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(54) **REFRIGERATOR APPLIANCE**

(57) A refrigerator appliance (100) comprises an evaporator (130) that forms with a compressor (140) and a condenser (150) a closed cooling circuit wherein a refrigerant fluid is made to circulate. The condenser (150) is configured as a skin condenser and comprises a serpentine tube (160) associated with a thermally conductive layer (170). The thermally conductive layer (170) is made up of a plurality of plates (171, 172) arranged such that a tail portion of a first plate (171) is superimposed to and connected with a front portion of a second plate (172). Straight portions (161, 162) of the serpentine tube (160) are clinched between the two plates at their connection interface. A defrost water drain pipe (180) typically used to drain condensation water from the evaporator is arranged in thermal exchange contact with the skin condenser (150).

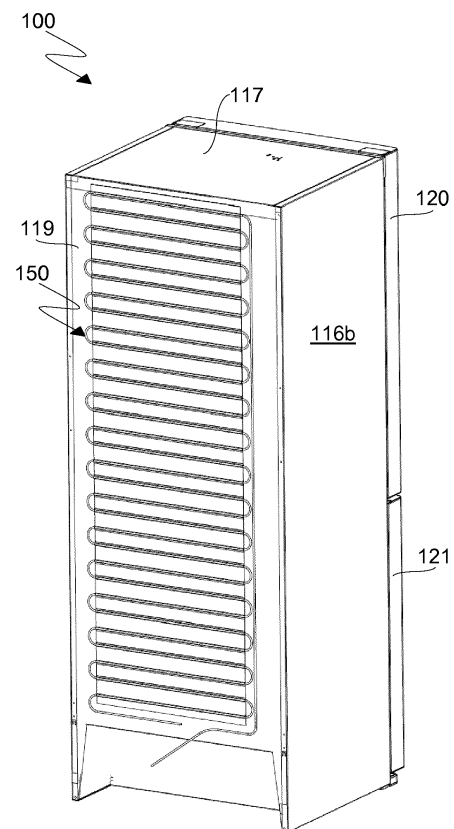


Fig.2

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Description

Technical field of the invention

[0001] The present invention generally relates to refrigerator appliances and more particularly to household refrigerator appliances having a skin condenser.

Background

[0002] Refrigerator appliances conventionally comprise a cabinet made up of an inner container and an outer container that define between them a cavity filled with a thermally insulating material like e.g. a polyurethane foam. The cabinet comprises a door that is pivotally assembled on one of its side walls.

[0003] It is known that a standard refrigeration cycle includes four stages. First, a refrigerant fluid in a gaseous phase is compressed by a compressor to high pressure and high temperature. Second, the refrigerant fluid is made to flow through a condenser wherein it is cooled by heat exchange with ambient air and changes phase from gaseous to liquid. Third, the refrigerant fluid passes through an expansion device that reduces its pressure and temperature. The refrigerant fluid is then fed to an evaporator arranged in thermal contact with the inside of the cabinet where it evaporates thus absorbing heat from the cabinet cavity. The refrigerant fluid exiting the evaporator returns to the compressor and the cycle is repeated.

[0004] The condenser is typically in the form of a plate on tube (PoT) or wire on tube (WoT) heat exchanger mounted on the back wall of the refrigerator cabinet and spaced apart from it by using e.g. brackets. Cooling may occur due to natural convection or by drawing or blowing air across the condenser typically by way of a fan.

[0005] Alternatively to plate on tube (PoT) or wire on tube (WoT) heat exchangers, "skin condensers" have been proposed. These condensers comprise tubes that are attached to or integrated into one or more of the cabinet walls.

[0006] Compared to plate on tube (PoT) or wire on tube (WoT) heat exchangers, skin condensers have a smaller number of parts and are less cumbersome. Manufacturing costs are therefore lower and risks of contacting parts protruding from the back wall of a refrigerator appliance are reduced.

[0007] It is known that, in order to achieve a thermal exchange rate comparable to that of a plate on tube (PoT) or wire on tube (WoT) heat exchanger, a large surface area of the condenser is required. Skin condensers integrated in the cabinet walls generally have a poor thermal exchange rate due to the contact with the insulation layer of the cabinet.

[0008] Also known are skin condenser where a serpentine tube is glued on a thermally conductive layer applied to the outer surface of the back wall of the refrigerator cabinet. An example of a skin condenser of this type

is disclosed by WO 2019/020175 A1. This configuration allows to increase thermal exchange with the environment surrounding the refrigerator appliance, because the tube is arranged outside the refrigerator cabinet.

[0009] However, contact with the thermally conductive layer is rather limited, because the serpentine has a cross section with a substantially circular shape. Hence, thermal exchange with the outer environment is penalized.

[0010] In addition to this, possible planarity issues of the conductive layer and/or of the tube may negatively affect their mutual contact.

Summary of the invention

[0011] The technical problem underlying and solved by the present invention is therefore to provide a refrigerator appliance with a skin condenser that allows to overcome the drawbacks mentioned above with reference to the prior art.

[0012] This problem is solved by a refrigerator appliance according to the independent claim 1. Preferred features of the present invention are set forth in the dependent claims.

[0013] The refrigerator appliance of the invention comprises an evaporator that forms with a compressor and a condenser a closed cooling circuit wherein a refrigerant fluid is made to circulate.

[0014] The condenser is configured as a skin condenser and comprises a serpentine tube associated with a thermally conductive layer. Thanks to this feature, not only can the outer size of the refrigerator appliance be reduced and manufacturing costs be lowered, but the size of the refrigerator cavity can be enlarged to achieve a larger storing capacity for the benefit of the users.

[0015] According to a preferred embodiment of the invention, the thermally conductive layer forms the whole back wall of the outer casing of the cabinet of the refrigerator appliance. Hence, together with the other cabinet walls the skin condenser allows to contain the insulating foam during the foaming process.

[0016] According to a preferred embodiment of the invention, the thermally conductive layer is made up of a plurality of plates arranged such that a tail portion of a first plate is superimposed to and connected with a front portion of a subsequent, second plate. The straight portions of the serpentine tube are clinched between the two plates at their connection interface, thus allowing to achieve a good surface contact with the thermally conductive layer as a whole. This results in an effective thermal exchange with the outer environment and hence in a good thermal performance of the skin condenser. Energy consumption of the refrigerator appliance is thus effectively reduced compared to prior art appliances of a similar size.

[0017] According to the invention, the defrost water drain pipe typically used to drain defrost water from the evaporator is advantageously arranged in thermal exchange contact with the skin condenser. Thanks to this

configuration, heat extracted from the refrigeration fluid can effectively be used to prevent unwanted ice clogging of defrost water inside the pipe and to effectively warm up defrost water, allowing a quicker evaporation. This also allows to use a smaller tray to collect defrost water.

[0018] According to a further embodiment of the invention, phase-change materials may effectively be associated with the skin condenser to promote thermal exchange and increase energy efficiency. Phase change materials may be applied to the thermally conductive layer in the form of a coating of the plates or as blocks/pouches attached thereto, and combinations thereof.

[0019] Further advantages, features and operation modes of the present invention will become clear from the following detailed description of embodiments thereof, which are given for illustrative and not-limiting purposes.

Brief description of the drawings

[0020] Reference will be made to the figures of the accompanying drawings, in which:

- figure 1 is a front, perspective view showing a refrigerator appliance according to the present invention;
- figure 2 is a rear, perspective view of the refrigerator appliance of figure 1;
- figure 3 is a schematic longitudinal section of the refrigerator appliance of figure 1, taken along a plane passing through line III-III of figure 1;
- figure 4 is a plan view of a skin condenser of the refrigerator appliance according to the invention;
- figure 5 is a detail view showing a partial longitudinal section of the skin condenser of figure 4, taken along a plane passing through line V-V of figure 1;
- figure 6 is a detail view schematically showing a partial longitudinal section of the back wall of a refrigerator appliance according to an embodiment of the invention;
- figure 7 is a detail view showing a partial longitudinal section of the skin condenser of a refrigerator appliance according to a further embodiment of the invention.

Detailed description of preferred embodiments

[0021] With reference to the figures, a refrigerator appliance according to the invention is generally indicated by reference number 100.

[0022] In the figures, the refrigerator appliance 100 is shown with reference to a three-dimensional coordinate system. A first axis X and a second axis Y that are mu-

tually perpendicular define a horizontal plane, while a third axis Z, perpendicular to said horizontal plane, defines a vertical axis along which the force of gravity acts.

[0023] The refrigerator appliance 100, hereinafter also referred to as refrigerator only, comprises a cabinet 110 whose cavity is configured to store food items. The appliance shown in the drawings is e.g. a "bottom mount" refrigerator, where a refrigerator compartment 111 is formed above a freezer compartment 112 in a vertical direction and are separated from each other by a mullion 113. An evaporator is provided to cool the refrigerator compartment 111 and the freezer compartment 112 at cooling temperatures typically comprised between 1°C and 10°C and between -18°C and -28°C, respectively.

[0024] It will be appreciated that neither the type of refrigerator, nor the configuration of the evaporator are limiting features of the invention.

[0025] The cabinet 110 comprises an inner casing or liner 114 e.g. made of a polymeric material, where the refrigerator compartment 111 and the freezer compartment 112 are formed, and an outer casing 115. The outer casing 115 is spaced apart from the inner casing 114 so as to define a cavity filled with a thermally insulating material such as e.g. polyurethane foam.

[0026] The outer casing 115 typically has a parallelepiped shape and comprises a pair of spaced apart side walls 116a, 116b, a top wall 117, a bottom wall 118 and a back wall 119. These walls may e.g. be made of sheet metal or a plastic material.

[0027] The refrigerator compartment 111 and the freezer compartment 112 are selectively accessible through respective doors 120, 121.

[0028] As anticipated above, the refrigerator appliance 100 comprises an evaporator, such as e.g. an evaporator 130 that is arranged e.g. below the mullion 113, allowing to cool air which is supplied to the refrigerator compartment 111 and the freezer compartment 112, respectively, via a fan and a damper (not shown). Independently of its arrangement within the cabinet structure, the evaporator 130 is part of a closed cooling circuit of the refrigerator appliance 100 also comprising a compressor 140 and a condenser 150, wherein a refrigerant fluid is made to circulate.

[0029] The refrigerant fluid fills the closed cooling circuit. The compressor 140 is operated by a control unit (not shown) of the refrigerator appliance 100, and makes the refrigerant fluid to circulate through the condenser 150 and then through the evaporator 130. When flowing through the condenser 150, the refrigerant fluid is cooled down and changes phase from the gaseous to the liquid one while releasing heat that is dissipated by the condenser 150. When flowing through the evaporator 130 the refrigerant fluid evaporates, thus subtracting heat from surrounding air, which is cooled and can be supplied to the refrigerator and freezer compartments.

[0030] The condenser 150 is configured as a skin condenser and comprises a serpentine tube 160 associated with a thermally conductive layer 170 made of e.g.

steel or aluminum.

[0031] According to the invention, the thermally conductive layer 170 forms at least a portion of at least one of the walls of the outer casing 115 of the cabinet 110.

[0032] According to a preferred embodiment of the invention, the thermally conductive layer 170 forms the whole back wall 119 of the outer casing 115, which advantageously allows to use the skin condenser 150 together with the other walls of the outer casing to contain the insulating foam during the foaming process.

[0033] The serpentine tube 160 runs along the whole thermally conductive layer 170 so as to maximize thermal exchange with the outer environment.

[0034] According to a preferred embodiment of the invention and as shown in figure 5, the thermally conductive layer 170 is made up of a plurality of plates 171, 172, etc., arranged such that a tail portion of a first plate, e.g. plate 171, is superimposed to and connected with a front portion of a subsequent, second plate, e.g. plate 172.

[0035] With particular reference to the longitudinal section of figure 5, it will be appreciated that every one of the straight portions 161, 162, etc., of the serpentine tube 160 is clinched between a pair of plates of the thermally conductive layer 170, where the tail portion of a plate is superimposed to and connected with the front portion of a subsequent plate. Thanks to this configuration, a good surface contact is achieved between the straight portions of the serpentine tube 160 and the thermally conductive layer 170 as a whole, which results in an effective thermal exchange with the outer environment and hence in a good thermal performance of the skin condenser 150.

[0036] In the embodiment shown in the figures, the straight portions 161, 162, etc. of the serpentine tube 160 run horizontally and the thermally conductive layer 170 is made up of a plurality of rectangular plates arranged with their longer sides in the horizontal direction.

[0037] It will be appreciated that a vertical arrangement, whereby the straight portions 161, 162, etc. of the serpentine tube 160 and the plates 171, 172, etc. of the thermally conductive layer 170 are arranged vertically, could be used as well.

[0038] As explained above, the thermally conductive layer 170 forms at least a portion of at least one of the walls of the outer casing 115 of the cabinet 110, and preferably the whole wall. Anchoring means are foreseen to allow connection between such portion or such wall to the neighboring walls of the outer casing 115. To this aim flap-shaped portions may e.g. be formed on opposite sides of the plates 171, 172, etc. forming the thermally conductive layer 170. Equivalent assembly means may be used as well. For instance flap-shaped portions might be formed on the side walls 116a, 116b, on the top wall 117 and on the bottom wall 118.

[0039] Turning now to figure 6, according to the invention a water drain pipe 180 typically used to drain condensation water from the evaporator 130 is advantageously arranged in thermal exchange contact with the skin condenser 150. The drain pipe 180 may be arranged

in direct contact with the thermally conductive layer 170 or slightly spaced apart from it, so that it is protected by a small amount of insulating foam.

[0040] Thanks to this configuration, heat extracted from the refrigeration fluid can effectively be used to prevent unwanted ice clogging of defrost water inside the pipe and to effectively warm up defrost water, allowing a quicker evaporation throughout its path to a pan 190 typically arranged close to the compressor 140 in a machine compartment of the refrigerator appliance 100.

[0041] In order to maximize heat exchange with the thermally conductive layer 150, the defrost water pipe 180 may advantageously have a serpentine shape. This allows to exploit the thermal exchange with the skin condenser 150 to make condensation water to evaporate even before reaching the pan 190.

[0042] According to an embodiment of the invention, the pan 190 may advantageously be arranged on the compressor 140, as schematically shown in figure 3, so as to exploit the thermal energy resulting from the operation of the compressor motor as a further means to evaporate condensation water.

[0043] According to a further embodiment of the invention, phase-change materials (hereinafter also PCM materials) may effectively be used in combination with the skin condenser 150 described above to promote thermal exchange and increase energy efficiency.

[0044] It is known that phase change materials are substances having a high heat of fusion which are capable of storing and releasing large amounts of thermal energy when melting and solidifying. Heat is absorbed or released when the material changes from solid to liquid and vice versa.

[0045] During a solid-to-liquid phase change materials behave like sensible heat storage means, as their temperature rises when they absorb heat. When PCM materials reach the temperature at which they change phase, e.g. their melting temperature, they absorb large amounts of heat at an almost constant temperature. A PCM material continues to absorb heat without a significant rise in temperature until phase change is complete, e.g. until all the material is transformed from the solid phase to the liquid phase.

[0046] PCM materials may be applied to the thermally conductive layer 170 in the form of blocks/pouches 200 attached thereto between subsequent condenser coils 161, 162, as shown in figure 7. Recessed portions (not shown in the figure 7) may be formed in the plates 171, 172, etc., of the thermally conductive layer 170 so as to accommodate the blocks/pouches 200 and increase the contact surface in order to promote thermal exchange.

[0047] Several types of PCM may be considered for this application, such as e.g. paraffin wax, which has a melting temperature of about 40°C. Alternatively to PCM blocks/pouches, a coating of the plates with PCM materials can be foreseen.

[0048] The present invention has hereto been disclosed with reference to preferred embodiments thereof.

It will be appreciated that there may be other embodiments relating to the same inventive idea, all of which are included in the scope of protection defined by the claims set out below.

Claims

1. A refrigerator appliance (100) comprising:

- a cabinet (110) configured to store food items, said cabinet (110) comprising an inner casing (114) and an outer casing (115) spaced apart from each other so as to define a cavity filled with a thermally insulating material;
- a closed cooling circuit operably connected to the cabinet (110), said closed cooling circuit comprising an evaporator (130), a compressor 140 and a condenser (150), wherein a refrigerant fluid is made to circulate;

wherein said condenser (150) is configured as a skin condenser having a tube (160) associated with a thermally conductive layer (170), said tube (160) having at least a portion with a serpentine shape, wherein said thermally conductive layer (170) is made up of a plurality of plates (171, 172) arranged such that a tail portion of a first plate (171) is superimposed to and connected with a front portion of a second plate (172), wherein said serpentine tube (160) has substantially straight portions (161, 162) clinched between the tail portion of the first plate (171) and the front portion of the second plate (172) superimposed to and connected with each other, and wherein a defrost water drain pipe (180) configured to drain condensation water from the evaporator (130) is in thermal exchange contact with the skin condenser (150).

2. The refrigerator appliance (100) of claim 1, wherein the tube (160) runs along the entire thermally conductive layer (170).

3. The refrigerator appliance (100) of claim 1 or 2, wherein the thermally conductive layer (170) forms at least a portion of at least one of the walls of the outer casing (115) of the cabinet (110).

4. The refrigerator appliance (100) of claim 3, wherein the thermally conductive layer (170) forms an entire wall of the outer casing (115) of the cabinet (110).

5. The refrigerator appliance (100) of claim 4, wherein the thermally conductive layer (170) forms the back wall (119) of the outer casing (115) of the cabinet (110).

6. The refrigerator appliance (100) of any one of the previous claims, wherein the defrost water drain pipe (180) has a serpentine shape.

7. The refrigerator appliance of any one of the previous claims, wherein phase-change materials are associated with the thermally conductive layer (170) and/or the serpentine tube (160) of the skin condenser (150).

8. The refrigerator appliance of claim 7, wherein said phase-change materials are applied to the thermally conductive layer (170) and/or the serpentine tube (160) in the form of blocks/pouches (200) attached thereto or of a surface coating.

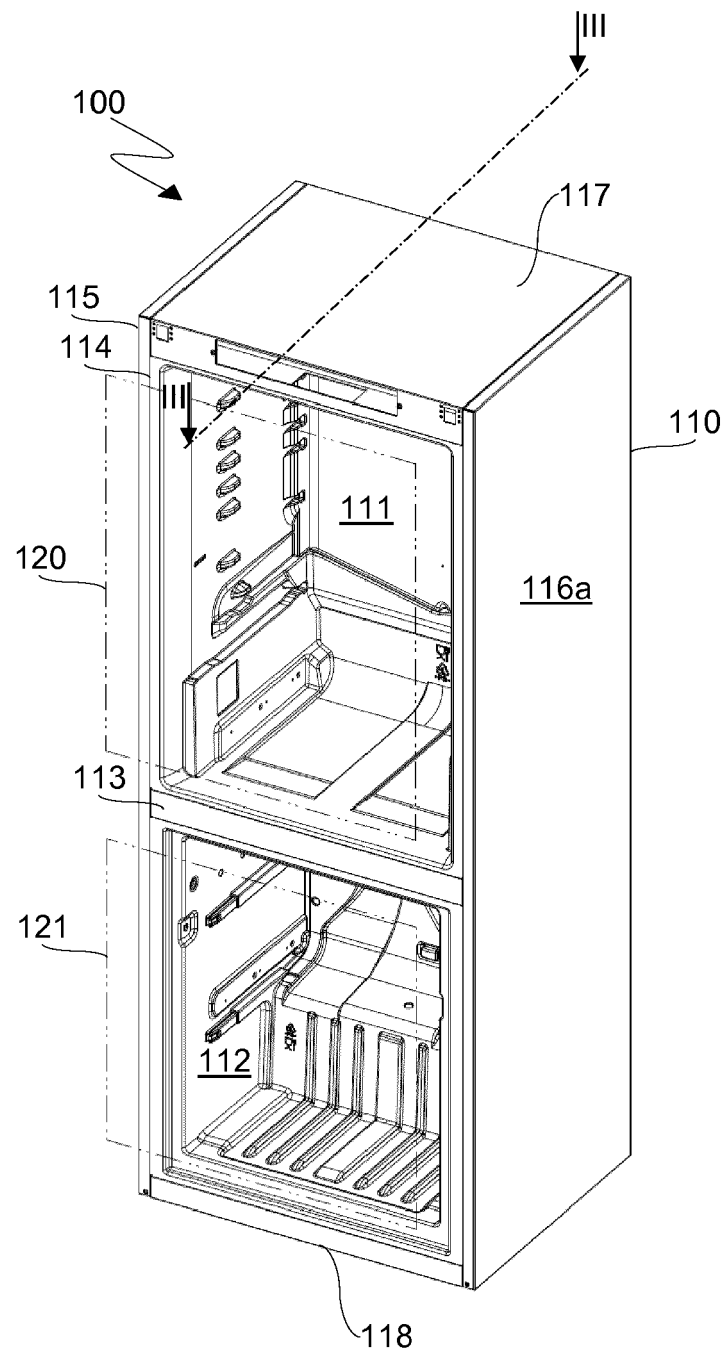


Fig.1

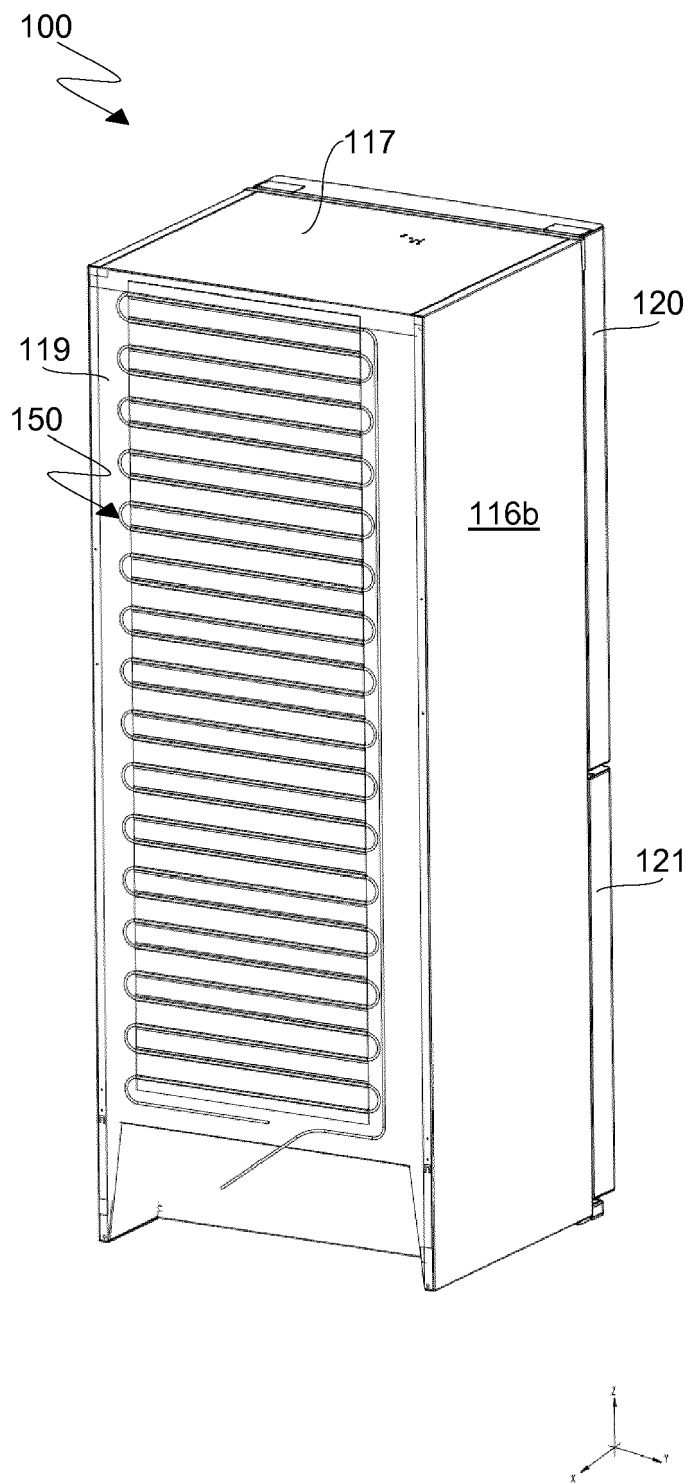


Fig.2

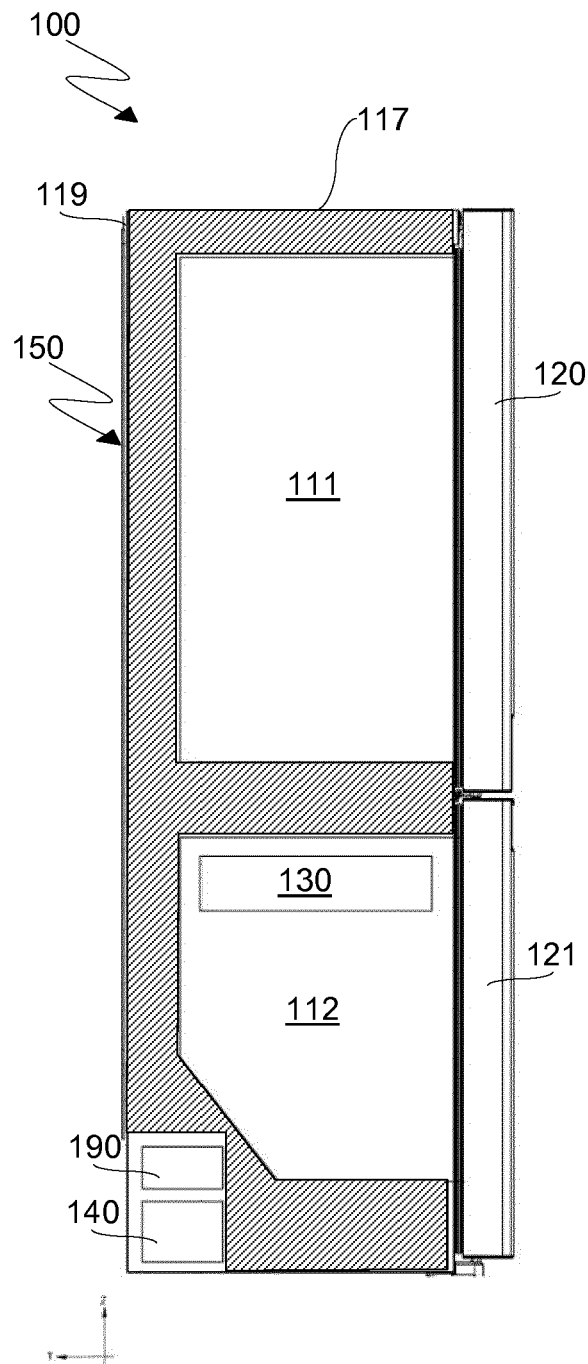


Fig.3

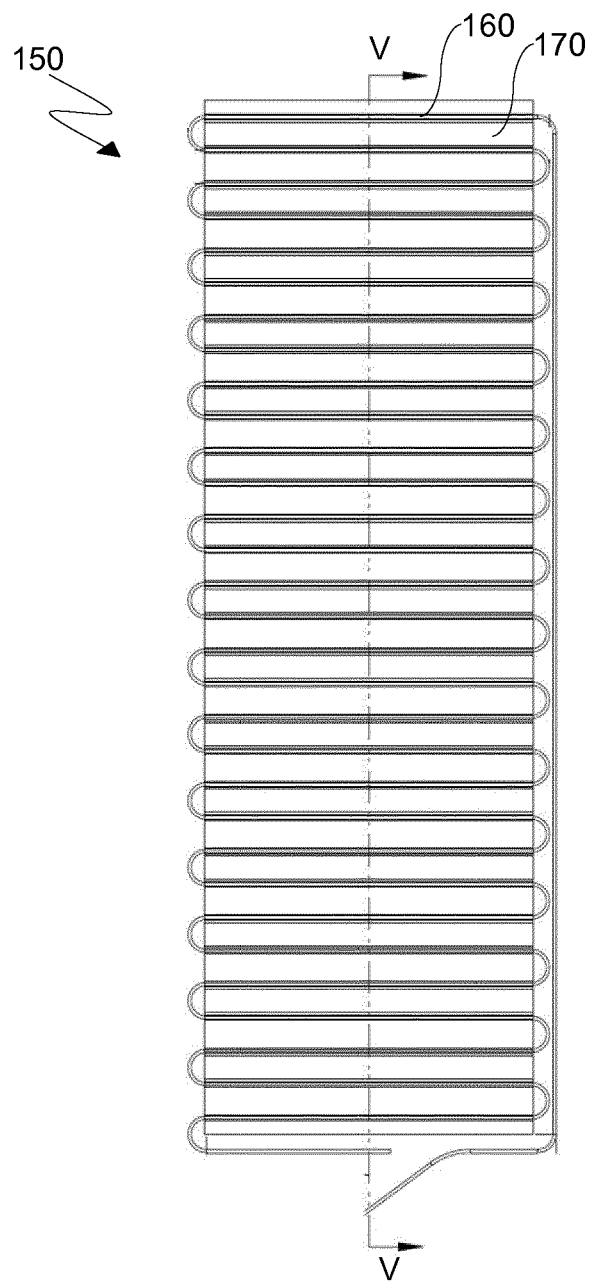


Fig.4

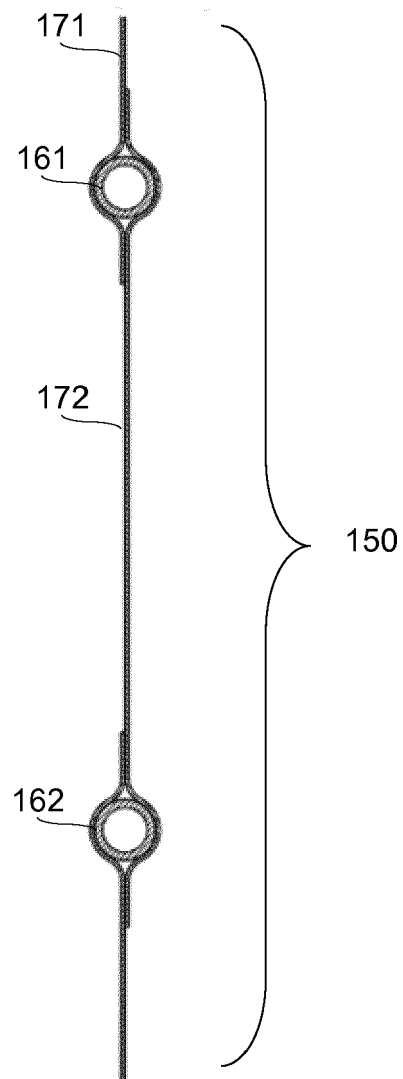


Fig.5

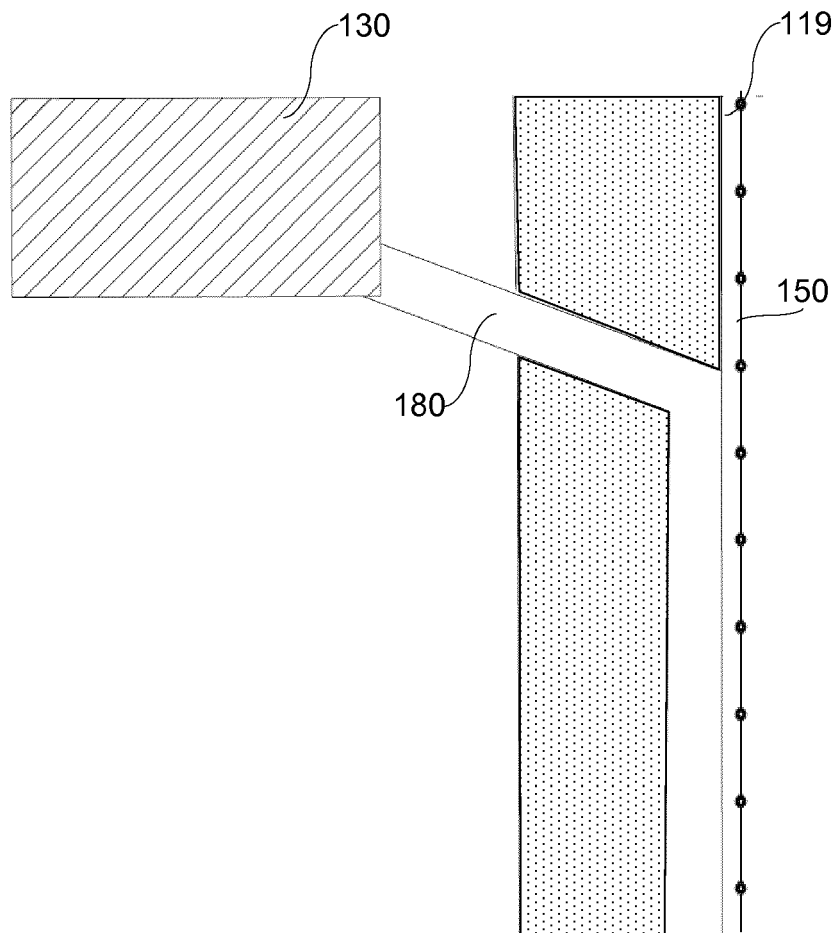


Fig.6

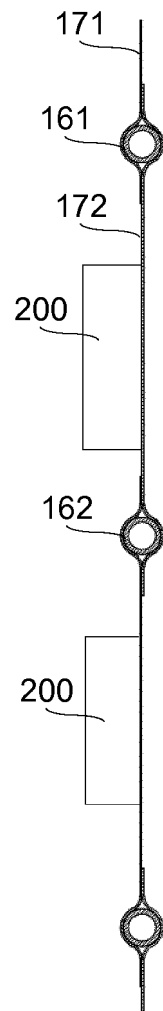


Fig.7



EUROPEAN SEARCH REPORT

 Application Number
 EP 19 18 2735

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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Y,D	WO 2019/020175 A1 (ELECTROLUX APPLIANCES AB [SE]) 31 January 2019 (2019-01-31) * figures 1,4 * -----	3-5	TECHNICAL FIELDS SEARCHED (IPC) F25B F25D F28F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 November 2019	Examiner Bidet, Sébastien
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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29-11-2019

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REFERENCES CITED IN THE DESCRIPTION

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