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(54) **AN APPARATUS AND METHOD FOR DETECTING FREEZING OF A SUBSTANCE**

(57) An apparatus (2) for detecting freezing of a substance (3) includes a conduit (4) containing a substance (3) having a freezing temperature below which the substance (3) is in a solid state and above which the substance (3) is in a liquid state. The apparatus (2) also includes a layer (9) that is permeable to the substance (3) in its liquid state. The conduit (4) is arranged to convey the substance (3) to the layer (9). The apparatus (2) also includes a flow meter (6) constructed and arranged to obtain a measure of the flow rate of the substance (3) through the layer (9), whereby the flow rate of the substance (3) through the layer (9) detected by the flow meter (6) varies depending on the degree of freezing of the substance (3) on or in the layer (9).

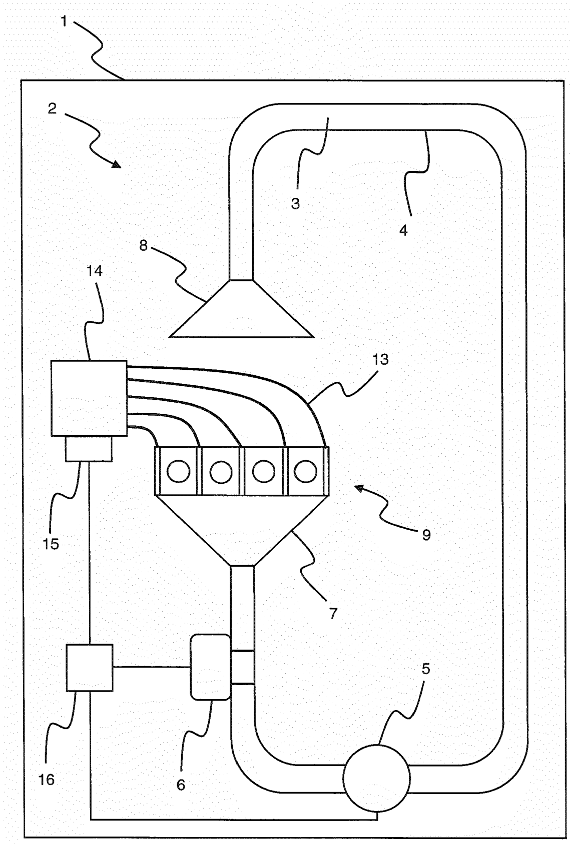

Figure 1

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Description

Technical Field

[0001] The present disclosure relates to an apparatus and method for detecting freezing of a substance.

Background

[0002] So-called frost-free refrigeration apparatus, such as freezers and refrigerators and the like, employ various complex methods for preventing a build-up of ice. One example of such a method is periodically heating the freezer or refrigerator to melt any ice that may have formed inside. This process can be wasteful and inefficient.

Summary

[0003] According to a first aspect disclosed herein, there is provided an apparatus for detecting freezing of a substance, the apparatus comprising: a conduit containing a substance having a freezing temperature below which the substance is in a solid state and above which the substance is in a liquid state; a layer that is permeable to the substance in its liquid state; the conduit being arranged to convey the substance to the layer; and a flow meter constructed and arranged to obtain a measure of the flow rate of the substance through the layer, whereby the flow rate of the substance through the layer detected by the flow meter varies depending on the degree of freezing of the substance on or in the layer.

[0004] This allows the apparatus to be used to effectively measure the degree of freezing of the substance on or in the layer by monitoring the flow rate of the substance through the layer detected by the flow meter. Such an apparatus can be used, for example, in monitoring the degree of freezing of a component in a refrigeration apparatus.

[0005] In an example, the apparatus is constructed and arranged so that the substance circulates around the apparatus in a closed loop.

[0006] In an example, the layer comprises a plurality of walls which define at least one channel between the walls. In an example, the layer comprises a plurality of walls which define a plurality of channels between the walls.

[0007] In an example, the plurality of walls are formed from a material having a high thermal conductivity. In an example, the material is a metal. In an example, the metal is stainless steel.

[0008] In an example, the layer comprises one or more nodes located within the layer at a position for impeding the flow of the substance through the layer. In an example, the layer comprises a plurality of nodes located within the layer at a position for impeding the flow of the substance through the layer. In an example, each node is a mesh.

[0009] In an example, each node is formed from a material having a rough outer surface. In an example, each node is formed from a fibrous material. In an example, each node is formed from cotton.

[0010] According to a second aspect disclosed herein, there is provided a refrigeration apparatus comprising an apparatus as described above.

[0011] In an example, the refrigeration apparatus comprises a component, a heater on or near the component, and one or more heat transfer elements connecting the component to the layer.

[0012] In an example, the component is a heat exchanger. In an example, the component is an evaporator.

[0013] In an example, the refrigeration apparatus comprises a controller, wherein the controller is configured to: activate the heater for a predetermined time interval when the controller senses that the flow rate of the substance through the layer detected by the flow meter is equal to or below a predetermined threshold flow rate.

[0014] According to a third aspect disclosed herein, there is disclosed a method for detecting freezing of a substance, the method comprising: conveying a substance to a layer, the substance having a freezing temperature below which the substance is in a solid state and above which the substance is in a liquid state, and the layer being permeable to the substance in its liquid state; and obtaining a measure of the flow rate of the substance through the layer, wherein the flow rate of the substance through the layer detected by the flow meter varies depending on the degree of freezing of the substance on or in the layer.

[0015] In an example, the method comprises circulating the substance through the layer and the flow meter in a closed loop.

[0016] In an example, the layer comprises a plurality of walls which define at least one channel between the walls. In an example, the layer comprises a plurality of walls which define a plurality of channels between the walls.

[0017] In an example, the plurality of walls are formed from a material having a high thermal conductivity. In an example, the material is a metal. In an example, the metal is stainless steel.

[0018] In an example, the layer comprises one or more nodes located within the layer at a position for impeding the flow of the substance through the layer. In an example, the layer comprises a plurality of nodes located within the layer at a position for impeding the flow of the substance through the layer. In an example, each node is a mesh.

[0019] In an example, each node is formed from a material having a rough outer surface. In an example, each node is formed from a fibrous material. In an example, each node is formed from cotton.

[0020] According to a fourth aspect disclosed herein, there is disclosed a method comprising: conveying a substance to a layer, the substance having a freezing temperature below which the substance is in a solid state and above which the substance is in a liquid state, and the layer being permeable to the substance in its liquid state; obtaining a measure of the flow rate of the substance through the layer, wherein the flow rate of the substance through the layer detected by the flow meter varies depending on the degree of freezing of the substance on or in the layer; activating a heater that is on or near the component for a predetermined time interval when the flow rate of the substance through the layer detected by the flow meter is equal to or below a predetermined threshold flow rate.

[0021] In an example, the component is a heat exchanger. In an example, the component is an evaporator.

Brief Description of the Drawings

[0022] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 shows schematically a side view of a first example of a refrigeration apparatus including an apparatus for detecting freezing of substance; and

Figure 2 shows schematically a close up side view of the permeable layer shown in Figure 1;

Figure 3 shows schematically a close up side view of the permeable layer shown in Figure 1; and

Figure 4 shows schematically a side view of the apparatus shown in Figure 1 and a perspective view of a second example of a permeable layer.

Detailed Description

[0023] As mentioned previously, refrigeration apparatus, such as for example frost-free freezers and refrigerators and the like, prevent a build-up of ice, particularly on for example the heat exchanger, using relatively complex or inefficient methods. One such method is periodically activating a heater that is located on or near the heat exchanger to melt any ice that may have formed. Often these methods are wasteful, particularly if heaters are used excessively, and inefficient. These methods have no regard for whether ice has actually formed, and simply periodically heat the heat exchanger regardless.

[0024] Referring now to Figure 1, there is shown schematically an example of a refrigeration apparatus 1 including an apparatus 2 for detecting freezing of a substance 3. The substance 3 has a freezing temperature below which the substance 3 is in a solid state and above which the substance 3 is in a liquid state. In this example, the substance 3 is water/ice. The refrigeration apparatus may be a refrigerator or a freezer or the like.

[0025] The apparatus 2 includes a conduit 4, a pump 5, a flow meter 6, a funnel 7, a spraying tool 8 and a permeable layer 9.

[0026] The conduit 4 contains the substance 3 and is arranged to transport the substance 3 to and from the permeable layer 9. In this example, the conduit 4 operates in a closed loop with the pump 5, the flow meter 6, the funnel 7, the spraying tool 8 and the permeable layer 9. The substance 3 is preserved within the closed loop. The conduit 4 may be any type of channel that is suitable for transporting a substance 3 in its liquid state, such as a pipe or a duct. In this example, an outflow of the conduit 4 is connected to the spraying tool 8, which in this example is located above the permeable layer 9, and an inflow of the conduit 4 is connected to the funnel 7, which is connected to the outflow of the permeable layer 9, in this example below the permeable layer 9.

[0027] The pump 5 is provided in line with the conduit 4. Activation of the pump 5 transports the substance 3 through the conduit 4, around the closed loop, out of the spraying tool 8 and towards the permeable layer 9.

[0028] The flow meter 6 is provided at the outflow side of the permeable layer 9 and in line with the conduit 4. The flow meter 6 is located so that it can obtain a measure of the flow rate of the substance 3 through the permeable layer 9. The flow rate of the substance 3 through the permeable layer 9 detected by the flow meter 6 varies depending on the degree of freezing of the substance 3 on or in the permeable layer 9. If the temperature on or in the permeable layer 9 is above the freezing point of the substance 3, the substance 3 will remain in a liquid state and so the liquid substance can flow through the permeable layer (as is shown in Figure 2, which is described below). However, if the temperature on or in the permeable layer 9 decreases to below the freezing point of the substance 3, at least a portion of the substance 3 will freeze and thus transition into a solid state on or in the permeable layer 9. The solid substance deposited on or in the permeable layer 9 at least partially blocks the permeable layer 9, reducing its permeability (as is shown in Figure 3, which is described below). If the permeable layer 9 is at least partially blocked, the flow rate of the substance 3 in its liquid state through the permeable layer 9 decreases and therefore the flow rate detected by the flow meter 6 decreases. Accordingly, the flow rate of the substance 3 in its liquid state through the permeable layer 9 detected by the flow meter 6 can be used to provide a measure of the temperature within the permeable layer 9.

[0029] The funnel 7 is connected between the outflow of the permeable layer 9 and inflow of the conduit 4 so that it conveys the substance 3 from the permeable layer 9 to the conduit 4 and towards the flow meter 6. In this example, the permeable layer 9 has a much greater cross sectional area than the conduit 4 and so the funnel 7 has a shape that can channel the substance 3 from the outflow of the permeable layer 9 into the conduit 4.

[0030] The spraying tool 8 is connected to the outflow of the conduit 4. The spraying tool 8 is constructed and arranged to evenly distribute the substance 3 in its liquid state flowing through the conduit 4 over an upper surface of the permeable layer 9. In this example, the spraying tool 8 is a simple mechanical device having a plurality of nozzles arrayed over the upper surface of the permeable layer 9.

[0031] The permeable layer 9 is constructed and arranged so that it is permeable to the substance 3 when the substance 3 is in its liquid state. That is, when the substance 3 is in its liquid state, the substance 3 can pass through the permeable layer 9. However, when the substance 3 is in its solid state (e.g. the temperature of the substance 3 has decreased below its freezing point so that it has frozen), the substance 3 cannot pass through the permeable layer 9. Indeed, in this example, when the substance 3 is in its solid state tends to adhere to the permeable layer 9 rather than passing through it.

[0032] Figures 2 and 3 show schematic, partially sectioned side views of the permeable layer 9 to show additional details. In this example, the permeable layer 9 includes a lattice-like structure formed from a highly thermally conductive material such as a metal. The lattice-like structure may be formed from, for example, stainless steel. In this example, the lattice-like structure includes a plurality of walls 10 that are arranged to be substantially parallel to one another so that they define a plurality of channels 11 between the walls 10. The walls 10 in this example are arranged to be substantially vertical and they therefore define a plurality of substantially vertical channels 11. The walls 10 may be arranged in a honeycomb or square or rectangular lattice-like structure.

[0033] In this example, a node 12 is positioned within each channel 11. Each node 12 is constructed and arranged so that it impedes flow of the substance 3 through the channel 11 that it sits within when the substance 3 is in its liquid state. Similarly, each node 12 is arranged so that when the substance 3 is in its solid state, the substance 3 tends to adhere to the node 12 and thus remains within or in the vicinity of the corresponding channel 11. This partially or fully blocks flow of the substance 3 in its liquid state through the channel 11. In this example, each node 12 is formed from a material having a relatively rough outer surface so as to improve the adhesion between the node 12 and the substance 3 in its solid state. The node 12 may be formed from for example a fibrous natural or synthetic material. A particularly suitable example is cotton. In this example, each node 12 is formed of a bundle of cotton wool wrapped around a metal wire or mesh.

[0034] Figure 2 shows the substance 3 in its liquid state and flowing through the open channels 11 of the permeable layer 9.

[0035] Figure 3 shows the substance 3 frozen into its solid state and adhered to the node 12. The frozen substance 3 is fully blocking flow through the channels 11 of the permeable layer 9. Consequently, the flow rate of the substance 3 through the permeable layer 9 detected by the flow meter 6 is lower than when at least one of the channels 11 is open.

[0036] Figure 4 shows schematically a perspective view of a second example of a permeable layer 29. The remaining components of the apparatus 2 shown in Figure 4 are the same as the apparatus 2 shown in Figure 1. In this example, the lattice-like structure of the permeable layer 29 includes twelve walls 210 that are arranged to be substantially parallel to one another so that they define eleven channels 211 between the walls 210. A node 213 is suspended within each channel at a location that impedes flow of the substance 3 through the channel 211 that it sits within when the substance 3 is in its liquid state. Each node 214 is attached to the lattice-like structure at opposing ends of the channel 211 that it sits within.

[0037] Referring now back to Figure 1, the lattice-like structure of the permeable layer 9 is thermally connected to a surface of a component of the refrigeration apparatus 1 by a plurality of heat transfer elements, which in this example are metal wires 13. In this example, the wires 13 are connected to the walls 10 of the lattice-like structure so that they transfer heat between the walls 10 and the component. Therefore, if the temperature of the surface of the component to which the thermally conductive wires 13 are attached decreases, the temperature of the walls 10 decreases.

[0038] In this example, the component is a heat exchanger 14. The heat exchanger 14 reduces the temperature of a compartment (not shown) of the refrigeration apparatus 1, in which a user can store goods such as food. A heater 15 is located on the heat exchanger 14 so that activation of the heater 15 increases the temperature of the heat exchanger 14. If the temperature is increased sufficiently, any ice formed on the heat exchanger 14 during use of the refrigeration apparatus 1 is melted. In another example, the heater 15 is located near the heat exchanger 14. In this example, ice can form on the heat exchanger 14 during use, which reduces the efficiency of the heat exchanger 14. Therefore, activating the heater 15 melts the ice and consequently improves the functioning of the heat exchanger 14.

[0039] A controller 16, which may be a processor or the like, is provided within the refrigeration apparatus 1 for controlling operation of the pump 5 to circulate the substance 3 around the closed loop of the apparatus 2. The controller 16 also controls the operation of the heater 15 to melt ice build-up on the heat exchanger 14. The controller 16 is connected to the flow meter 6, the pump 14 and the heater 15.

[0040] The controller 16 is configured to activate and deactivate the heater 15 depending on the flow rate of the substance 3 through the permeable layer 9 detected by the flow meter 6. In particular, the controller 6 activates the heater 15 for a predetermined time interval if the flow meter 6 detects a flow rate of the substance 3 that is below a predetermined threshold flow rate. The predetermined threshold flow rate flow rate corresponds to a flow rate of the substance 3 through the permeable layer 9 that is indicative of a build-up of ice on the heat exchanger 14, as is described below.

[0041] As mentioned above, the flow rate of the substance 3 through the permeable layer 9 varies depending on the degree of freezing/solidification of the substance 3 on or in the channels 11 of the permeable layer 9. The degree of freezing of the substance 3 depends on the temperature of the substance 3. The temperature of the substance 3 as it passed over the permeable layer 9 depends (mostly) on the temperature of and within the permeable layer 9, which is subject to heat transfer to and from the heat exchanger 14 through the wires 13. If the temperature of the substance 3 decreases from above to below its freezing point, which for water is 0°C, the substance freezes from its liquid state into its solid state. Similarly, if the temperature of the substance 3 increases from below to above its freezing point, the substance melts from its solid state into its liquid state.

[0042] A method of defrosting the heat exchanger 14 will now be described. Whilst the refrigeration apparatus 2 is active, the controller 16 carries out the method of defrosting regularly such as, for example, every 10 minutes or every 15 minutes.

[0043] Initially, the controller 16 activates the pump 5, which circulates the substance 3 in its liquid state around the closed loop of the apparatus 2 shown in Figure 1. The substance 3 is pumped through the conduit 4 and out of the outflow of the conduit 4 through the spraying tool 8. The spraying tool 8 distributes the liquid substance 3 homogeneously over an upper surface of the permeable layer 9.

[0044] The walls 10 of the permeable layer 9 are connected to a surface of the heat exchanger 14 by the wires 13, which are heat transfer elements. Therefore, if the temperature of the surface of the heat exchanger 14 is below the temperature of the permeable layer 9, heat transfers from the permeable layer 9 to the heat exchanger 14 via the wires 13, thereby reducing the temperature of the permeable layer 9. Similarly, if the temperature of the surface of the heat exchanger 14 is above the temperature of the permeable layer 9, heat transfers from the heat exchanger 14 to the permeable layer 9 via the wires 13, thereby increasing the temperature of the permeable layer 9.

[0045] If the temperature of the surface of the heat exchanger 14 is such that the temperature of the permeable layer 9 is above the freezing point of the substance 3, the temperature of the substance 3 will also be above its freezing point and so it remains in its liquid state. The liquid substance 3 thus flows freely through the open and unblocked channels 11 under the force of gravity and thus permeates through the permeable layer 9 (see Figure 2). The substance 3 then falls into the funnel 7, which directs it towards the inflow of the conduit 4 and towards the flow meter 6. As the substance passes the flow meter 6, the flow meter 6 detects the flow rate of the substance, which is effectively the flow rate of the substance 3 through the permeable layer 9. The controller 16 then deactivates the pump 5 circulating the substance 3 in its liquid state around the closed loop of the apparatus 2.

[0046] In this example, the flow rate of the substance 3 through the permeable layer 9 detected by the flow meter 6 is above the predetermined threshold flow rate and therefore the controller 16 takes no action regarding the heater 14.

[0047] If the temperature of the surface of the heat exchanger 14 decreases sufficiently so that the temperature of the permeable layer 9 decreases to be below the freezing point of the substance 3, the temperature of a at least a portion of the substance 3 flowing through the permeable layer 9 will drop to below the freezing point of the substance 3. This portion of the substance 3 then freezes into a solid as it passes through a channel 11 of the permeable layer 9. The frozen substance 3 adheres to the node 12 and at least partially blocks the channel 11, thereby reducing the flow rate through the channel 11 of any liquid substance 3 that has not frozen. Indeed, if the temperature of heat exchanger 14/the permeable layer 9 is low enough, or if the temperature of the heat exchanger 14/permeable layer 9 remains below the freezing point of the substance 3 for a sufficiently long period of time, the frozen substance 3 can completely block a channel 11 and thereby fully prevent any liquid substance 3 from flowing through the channel 11 (see Figure 3).

[0048] If the channels 11 are partly or fully blocked by frozen substance 3, the flow rate of the substance 3 through the permeable layer 9 measured by the flow meter 6 decreases. The controller 16 senses this decrease in the flow rate detected by the flow meter 6 and deactivates the pump 5. If the flow rate measured by the flow meter 6 drops to be below the predetermined threshold flow rate, the controller 16 activates the heater 15. In this example, the predetermined threshold flow rate corresponds to a flow rate that indicates the temperature of the surface of the heat exchanger 14 to which the wires 13 are attached may be such that ice can build up on the surface of the heat exchanger 14 (i.e. the temperature of the surface of the heat exchanger 14 is below the freezing point of water). Activating the heater 15 heats the surface of the heat exchanger 14, increasing its temperature. If the temperature of the surface of the heat exchanger 14 increases above the freezing point of water, any ice build-up on the heat exchanger 14 melts.

[0049] The heater 15 remains activated for a predetermined period of time. The wires 13 conduct heat from the heated heat exchanger 14 surface to the lattice-like structure of the permeable layer 9, which increases the temperature of the permeable layer 9 and consequently increases the temperature of the frozen substance 3 to above its freezing point. The frozen substance 3 then melts and the channels 11 become unblocked, allowing substance 3 in its liquid state to once again pass through the permeable layer 9.

[0050] Accordingly, the apparatus 2 can effectively sense when there is a build-up of ice on a component of the refrigeration apparatus 1 (such as the heat exchanger 14) and then control the activation and deactivation of the heater 15 associated with the component to melt the ice. Melting the ice improves the functioning of the component. In prior art refrigeration apparatus, a heater is activated periodically, with no regard to the actual ice build-up and whether or not it is actually required to be activated. Therefore, controlling the activation and deactivation of the heater 15 so that it only activates when required (i.e. when there is a build-up of ice) minimises unnecessary energy use by the heater 15 whilst ensuring that the ice build-up on the component is melted when required.

[0051] It will be understood that the controller referred to herein may in practice be provided by a single chip or integrated circuit or plural chips or integrated circuits, optionally provided as a chipset, an application-specific integrated circuit (ASIC), field-programmable gate array (FPGA), digital signal processor (DSP), graphics processing units (GPUs), etc. The chip or chips may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry, which are configurable so as to operate in accordance with the exemplary embodiments. In this regard, the exemplary embodiments may be implemented at least in part by computer software stored in (non-transitory) memory and executable by the processor, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware).

[0052] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope of the invention, which is defined in the claims.

[0053] For example, the apparatus may also be used in other applications where it may be useful to determine or detect that a reduction in temperature by sensing that a substance has frozen or solidified.

Claims

1. An apparatus for detecting freezing of a substance, the apparatus comprising:

   a conduit containing a substance having a freezing temperature below which the substance is in a solid state and above which the substance is in a liquid state;
   a layer that is permeable to the substance in its liquid state;
   the conduit being arranged to convey the substance to the layer; and
   a flow meter constructed and arranged to obtain a measure of the flow rate of the substance through the layer, whereby the flow rate of the substance through the layer detected by the flow meter varies depending on the degree of freezing of the substance on or in the layer.

2. An apparatus according to claim 1, wherein the apparatus is constructed and arranged so that the substance circulates around the apparatus in a closed loop.

3. An apparatus according to claim 1 or claim 2, wherein the layer comprises a plurality of walls which define at least one channel between the walls.

4. An apparatus according to any preceding claim, wherein the layer comprises one or more nodes located within the layer at a position for impeding the flow of the substance through the layer.

5. An apparatus according to claim 4, wherein each node is formed from a material having a rough outer surface.

6. A refrigeration apparatus comprising an apparatus according to any preceding claim.

7. A refrigeration apparatus according to claim 6, comprising a component, a heater on or near the component, and one or more heat transfer elements connecting the component to the layer.

8. A refrigeration apparatus according to claim 7, wherein the component is a heat exchanger.

9. A refrigeration apparatus according to claim 7 or claim 8, comprising a controller, wherein the controller is configured to:

   activate the heater for a predetermined time interval when the controller senses that the flow rate of the substance through the layer detected by the flow meter is equal to or below a predetermined threshold flow rate.

10. A method for detecting freezing of a substance, the method comprising:

   conveying a substance to a layer, the substance having a freezing temperature below which the substance is in a solid state and above which the substance is in a liquid state, and the layer being permeable to the substance in its liquid state; and
   obtaining a measure of the flow rate of the sub-

stance through the layer,
wherein the flow rate of the substance through the layer detected by the flow meter varies depending on the degree of freezing of the substance on or in the layer.

11. A method according to claim 1, comprising circulating the substance through the layer and the flow meter in a closed loop.

12. A method according to claim 10 or claim 11, wherein the layer comprises a plurality of walls which define at least one channel between the walls.

13. A method according to any one of claims 10 to 12, wherein the layer comprises one or more nodes located within the layer at a position for impeding the flow of the substance through the layer.

14. A method according claim 13, wherein each node is formed from a material having a rough outer surface.

15. A method for defrosting a component of a refrigeration apparatus, the method comprising:

conveying a substance to a layer, the substance having a freezing temperature below which the substance is in a solid state and above which the substance is in a liquid state, and the layer being permeable to the substance in its liquid state;
obtaining a measure of the flow rate of the substance through the layer, wherein the flow rate of the substance through the layer detected by the flow meter varies depending on the degree of freezing of the substance on or in the layer;
activating a heater that is on or near the component for a predetermined time interval when the flow rate of the substance through the layer detected by the flow meter is equal to or below a predetermined threshold flow rate.

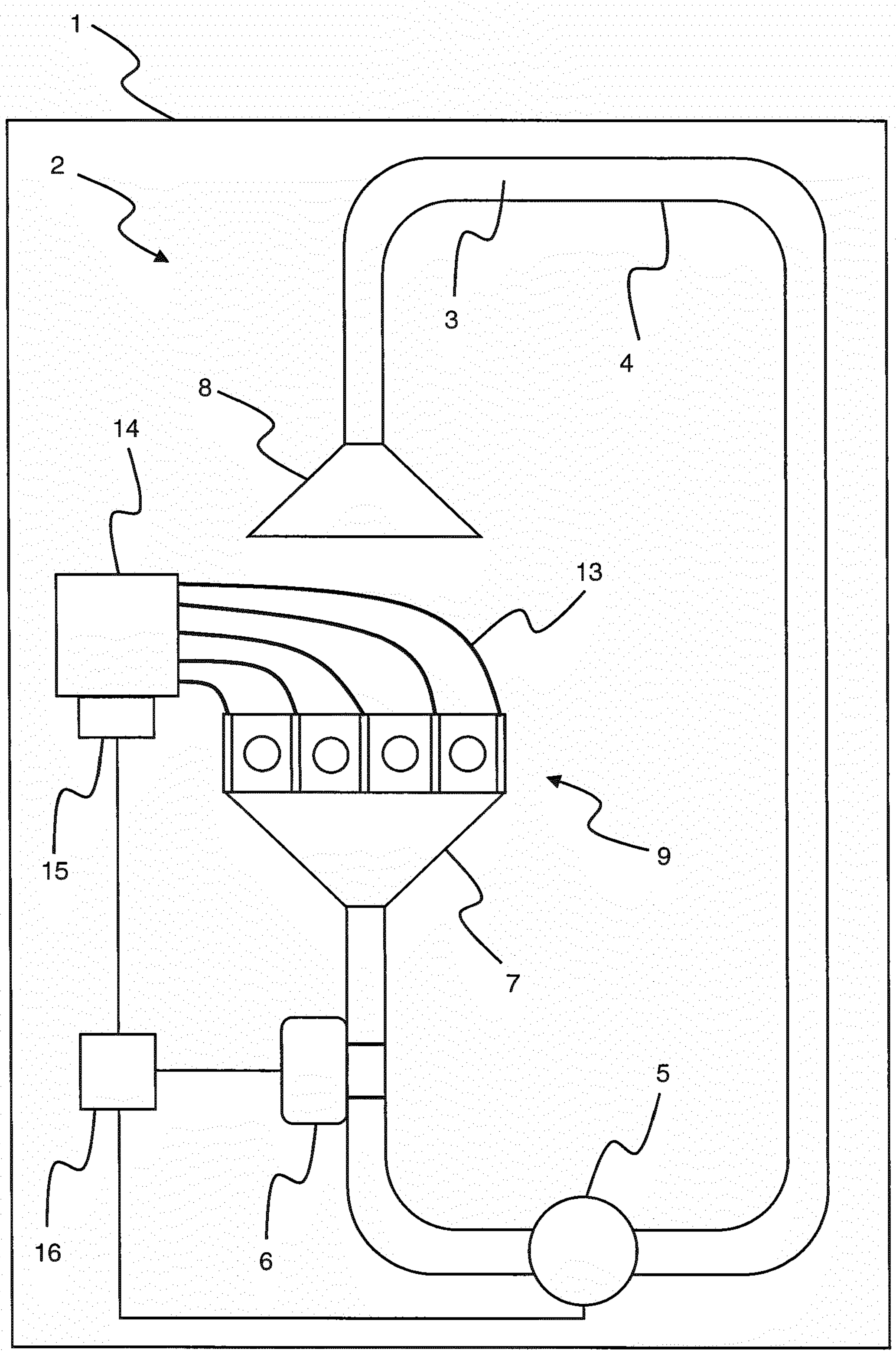

Figure 1

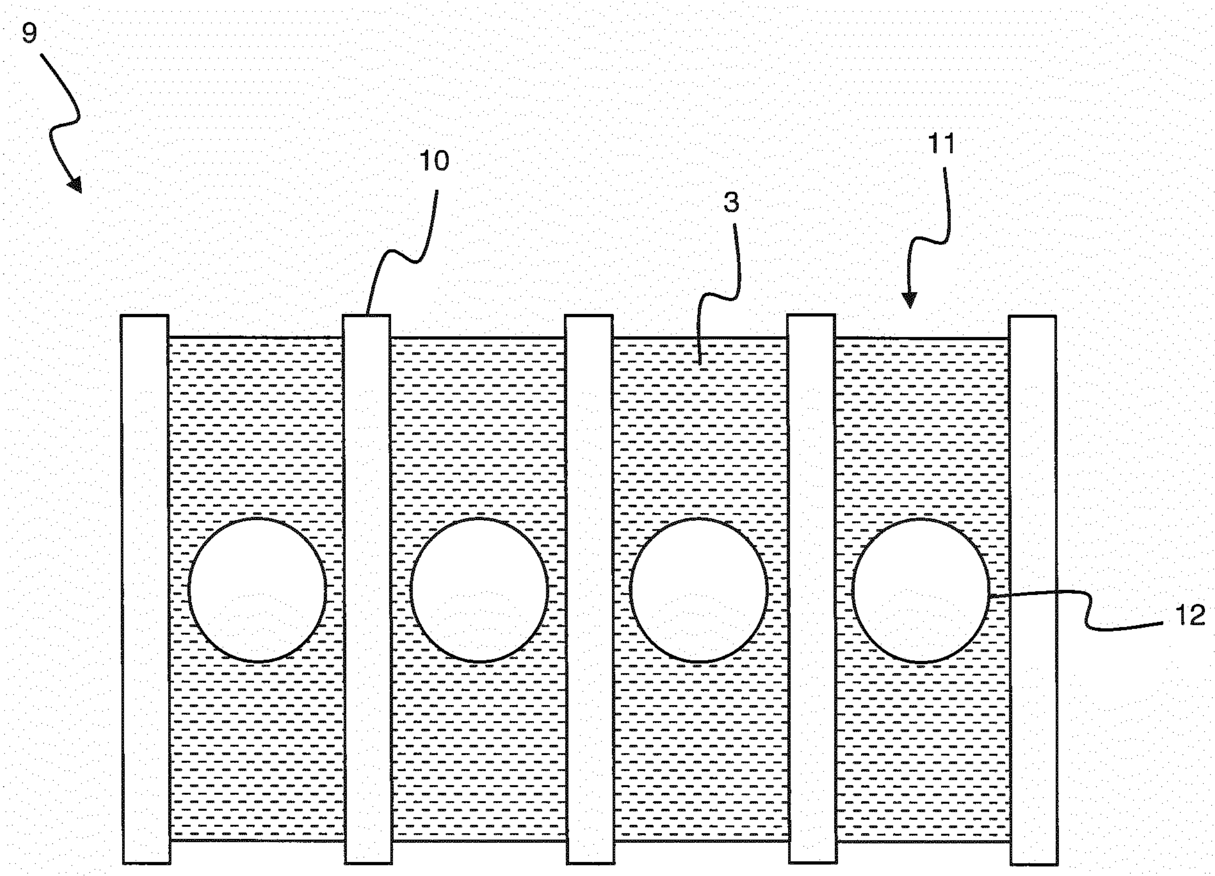

Figure 2

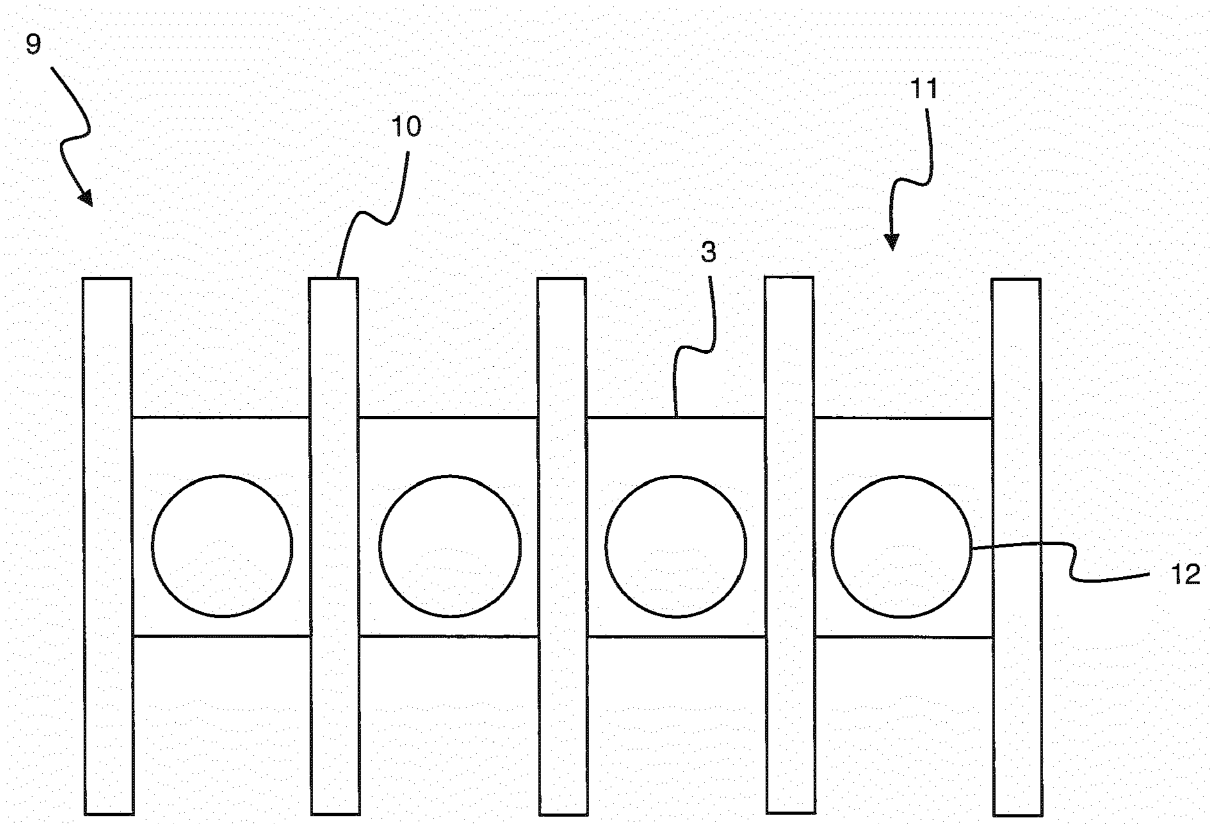

Figure 3

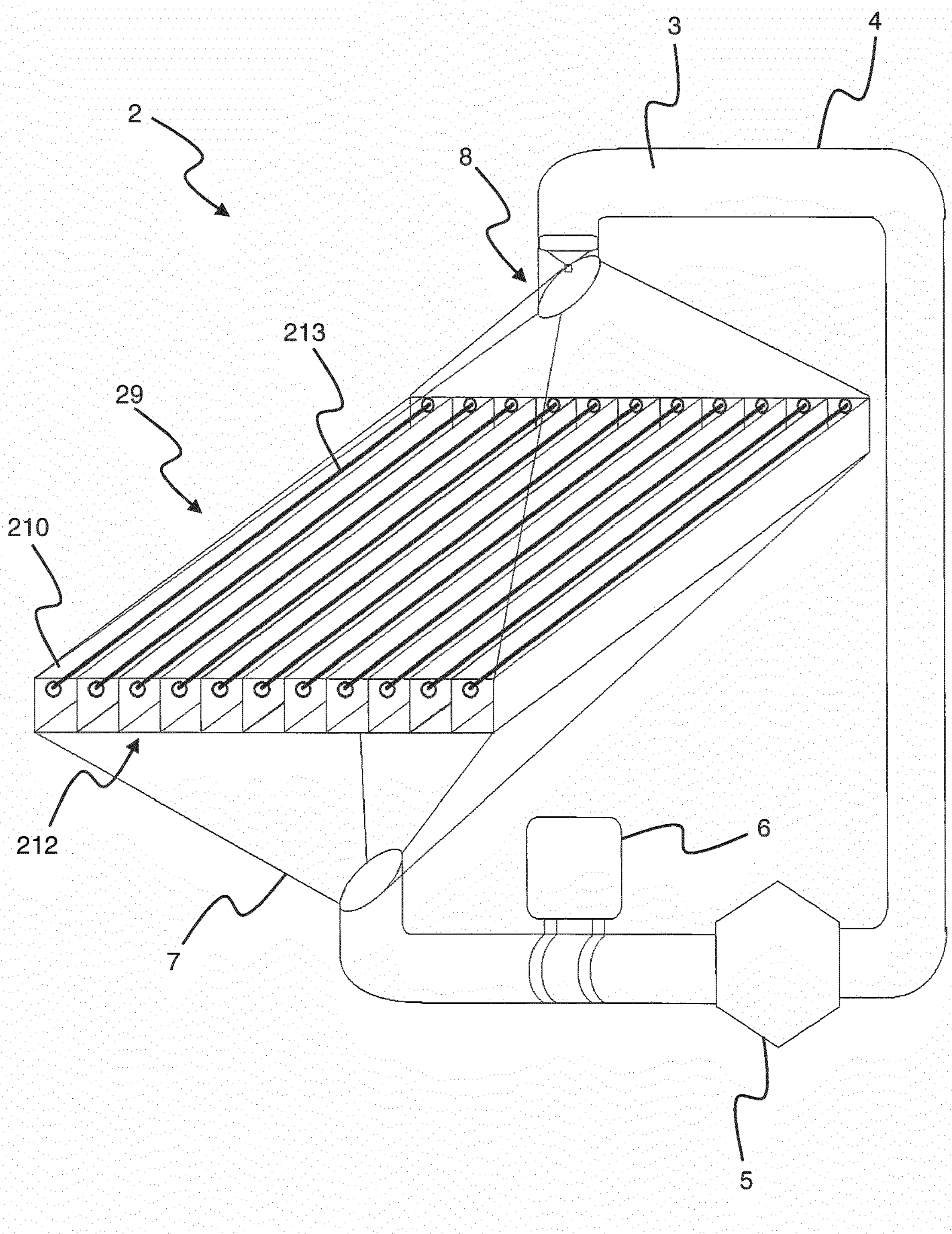

Figure 4

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 3538

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 2014 016155 A (TAKASAGO THERMAL ENGINEERING) 30 January 2014 (2014-01-30) * abstract; figures 1-6 * * paragraphs [0008], [0010], [0020], [0023], [0028], [0031] * -----	1-15	INV. F25C5/08
X	JP H11 257694 A (ISHIKAWAJIMA HARIMA HEAVY IND) 21 September 1999 (1999-09-21) * abstract; figures 1-7 * -----	1-15	
A	CN 104 792 080 A (WANG FEIBO; ZHOUSHAN OUSENTIANYUAN TECHNOLOGY CO LTD) 22 July 2015 (2015-07-22) * abstract; figure 1 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F25C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	7 March 2018	Bidet, Sébastien

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 17 19 3538

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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