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(54) Title: SENSOR FOR DETECTION A TIME TEMPERATURE VARIATION

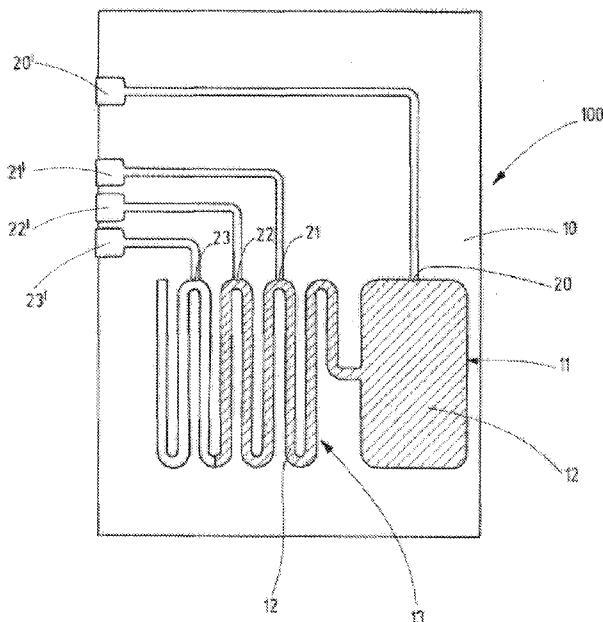


Fig.1

(57) Abstract: The invention relates to a sensor for detecting a time-temperature variation. For rendering a sensor available of simple construction and robust nature the sensor comprises a storage container for taking in a substance and includes a line system connected to the storage container, in which the sensor is arranged such that the substance present in the storage container after activation of the sensor spreads out inside the line system and that the spreading velocity of the substance is dependent on the ambient temperature of the sensor.



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## SENSOR FOR DETECTION A TIME TEMPERATURE VARIATION

DESCRIPTION

The invention relates to a sensor for detecting a time-temperature variation.

Sensors of this type are basically known from the state of the art. They are particularly used for indicating whether perishable or decomposable products such as food-stuffs, drugs, chemicals, photographic films or similar were exposed to undesired time-temperature variations, which would lead to a considerable decomposition of these products, or whether these products, while being processed or maintained, were exposed only to desired time-temperature variations. With these products often not the instantaneous temperature values are of interest, but their integral value with respect to time, since a rather long storage with slight deviations from the desired storage temperature is normally more harmful to the products than brief, strong deviations from the desired storage temperature.

A sensor of the type defined in the opening paragraph or a method respectively for the deposition of such a sensor or indicator respectively on a product is disclosed for example in DE 27 06 741 C2. An indicator is used therein which comprises at least an acetylenic compound with at least two conjugated acetylene groups per molecule. Depending on how long this compound is exposed to a certain ambient temperature, it adopts a different hue and as a result allows of crude conclusions as regards certain time-temperature variations. However, a precise opinion is not always possible. Also an automatic evaluation of the sensor results is difficult. In addition, the preparation of the compound is highly complex.

Basically, it is advantageous for the automatic evaluation of the states detected by the sensor if such sensor are coupled to what are known as RFID transponders. RFID tags can then be applied on or in the respective products and operate by means of inductively included power. The voltage generated in this manner can furthermore be used for supplying power to a suitable sensor which records the storage conditions of the respective product. The use of an RFID tag in the form of a label, extended by a respective sensor is disclosed for example in patent US 68 06 898 B1.

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According to US 68 06 898 B1 there is in addition to a known ID tag on a transponder a sensor for detecting respective signals and a storage component which can passively save the variation of one or more physical or chemical environment variables.

5 The need for such an RFID tag extended by a sensor is especially felt in the packaging industry. In addition to an improvement of the readability as a result of the removal of the necessity of a direct eye contact with the lable it is possible to achieve an added value compared to the bar code by means of integrated sensor elements of the environment variables.

10 The sensors from US 6,806,898 B1, however, measure only instantaneous values. In the case of foodstuffs, foodstuff packagings or other perishable or decomposable products defined in the second paragraph, the integral variables of the measured values, however, play a decisive role. For example, sensors of the type defined in the opening paragraph would indicate the integral or the total value of the thermal effects (time and temperature) and not only that a certain temperature was exceeded. In consequence, with  
15 the known sensors which are used in combination with RFID transponders, the instantaneous values are required to be recorded, which as a rule requires the inclusion of additional electronic elements. Furthermore, in view of product security and product quality a tag integrated with the packaging and whose sensor is activated and cannot be removed without damaging the packaging is aimed for in lieu of a stick-on lable. In addition, the tag  
20 including sensor elements and memories is to have a certain robustness to outside mechanical loads in order not to suffer any damage during transport and tactile handling.

Previous solutions such as for example the so-called smart-active label are extensions to the known smart label, flat RFID tags with a planar wound antenna, which are extended by an independent energy source. The energy source, which is in most cases  
25 present in the form of an accumulator, has for its object to supply the necessary power to the external sensor elements with a data logger and an optional display. For integration with a packaging material, however, the solutions based on the use of accumulators are unsuitable because, compared with the bar code, they neither satisfy the conditions as regards costs nor as regards the additional space necessary for the integration with the  
30 packaging material.

Therefore, it is an object of the present invention to provide a sensor of the type defined in the opening paragraph which has a simple and robust construction and

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allows of detecting a time-temperature variation. This object is achieved by means of the characteristic features as defined in claim 1. Advantageous embodiments of the invention are revealed in the dependent claims.

5 The invention provides that the sensor comprises a storage container which is arranged for receiving or respectively storing a substance. The sensor further includes a line system which is connected to the storage container in such a way that the substance can be transferred from the storage container into the line system. Finally, the sensor is arranged such that, subsequent to its activation, the substance present in the storage container spreads inside the line system and that the spreading velocity is dependent on the ambient temperature of the sensor. Worded differently, the substance present in the storage container after the activation of the sensor flows into the line system and spreads inside the line system. Depending on the ambient temperature that prevails, there is a varying time duration which is necessary for the substance to spread inside the line system or for flowing along inside the line system.

15 The basic idea of the invention is therefore that the substance after activation of the sensor spreads along a defined path inside the line system and the spreading velocity depends on the ambient temperature. Depending on how long it takes for the substance to spread along the predefined path, conclusions may be arrived at as regards the time-temperature variation. Conversely, conclusions may also be arrived at as regards the time-temperature variation if after a predefined period of time the path is determined that is covered by the substance.

25 Basically, any substance suitable for the present application can be used. It is expedient that the substance for the respective use with the expected temperature range to be a liquid, so that a spreading or flowing respectively inside the line system is a possible. The substance is furthermore embodied such that its spreading velocity is dependent on the ambient temperature. In an advantageous manner this is achieved in that the viscosity of the substance changes in dependence on temperature. The higher the temperature that has an effect on the sensor and thus the substance, the less the viscosity will be and the higher the spreading velocity or rate of creep is of the substance inside the line system.

30 Therefore, with the sensor according to the invention it is possible to detect a time-temperature variation in integrated form and to indicate same as a single read out.

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Depending on the desired use one or more reference points can be provided in the line system. Depending on whether the substance has reached the reference point or reference points, various statements may be made about the time-temperature variation. Therefore, a simple-construction and robust sensor is created which detects the time-temperature variation in integrated form.

The function and thus also the adaptation of the sensor to the respective features or respective use is controlled by the viscosity of the substance as well as the composition of the line system as regards diameter and imperfections of the surface.

The sensor can fundamentally be used linked to an RFID transponder because then the transponder conveys the detected time-temperature variations to a respective receiver apparatus.

In an advantageous embodiment of the invention the sensor is activated in that the ambient temperature of the sensor reaches a predefined activation temperature. It is especially advantageous when the activation temperature is equal to the melting point of the substance. If the ambient temperature exceeds the melting point of the substance, the viscosity of the substance will drop so far that the substance can flow from the storage container into the line system. Below the measuring temperature on the other hand there will be no flowing action, so that the substance continues to dwell in the storage container. As a result, the sensor can be activated in a simple and efficient manner without special activation means or the like being necessary for this purpose. Basically, however, additional activation means may be provided.

In order to guarantee after activation of the sensor a spreading of the substance through the whole line system, it is expedient for the line system to include at least one capillary. A capillary is in this context deemed to be understood to be any line or any tube or the like that has such a small diameter that in the capillary, with respect to the respectively used substance, the physical effect of capillarity is found. Thus when the required activation temperature is reached and the fluidity of the substance is sufficiently high, it will spread out on the basis of the capillary effect in the line system.

In a highly simple and expediently arranged embodiment the line system therefore comprises a single capillary. In order to reduce the required space for the line system it is further advantageous to lay out this capillary or further lines respectively of the line system in a meander like fashion.

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Advantageously the substance is electrically conductive. By applying electrical contacts to the storage container or line system respectively it is then possible to detect the respective time-temperature variation in a simple manner. The line system should comprise at least one, but also more than one contacts while they are expediently arranged within range of the predefined reference points. Also expediently arranged is a contact at the storage container. The resolution of the sensor is then determined by the number of contacts. The more contacts are available the more different states can be detected or represented respectively.

For a simple manufacture and versatile embodiment it is further advantageous for the sensor to comprise a substrate in which the storage container and the line system are present. It is especially expedient for the storage container and the line system to be embossed or etched into the substrate. This provides that in a simple and cost-effective way a compact sensor arrangement can be manufactured.

In addition, the invention provides a method for detecting a time-temperature variation by means of a sensor, in which after activation of the sensor a substance flows along a line system provided at the sensor, in which the flow rate of the substance depends on the ambient temperature and in which the sensor determines whether or when the substance reaches one or more than one predefined reference points inside the line system. The method according to the invention in a simple way meets the requirement of detecting a time-temperature variation. Depending on how high the value of the temperature is the flow rate of the substance will change and thus the duration the substance needs to reach the one or more than one predefined reference points in the line system. Because of the fact that the sensor determines whether the reference points have either or not been reached by the substance, statements with respect to the time-temperature variation can be derived depending on the features found.

For determining the time-temperature variation it is expedient to use an electrically conductive substance and apply a current to the substance. This happens when respective contacts are provided while the line system is suitably contacted within the range of its contact points. In addition, a contact is advantageously provided in the storage container. If a current between the contact of the storage container and the contact of a specific reference point can or cannot be measured, statements with respect to the temperature-time variation can be derived therefrom.

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It is furthermore advantageous that when the sensor is deactivated, the last time-temperature variation is stored. This may particularly in an advantageous manner take place by the change of the aggregate state of the substance from fluid to solid. In the embodiment in which the activation of the sensor takes place in that the melting  
5 temperature of the substance is reached, the deactivation takes place in that the melting temperature is fallen short of. This provides that the last reached state with respect to the time-temperature variation is stored as a lasting value at deactivation.

Furthermore the invention provides a method for the manufacture of a sensor for detecting a time-temperature variation, in which a storage container as well as a line  
10 system comprising at least one capillary are embossed in a substrate more particularly by means of a subtractive method. In addition, an electrically conductive substance is provided in the storage container and an electrical contact is arranged at the storage container and at least a further electrical contact is arranged at the line system.

The following description relating to the appended drawing, the whole given  
15 by way of non-limiting example, will provide better understanding of how the invention can be realized, in which:

Fig. 1 shows a sensor according to the invention.

In Fig. 1 is represented a sensor according to the invention, which has reference numeral 100.

20 The sensor 100 comprises a basic substrate 10 in which a storage container 11 as well as a line system 13 connected thereto is embossed by means of a subtractive method. The line system 13 comprises a single capillary line which is arranged as a meander structure. Inside the storage container 11 there is an electrically conductive substance 12 which is hatched in the Figure. Electrical contacts 20, 21, 22, 23 are arranged  
25 on the storage container 12 as well as on three in-line turning points of the line system 13 arranged as a meander structure. Each contact 20, 21, 22, 23 is connected to lines via a respective terminal 20', 21', 22', 23'.

The embodiment of a sensor 100 shown in Fig. 1 can highly advantageously be used for controlling a sterilization process in an autoclave. In particular foodstuff  
30 packaging is to be subjected to such sterilization processes in order to destroy germs which end up in the packaging during the packaging or preparation of the foodstuff. It is then necessary to subject the foodstuff packaging to a minimum temperature long enough so that

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the packaging is heated thoroughly for a sufficiently long period of time. At the same time a maximum temperature and a maximum time should not be exceeded because otherwise the contents of the packaging may suffer damage (destruction of the substance contained therein or reduction of the taste). Furthermore, autoclaves are for example often used in the  
5 medical field, which represents a further example of embodiment of the present invention.

The sensor 100 represented in Fig. 1 is arranged such that with a known duration of the sterilization process there are up to three different options:

1. If a current is measured between the terminals 20' and 21', there may be detected that the minimum sterilization time is reached at a minimum sterilization temperature.  
10 Worded differently, the object to be sterilized has been sterilized sufficiently.
2. If in addition a current is measured between the terminals 20' and 22', the ideal time-temperature variation with respect to the sterilization process has been reached.
3. If a current is measured between the terminals 20' and 23', the maximum time-temperature variation has been exceeded and the object may have suffered damage.

15 In the present example the substance 12 has flown to a point which is located between the reference or contact points 22 and 23 respectively. Thus in the present example a current can be measured between the terminals 20' and 21' as well as between the terminals 20' and 22'. The object containing the sensor would thus already have reached the ideal time-temperature variation but not have exceeded the maximum time-temperature  
20 variation. If, on the other hand the ambient temperature in the present example fell short of the melting temperature of the substance 12, the existing state would be permanently stored as a result. In that case the time-temperature variation or state of the substance 12 could be read out as a 3-bit signal. Finer gradations with more signal bits can be directly derived as can non-linear characteristics by changes of the cross section or modifications of the  
25 surface in the line system.

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REFERENCE LIST

- 100 sensor
- 10 substrate
- 5 11 storage container
- 12 substance
- 13 line system
- 20 to 23 contacts, reference points
- 20' to 23' terminals
- 10

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**CLAIMS**

1. A sensor for detecting a time-temperature variation, characterized in that the sensor (100) comprises a storage container (11) which is arranged for or respectively storing a substance (12), as well as a line system (13) which is connected to the storage container in which the sensor (100) is arranged such that the substance (12) present in the  
5 storage container (11), subsequent to the activation of the sensor (100), spreads inside the line system (13) and in that the spreading velocity of the substance (12) is dependent on the ambient temperature of the sensor (100).
2. A sensor as claimed in claim 1, characterized in that the activation of the  
10 sensor (100) takes place when a predefined activation temperature, more particularly, of the melting temperature of the substance (12) takes place.
3. A sensor as claimed in claim 1, characterized in that the substance (12) has  
15 such form that its viscosity changes in dependence on the temperature.
4. A sensor as claimed in any one of the preceding claims, characterized in that  
the line system (13) includes at least one capillary.
5. A sensor as claimed in any one of the preceding claims, characterized in that  
20 the line system (13) has a meander like structure.
6. A sensor as claimed in any one of the preceding claims, characterized in that  
the substance (12) is electrically conductive and in that an electrical contact (20) is  
provided at the storage container (11) and at least one further, preferably three further  
25 electrical contacts (21, 22, 23) are provided at the line system (13).

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7. A sensor as claimed in any one of the preceding claims, characterized in that the sensor (100) comprises a substrate (10) at which the storage container (11) and the line system (13) are provided.
8. A method for detecting a time-temperature variation by means of a sensor (100), characterized in that after activation of the sensor (100) a substance (12) flows along a line system (13) provided at the sensor (100), in which the flow rate of the substance (12) depends on the ambient temperature and in which the sensor (100) determines whether the substance (12) reaches one or more than one predefined reference points inside the line system (13).
9. A method as claimed in claim 8, characterized in that the sensor (100) is activated when a predefined activation temperature is reached, more particularly the melting temperature of the substance (12).
10. A method as claimed in any one of the preceding claims 8 or 9, characterized in that the viscosity of the substance (12) changes in dependence on the ambient temperature.
11. A method as claimed in any one of the claims 8 to 10, characterized in that the substance (12) flows through the line system (13) on the basis of capillar forces influencing the substance (12).
12. A method as claimed in any one of the claims 8 to 11, characterized in that the time-temperature variation is determined by applying a current to the substance (12).
13. A method as claimed in any one of the claims 8 to 12, characterized in that when the sensor (100) is deactivated the last time-temperature variation is stored more particularly as a result of the change of the aggregate state of the substance (12) from fluid to solid.

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14. A method for the manufacture of a sensor (100) for detecting a time-temperature variation, characterized in that, more particularly by means of a subtractive method, a storage container (13) as well as a line system (13) including at least one capillary which is connected to the storage container (11) for exchanging fluid are embossed in a substrate (10), in that there is an electrically conductive substance (12) in the storage container (11) and in that an electrical contact (20) is provided at the storage container (12) as well as at least a further electrical contact (21, 22, 23) at the line system (13).

15. A use of a sensor (100) as claimed in any one of the claims 1 to 7 as well as a sensor (100) manufactured according to claim 14 in the field of foodstuffs, more particularly for controlling the sterilization of foodstuffs and/or foodstuff packaging.

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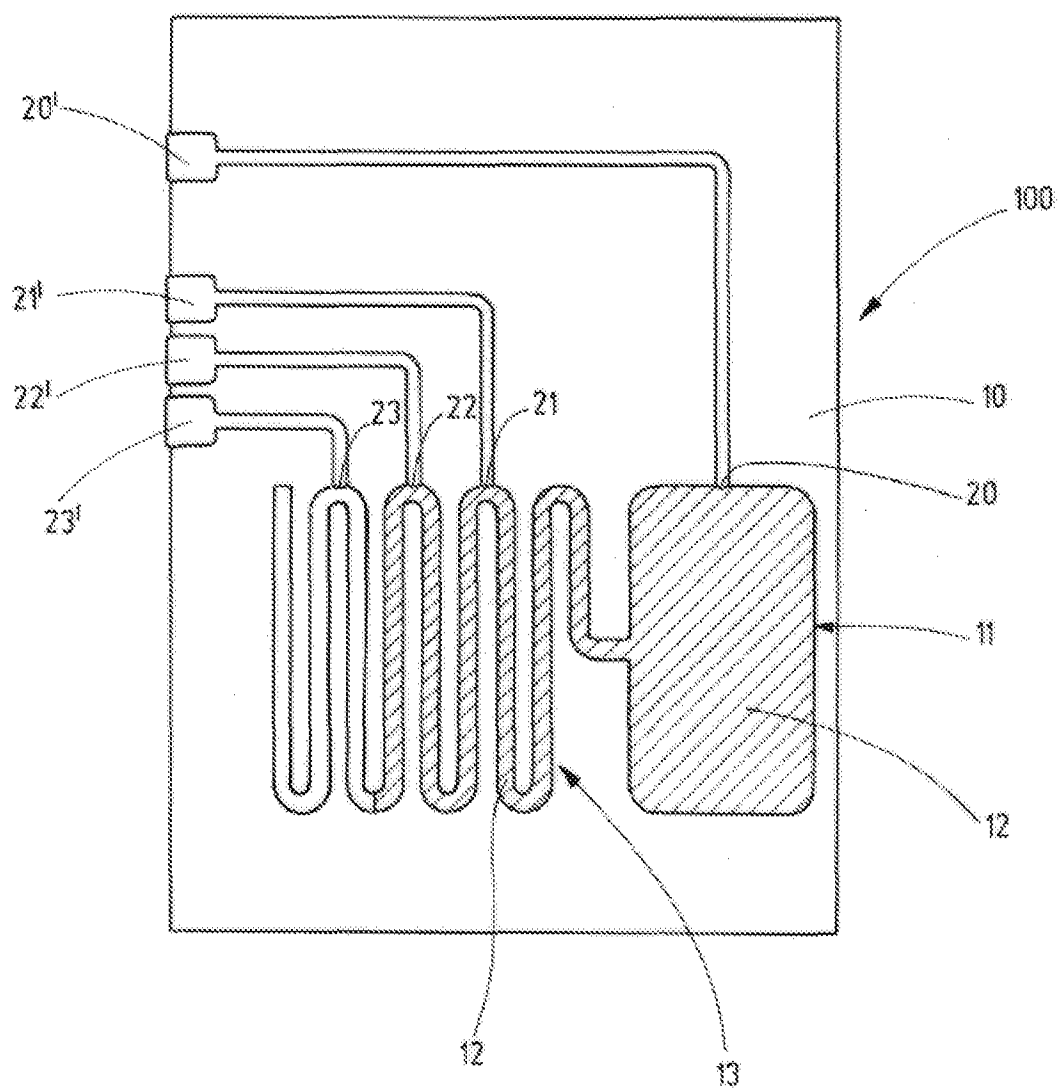


Fig.1

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2009/052229

## A. CLASSIFICATION OF SUBJECT MATTER

INV. G01K3/04

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)

G01K

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 practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                           | Relevant to claim No. |
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| X         | US 3 399 284 A (AYERS MORISON)<br>27 August 1968 (1968-08-27)<br>abstract<br>column 1, lines 15-25<br>column 21, lines 53-60<br>figures 43-46<br>columns 1-3 - column 4      | 1-15                  |
|           | -----<br>-/--<br>-----                                                                                                                                                       |                       |

☒ 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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"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.

"8" document member of the same patent family

Date of the actual completion of the international search

16 September 2009

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29/09/2009

Name and mailing address of the ISA/

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# INTERNATIONAL SEARCH REPORT

International application No  
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## C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                 | Relevant to claim No. |
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| X         | <p>US 6 379 036 B1 (HALDERMAN JONATHAN D [US]) 30 April 2002 (2002-04-30)<br/> abstract<br/> figures 1-5<br/> column 2, lines 44-67<br/> -----</p> | 1-15                  |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2009/052229

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