract; figures 1,4,5 * -----	1-12	INV. F24F11/00 G05D22/02 G01N27/12
X	JP 62 087843 A (NGK SPARK PLUG CO) 22 April 1987 (1987-04-22) * abstract; figures 1,4 * -----	1-12	
A	JP 62 087844 A (NGK SPARK PLUG CO) 22 April 1987 (1987-04-22) * abstract; figures * -----	1-12	
A	JP 04 062323 A (MATSUSHITA ELECTRIC IND CO LTD) 27 February 1992 (1992-02-27) * abstract; figures * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

F24F
G01N
G05D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 September 2009	González-Granda, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 16 2502

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
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30-09-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82