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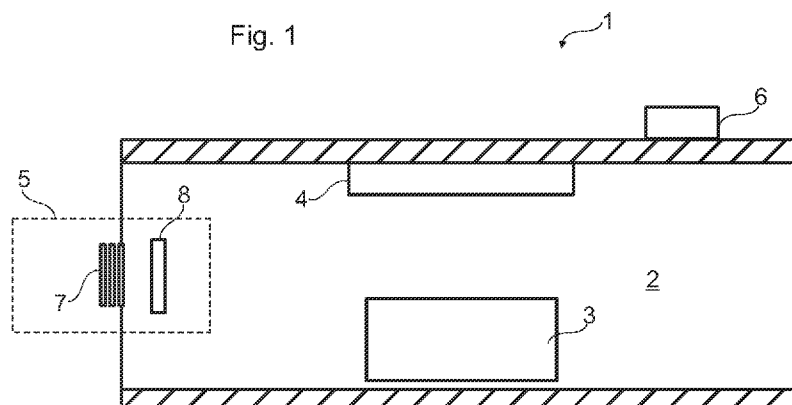
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(54) Title: REFRIGERATOR WITH IMPROVED FOOD SPOILAGE SENSING

Fig. 1



(57) Abstract: The present invention relates to a refrigerator (1) comprising: a chamber (2) for storing and refrigerating food (3); a door for opening/closing the chamber (2); a sensing unit (4) for sensing the level of the volatile organic compounds which are released by the food (3) in the chamber (2); a cleaning unit (5) for cleaning the ambient air inside the chamber (2); and a control unit (6) for determining the contamination level in the chamber (2) based on the level and for controlling the sensing unit (4) and the cleaning unit (5), wherein the control unit (6) has a food spoilage function for operating the cleaning unit (5).



REFRIGERATOR WITH IMPROVED FOOD SPOILAGE SENSING

The present invention relates to a refrigerator, in particular to a refrigerator with a food spoilage sensing facility.

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Refrigerators with food spoilage sensing facility are commonly known in the art.

This type of a refrigerator generally comprises: a chamber for storing and refrigerating food; a door for opening/closing the chamber; a sensing unit for sensing the level R of the volatile organic compounds which are released by the food in the chamber; a

10 cleaning unit for cleaning the ambient air inside the chamber; and a control unit for determining the contamination level S in the chamber based on the level R and for controlling the sensing unit and the cleaning unit, wherein the control unit has a food spoilage function for operating the cleaning unit.

15 CN203758163(U) discloses a refrigerator with a food spoilage sensing facility.

In general, the food in the chamber immediately starts spoiling due to the microorganism, and emits volatile organic compounds which cause a bad taste and a bad smell. Some kind of food products such as meat and sausages spoil in a

20 comparatively shorter time. The user usually identifies the inedible food in the chamber only after it has developed a very heavy smell and a rotten appearance. In such cases, the sensing unit becomes saturated due to the high VOC concentrations. Thus, a problem with the prior art refrigerator is that the food spoilage sensing cannot be accurately conducted.

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An objective of the present invention is to provide a refrigerator which solves the aforementioned problems of the prior art in a cost-effective way and which enables an improved sensing of the food spoilage.

This objective has been achieved by the refrigerator as defined in claim 1, and the control method as defined in claim 15. Further achievements have been attained by the subject-matters respectively defined in the dependent claims.

- 5 In the refrigerator of the present invention the control unit is further adapted to determine the contamination level S based on the currently sensed level R of the volatile organic compounds and a reference level R_0 of the volatile organic compounds which has been sensed by the sensing unit immediately after the preceding operation of the cleaning unit has been finished and the sensing unit has been initialized.

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- A major advantageous effect of the present invention is that the sensing of the food spoilage has been improved by virtue of the reference level R_0 which is sensed immediately after the last cleaning operation and the initialization of the sensing unit. Thereby the residual effects of the high VOC concentration on the sensing unit can be eliminated or reduced as much as possible, and the spoiling of the food can be early and accurately sensed. Another major advantageous effect of the present invention is that the quality of the food inside the chamber can be more reliably determined. Thereby, the performance of the food spoilage function of the refrigerator can be improved, and thus the preventive and protective actions against the food spoiling and the harmful VOC levels can be more reliably taken. Thereby, the user satisfaction can be increased.
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Additional features and additional advantageous effects of the refrigerator of the present invention will become more apparent with the detailed description of the embodiments with reference to the accompanying drawings in which:

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Figure 1 – is a schematic sectional partial view of a refrigerator according to an embodiment of the present invention;

Figure 2 – is a flowchart showing the steps of a method according to an embodiment of the present invention for controlling the refrigerator of Fig. 1;

Figure 3 – is a schematic sectional partial view of a refrigerator according to another embodiment of the present invention;

Figure 4 – is a flowchart showing the steps of a method according to another embodiment of the present invention for controlling the refrigerator of Fig. 3.

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The reference signs appearing on the drawings relate to the following technical features.

- | | |
|----|------------------------|
| | 1. Refrigerator |
| | 2. Chamber |
| 10 | 3. Food |
| | 4. Sensing unit |
| | 5. Cleaning unit |
| | 6. Control unit |
| | 7. Flap |
| 15 | 8. Carbon filter |
| | 9. Ion/ozone generator |

The refrigerator (1) comprises: a chamber (2) for storing and refrigerating food (3); a door (not shown) for opening/closing the chamber (2); a sensing unit (4) for sensing the level $\mathbb{R}$ of the volatile organic compounds (VOCs) which are released by the food (3) in the chamber (2); a cleaning unit (5) for cleaning the ambient air inside the chamber (2); and a control unit (6) for determining the contamination level $\mathbb{S}$ in the chamber (2) based on the level $\mathbb{R}$ and for controlling the sensing unit (4) and the cleaning unit (5), wherein the control unit (6) has a food spoilage function for operating the cleaning unit (5) (Fig. 1 and Fig. 3).

In the refrigerator (1) of the present invention, the control unit (6) is further adapted to determine the contamination level $\mathbb{S}$ based on the currently sensed level $\mathbb{R}$ of the volatile organic compounds and a reference level $\mathbb{R}_*$ of the volatile organic compounds

which has been sensed by the sensing unit (4) immediately after the preceding operation of the cleaning unit (5) has been finished and the sensing unit (4) has been initialized.

In an embodiment, the control unit (6) is further adapted to determine the contamination level S based on the time rate of the currently sensed level R of the volatile organic

compounds. Herein $S \propto \frac{1}{R_s} \frac{dR}{dt}$.

In another embodiment, the control unit (6) is further adapted to cause the cleaning unit (5) to start cleaning the chamber (2) when the contamination level S exceeds an upper level S_u .

In another embodiment, the control unit (6) is further adapted to cause the cleaning unit (5) to finish cleaning the chamber (2) when the contamination level S has dropped below a lower level S_l . Herein $S_l < S_u$.

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In another embodiment, the control unit (6) is further adapted to audibly and/or visually inform the user when the cleaning unit (5) has been started to clean the chamber (2) and/or when the cleaning unit (5) has finished cleaning the chamber (2).

20 In another embodiment, the refrigerator (1) further comprises: a flap (7) which is openable/closable and which is further adapted to aerate the chamber (2) (Fig. 1 and Fig. 3). In this embodiment, the control unit (6) is adapted to open the flap (7) when the cleaning unit (5) has been started to clean the chamber (3), and to close the flap (7) when the cleaning unit (5) has finished cleaning the chamber (2).

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In another embodiment, the sensing unit (4) is further adapted to sense the opening/closing of the door (Fig. 1 and Fig. 3). In this embodiment, the control unit (6) is further adapted to close the flap (7) after the door has been opened and closed by the user. Herein, the user can remove the spoiled food before the flap (7) is closed.

In another embodiment, the control unit (6) is further adapted to initialize the sensing unit (4) immediately after the flap (7) has been closed.

- 5 In another embodiment, the cleaning unit (5) comprises a carbon filter (8) which is adapted to filter the contaminated air inside the chamber (2) (Fig. 1).

In another embodiment, the carbon filter (8) is disposed in front of the flap (7) inside the chamber (2) (Fig. 1).

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In another embodiment, the cleaning unit (5) comprises an ion/ozone generator (9) which is adapted to clean the contaminated air inside the chamber (2) (Fig. 3).

- 15 In another embodiment, the ion/ozone generator (9) is disposed behind the flap (7) into an air channel (not shown) (Fig. 3).

- 20 In another embodiment, the refrigerator (1) comprises a locking means (not shown) for locking the door. In this embodiment, the control unit (6) is further adapted to lock the door and to open the flap (7) when causing the cleaning unit (5) to start cleaning the chamber (2) with the ion/ozone generator (9).

- In another embodiment, the control unit (6) is further adapted to cause the cleaning unit (5) to finish cleaning the chamber (2) with the ion/ozone generator (9) when the contamination level S has dropped below the lower level S_1 .

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- In another embodiment, the sensing unit (4) is further adapted to sense the ozone concentration A in the chamber (2). In this embodiment, the sensing unit (4) has an ozone sensor. In this embodiment, the control unit (6) is further adapted to keep the door locked unless the ozone concentration A has dropped below a predetermined value A_1 which poses no risk to the human health.
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In another embodiment, the predetermined value A_1 is equal to or less than 0.05 ppm by weight.

- 5 In another embodiment, the control unit (6) is further adapted to allow the user to enable or disable the food spoilage function.

The present invention provides a method of controlling the refrigerator (1). The method comprises: a step (S1-S3; S101-S103) of sensing the level R of the volatile organic
 10 compounds which are released by the food (3) in the chamber (2); a step (S4, S6; S104, S106) determining the contamination level S in the chamber (2) based on the level R ; and a step (S5,S7-S8; S105,S107-S112) of cleaning the ambient air inside the chamber (2) (Fig. 2 and Fig. 4).

- 15 In the method of the present invention the step (S4, S6; S104, S106) of determining the contamination level S is based on the currently sensed level R of the volatile organic compounds and a reference level R_0 of the volatile organic compounds which has been sensed immediately after the preceding cleaning step (S5, S7-S8; S105,S107-S112) has been finished and the sensing step (S1-S3; S101-S103) has been initialized in an
 20 initializing step (S9; S113) (Fig. 2 and Fig. 4).

A major advantageous effect of the present invention is that the sensing of the food (3) spoilage has been improved by virtue of the reference level R_0 which is sensed immediately after the last cleaning operation and the initialization of the sensing unit
 25 (4). Thereby the residual effects of the high VOC concentration on the sensing unit (4) can be eliminated or reduced as much as possible, and the spoiling of the food (3) can be early and accurately sensed. Another major advantageous effect of the present invention is that the quality of the food (3) inside the chamber (2) can be more reliably determined. Thereby, the performance of the food spoilage function of the refrigerator
 30 (1) can be improved, and thus the preventive and protective actions against the food (3)

spoiling and the harmful VOC levels can be more reliably taken. Thereby, the user satisfaction can be increased. Other advantageous effects of the present invention can be taken from the above described embodiments.

CLAIMS

1. A refrigerator (1) comprising: a chamber (2) for storing and refrigerating food (3); a
 5 door for opening/closing the chamber (2); a sensing unit (4) for sensing the level R of
 the volatile organic compounds which are released by the food (3) in the chamber (2); a
 cleaning unit (5) for cleaning the ambient air inside the chamber (2); and a control unit
 (6) for determining the contamination level S in the chamber (2) based on the level
 R and for controlling the sensing unit (4) and the cleaning unit (5), wherein the control
 10 unit (6) has a food spoilage function for operating the cleaning unit (5), characterized in
 that the control unit (6) is further adapted to determine the contamination level S based
 on the currently sensed level R of the volatile organic compounds and a reference level
 R_0 of the volatile organic compounds which has been sensed by the sensing unit (4)
 immediately after the preceding operation of the cleaning unit (5) has been finished and
 15 the sensing unit (4) has been initialized.
2. The refrigerator (1) according to claim 1, characterized in that the control unit (6) is
 further adapted to determine the contamination level S based on the time rate of the
 currently sensed level R of the volatile organic compounds, wherein $S \propto \frac{1}{R_0} \frac{dR}{dt}$.
- 20 3. The refrigerator (1) according to claim 1 or 2, characterized in that the control unit
 (6) is further adapted to cause the cleaning unit (5) to start cleaning the chamber (2)
 when the contamination level S exceeds an upper level S_1 .
4. The refrigerator (1) according to claim 3, characterized in that the control unit (6) is
 25 further adapted to cause the cleaning unit (5) to finish cleaning the chamber (2) when
 the contamination level S has dropped below a lower level S_2 , wherein $S_2 < S_1$.

5. The refrigerator (1) according to claim 4, characterized by further comprising: a flap (7) which is openable/closable and which is further adapted to aerate the chamber (2), wherein the control unit (6) is adapted to open the flap (7) when the cleaning unit (5) has been started to clean the chamber (3), and to close the flap (7) when the cleaning unit (5) has finished to clean the chamber (2).

6. The refrigerator (1) according to claim 5, characterized in that the sensing unit (4) is further adapted to sense the opening/closing of the door, wherein the control unit (6) is further adapted to close the flap (7) after the door has been opened and closed by the user.

7. The refrigerator (1) according to claim 6, characterized in that the control unit (6) is further adapted to initialize the sensing unit (4) immediately after the flap (7) has been closed.

8. The refrigerator (1) according to any one of claims 1 to 7, characterized in that the cleaning unit (5) comprises a carbon filter (8) which is adapted to filter the contaminated air inside the chamber (2).

9. The refrigerator (1) according to any one of claims 1 to 8 characterized in that the cleaning unit (5) comprises an ion/ozone generator (9) which is adapted to clean the contaminated air inside the chamber (2).

10. The refrigerator (1) according to claim 9, where dependent on claim 5, characterized by further comprising a locking means for locking the door, wherein the control unit (6) is further adapted to lock the door and to open the flap (7) when causing the cleaning unit (5) to start cleaning the chamber (2) with the ion/ozone generator (9).

11. The refrigerator (1) according to claim 10, characterized in that the control unit (6) is further adapted to cause the cleaning unit (5) to finish cleaning the chamber (2) with

the ion/ozone generator (9) when the contamination level S has dropped below the lower level S_2 , wherein $S_2 < S_1$.

12. The refrigerator (1) according to claim 10 or 11, characterized in that the sensing unit (4) is further adapted to sense the ozone concentration A in the chamber (2), wherein the control unit (6) is further adapted to keep the door locked unless the ozone concentration A has dropped below a predetermined value A_1 .

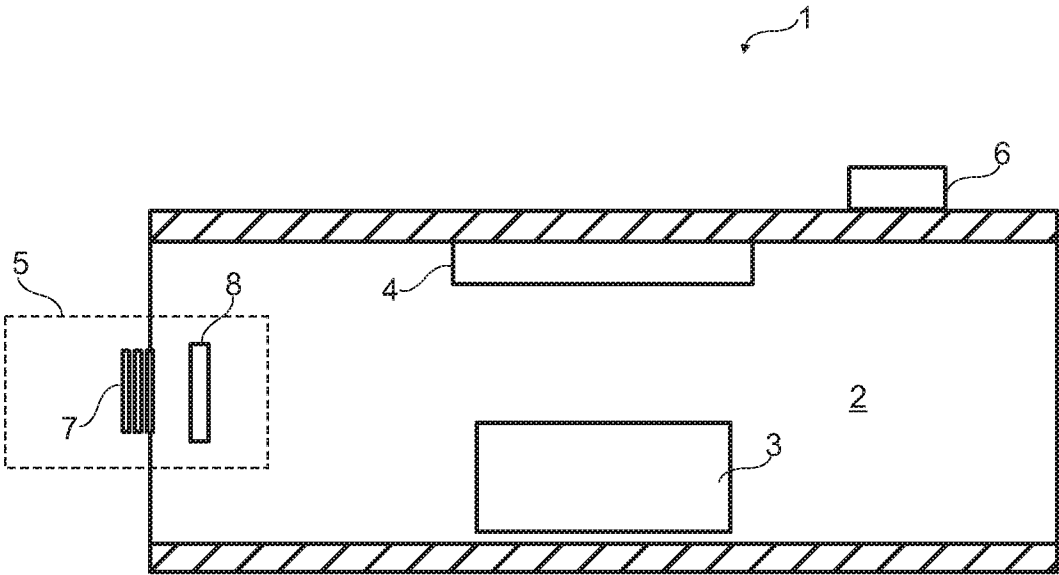
13. The refrigerator (1) according to claim 12, characterized in that the predetermined value A_1 is equal to or less than 0.05 ppm by weight.

14. The refrigerator (1) according to any one of claims 1 to 13, characterized in that the control unit (6) is further adapted to allow the user to enable or disable the food spoilage function.

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15. A method of controlling a refrigerator (1) comprising: a chamber (2) for storing and refrigerating food (3); and a door for opening/closing the chamber (2), the method comprising: a step (S1-S3; S101-S103) of sensing the level R of the volatile organic compounds which are released by the food (3) in the chamber (2); and a step (S4,S6; S104,S106) of determining the contamination level S in the chamber (2) based on the level R ; and a step (S5, S7-S8; S105, S107-S112) of cleaning the ambient air inside the chamber (2), the method being characterized in that the step (S4,S6; S104,S106) of determining the contamination level S is based on the currently sensed level R of the volatile organic compounds and a reference level R_0 of the volatile organic compounds which has been sensed immediately after the preceding cleaning step (S5, S7-S8; S105, S107-S112) has been finished and the sensing step (S1-S3; S101-S103) has been initialized in an initializing step (S9;S113).

Fig. 1



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Fig. 2

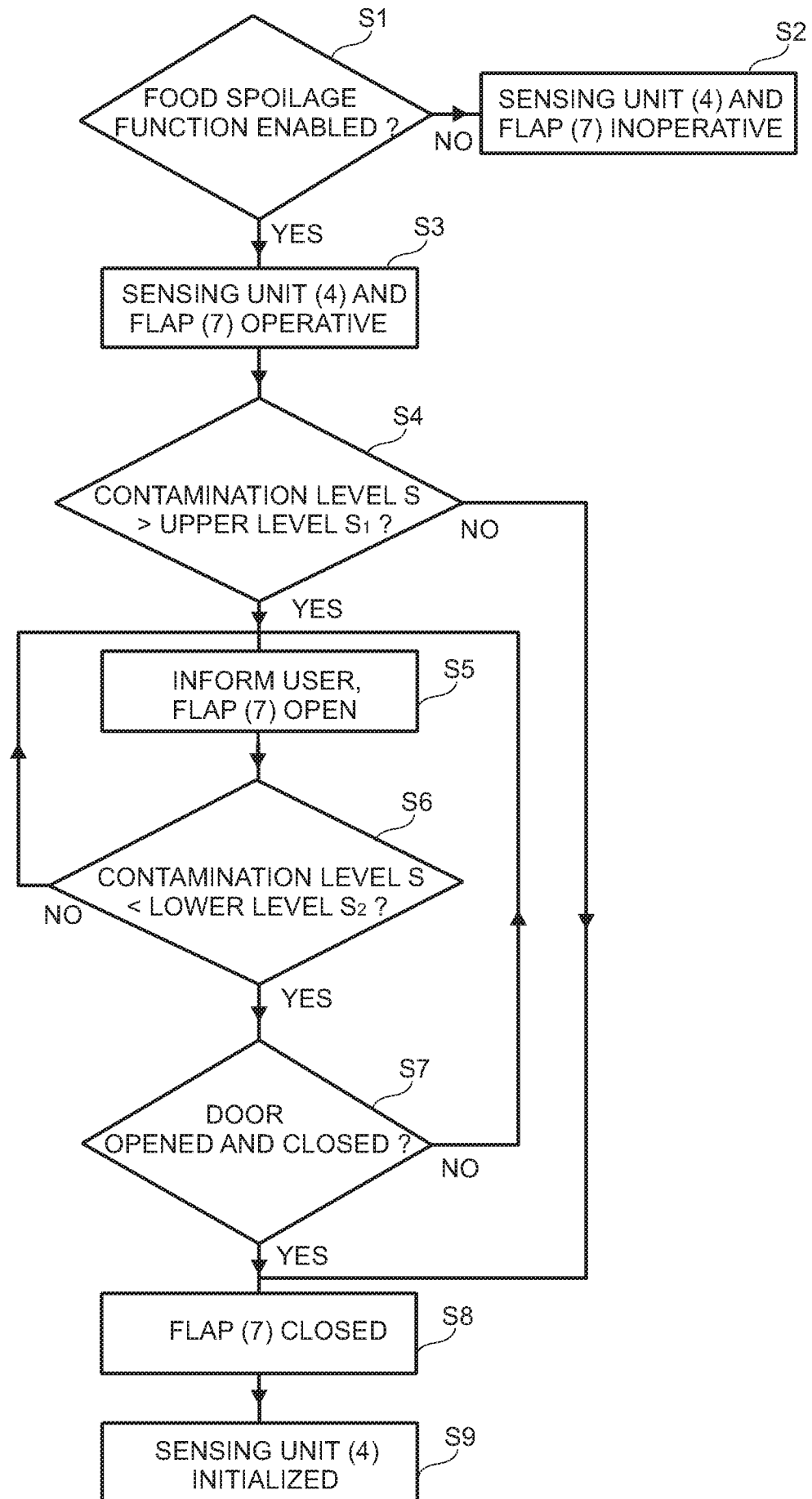
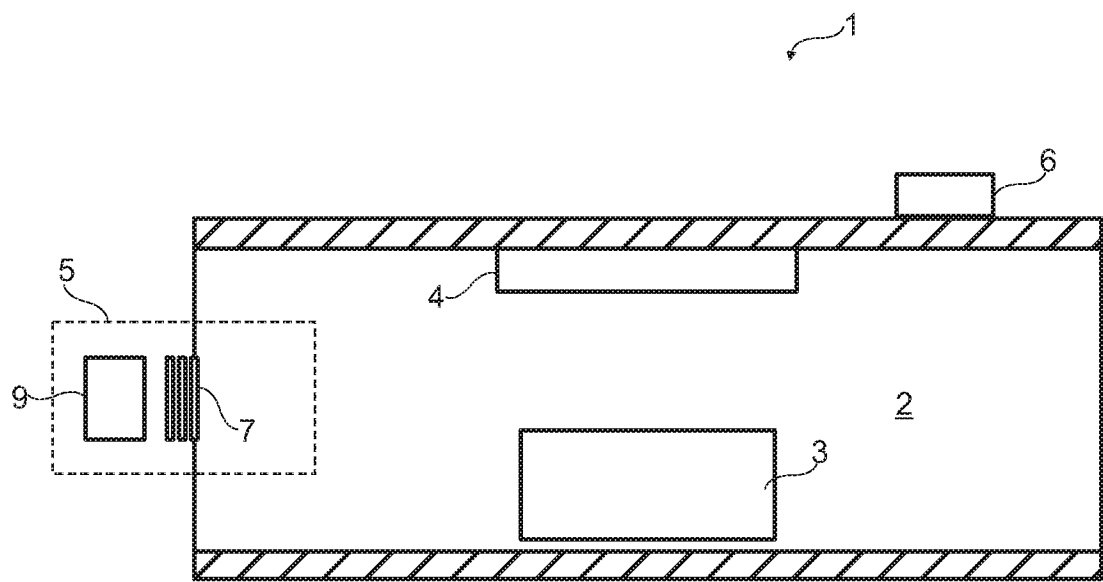


Fig. 3



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Fig. 4

