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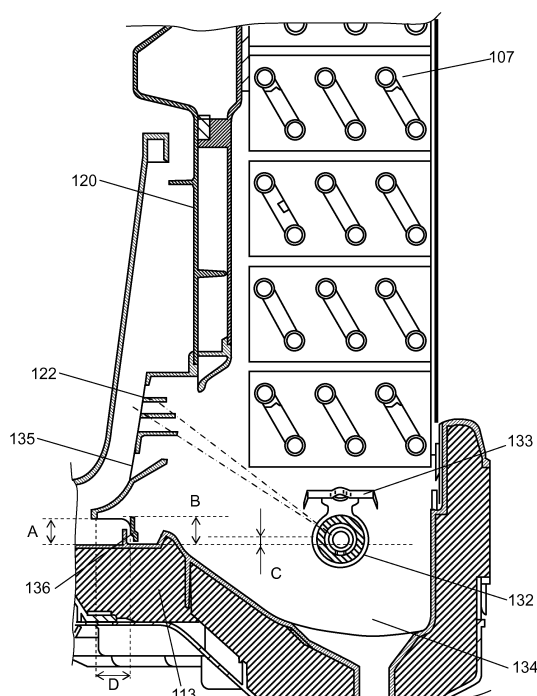
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(54) **REFRIGERATOR**

(57) Cooler (107) provided on the back surface side of a refrigerator, the cooler for generating cool air, defrosting heater (132) provided below cooler (107), and cooler cover (120) having cool air return port (135) are provided. Center of defrosting heater (132) is set on the upper side of a lower surface of a freezing compartment, projection member (136) protruding into the interior side is arranged on the lower surface of the freezing compartment, and a lower end of cool air return port (135) and an upper end of projection member (136) are overlapped with each other in the height direction.

FIG. 4



## Description

## TECHNICAL FIELD

5   **[0001]** The present invention relates to a refrigerator including a defrosting heater.

## BACKGROUND ART

10   **[0002]** In recent years, energy saving of a refrigerator is advanced more and more. In order to reduce a power consumption amount of the refrigerator, there are methods of improving efficiency of a compressor with a large input for enhancing cooling efficiency, and improving defrosting efficiency at the time of melting frost formed on a cooler.

15   **[0003]** Among the methods, as a conventional refrigerator in which the power consumption amount of the refrigerator is reduced, a refrigerator in which ventilation resistance of a cooling wind passage is reduced, a cooling wind amount is increased, and cooling efficiency is enhanced is disclosed (for example, refer to PTL 1). A refrigerator in which heat convection at the time of defrosting is facilitated (for example, refer to PTL 2).

20   **[0004]** Hereinafter, the conventional refrigerators will be described with reference to the drawings.

25   **[0005]** FIG. 25 is a detailed side cross sectional view of a cooler periphery of a conventional refrigerator. As shown in the figure, cooler 1 is installed between cooler cover 4 partitioning freezing compartment 2 and cooler compartment 3, and inner box 5 of a refrigerator body. On the lower side of a front surface of cooler 1, cool air return port 6 formed by cooler cover 4 is opened. An upper end of an opening of cool air return port 6 is placed on the upper side of a lower surface of cooler 1, and a lower end of the opening of cool air return port 6 is placed on the lower side of the lower surface of cooler 1. Enlarging the opening part of cool air return port 6 in such a way improves cool air circulation efficiency, so that a cooling performance is improved.

30   **[0006]** Defrosting heater 7 for melting frost formed on cooler 1 is disposed below cooler 1. In order to arrange defrosting heater 7, the back surface side of partition portion 9 partitioning freezing compartment 2 and vegetable compartment 8 is formed into a concave shape. By arranging defrosting heater 7 inside the concave shape, a flow of the return cool air from freezing compartment 2 is guided to cooler 1 without disturbing, so that heat exchange efficiency is improved.

35   **[0007]** Guide portions 10 are provided upward inside the opening of cool air return port 6 of cooler cover 4, so as to suppress heat from defrosting heater 7 heated at the time of defrosting from flowing into freezing compartment 2. Since guide portions 10 have a fixed angle  $\theta$  with respect to the horizontal direction on the side of cooler 1, the return cool air from freezing compartment 2 smoothly flows into cooler 1, so that heat exchange efficiency is improved.

40   **[0008]** With the above configuration, improvement of convection of the cool air flowing into cooler 1 enhances heat exchange efficiency, so that the consumed power of the refrigerator can be reduced.

45   **[0009]** FIGS. 26A and 26B are detailed side cross sectional views of a cooler periphery of another conventional refrigerator.

50   **[0010]** As shown in the figures, cooler 11, and cooler cover 12 covering cooler 11 and forming a wind passage are disposed on the back surface side of a freezing compartment of the refrigerator, and defrosting heater 13 for melting frost formed on cooler 11 is disposed below cooler 11. Cover heater 14 covering defrosting heater 13 is disposed on the upper side of defrosting heater 13.

55   **[0011]** Cover heater 14 is inclined in the front and rear direction, and a back end surface is lifted in such a manner that a gap between the end surface of cover heater 14 on the back surface side and a back surface wall is increased with respect to the interior side. Thereby, heat generated from defrosting heater 13 at the time of defrosting can be increased on the side of the back surface heat insulating wall. Thus, a temperature increase of freezing compartment 15 can be suppressed. Further, the heat generated by defrosting heater 13 can efficiently abut with the frost formed mainly on a pipe of cooler 11. Further, as shown in FIG. 26B, the cool air on the side of freezing compartment 15 in cooler cover 12 is cooled in freezing compartment 15 and brought down to the vicinity of the defrosting heater. Thus, convection is generated in cooler cover 12, so that there is an effect of stabilizing defrosting. Defrosting heater 13 itself is hidden from freezing compartment 15 by cover heater 14, and heater red heat at the time of defrosting is not visible.

60   **[0012]** In the refrigerator of the conventional example shown in FIG. 25, by enlarging the opening of cool air return port 6, and increasing an amount of wind passing through cooler 1, so as to improve cooling efficiency, there is an effect of achieving energy saving. However, since the angle of guide portions 10 is fixed to be the fixed angle  $\theta$ , a problem arises that with the defrosting heater substantially in a range from  $\phi$  10 mm to  $\phi$  20 mm, heater red heat is visible from a gap between the guide portions depending on an angle of watching.

65   **[0013]** In a recent trend of small space and large capacity in the refrigerator industry, in comparison to about 10 years ago, an interior capacity is increased by about 100 L with equivalent outer size. This is because a measure of eliminating an invalid space of the refrigerator is performed and wall thickness is reduced while a heat insulating performance of a body is improved. When the back surface of the partition portion is formed in a concave shape and defrosting heater 7 is disposed in the concave shape so as to be housed in the partition portion as in the above conventional example, an

invalid space is increased and an interior capacity is reduced. In addition, there is a problem that in a step of manufacturing the refrigerator, at the time of producing rigid urethane foams closely attached to inside of an outer box and the inner box, the rigid urethane foams are easily deformed and moldability is poor. Further, with the deformation of the rigid urethane foams, when cooler cover 4 in which the opening part of cool air return port 6 is enlarged is installed, size of cool air return port 6 is not regulated. From this, workability at the time of attachment becomes difficult, a decrease in yield ratio and reduction of an opening part area are generated. Thus, there is a problem that a sufficient cooling effect cannot be exerted.

**[0014]** In the refrigerator of the conventional example shown in FIGS. 26A and 26B, there is an effect of improving defrosting efficiency by facilitating the heat convection at the time of defrosting. However, due to inclination of cover heater 14, a frost formation amount onto the front surface side of cooler 11 is increased. Since the back surface side of cooler 11 is mainly defrosted at the time of defrosting, defrosting of the front surface side of cooler 11 where the frost formation amount is great is delayed, so that an entire defrosting time is extended. As a result, not only heat of defrosting heater 13 influences the interior and thus an interior temperature increase is caused, but also cooling is not performed during the defrosting time and hence an interior temperature increase due to heat invasion from the exterior of the refrigerator is accelerated, and particularly, there is a problem that frozen food is harmfully influenced.

**[0015]** Cooler 11 highly contributes to energy saving. In recent years, a measure of realizing energy saving at low cost by increasing a surface area on the air side with enlargement and an increase in the pipe number and in cooling fins is implemented. At this time, heat at the time of defrosting is convected on an outer periphery of cooler 11 due to the inclination of cover heater 14. A center part of cooler 11 does not easily receive a convection effect. Therefore, the effect is obtained in double-row pipe cooler 11. However, in the case where the pipe number is increased to three rows for energy saving, a problem arises that a cooling medium remains in a center pipe and defrosting is not easily performed.

**[0016]** The present invention provides a large capacity refrigerator in which an invalid space is suppressed, the refrigerator having a high cooling ability and consequently exerting a high energy saving performance.

**[0017]** As a conventional refrigerator for reducing a power consumption amount of the refrigerator, a refrigerator in which an energy saving effect is obtained by suppressing an interior inflow of the air warmed up by a defrosting heater so as to suppress an interior temperature increase is disclosed (for example, refer to PTL 3). Further, a refrigerator in which cooling efficiency is improved by letting the return cool air from the interior pass through a lower part of a cooler as far as possible is disclosed (for example, refer to PTL 4).

**[0018]** Hereinafter, the conventional refrigerators will be described with reference to the drawings.

**[0019]** FIG. 27 is a detailed side cross sectional view of a cooler periphery of a conventional refrigerator. As shown in the figure, cooler 21 is installed between cooler cover 24 partitioning freezing compartment 22 and cooler compartment 23, and inner box 25 of a refrigerator body. On the lower side of a front surface of cooler 21, cool air return port 26 formed by cooler cover 24 is opened. An upper end of an opening of cool air return port 26 is placed on the upper side of a lower surface of cooler 21, and a lower end of the opening of cool air return port 26 is placed on the lower side of the lower surface of cooler 21. By enlarging the opening part of cool air return port 26 in such a way, cool air circulation efficiency is improved, so that a cooling performance is improved. Warm air inflow space 28 into which the air warmed up by defrosting heater 27 is provided and opened on the lower side of cooler cover 24 between the interior side and the side of cooler 21.

**[0020]** Since the air warmed up by defrosting heater 27 flows into warm air inflow space 28 more than into the interior at the time of defrosting, an interior temperature increase can be suppressed. Since a heat energy amount warming up the interior at the time of defrosting can be reduced, an energy saving property is enhanced.

**[0021]** FIG. 28 is a detailed side cross sectional view of a cooler periphery of another conventional refrigerator.

**[0022]** As shown in the figure, in the refrigerator, cooler compartment 33 defined by cooler cover 31, the cooler compartment forming an air circulation passage with freezing compartment 32 is provided on a back surface of the freezing compartment. In cooler compartment 33, fan 34, cooler 35, cover heater 36, and defrosting heater 37 are disposed from the upper side. A bottom surface part serves as water receiving portion 38 for receiving defrosted water melted by heat of defrosting heater 37 at the time of defrosting. Further, cooler compartment inlet 39 in the circulation passage is formed on the front surface side of a lower part of cooler compartment 33. Gutter 40 for directing the return cool air toward the back surface side along the bottom surface part of cooler compartment 33, that is, water receiving portion 38 is provided in cooler compartment inlet 39. Guide 42 of a separate body for guiding the return cool air coming in along water receiving portion 38 to the front surface side of the cooler is provided in inner box 41 on the back surface side.

**[0023]** With the above configuration, an airflow coming into the side of inner box 41 serving as the back surface of cooler compartment 33 can be directed to a front surface part of cooler 35, and much of the cool air can pass through inside of the cooler from the upstream side of cooler 35. Therefore, distribution of the airflow flowing in inside cooler 35 can be improved, so that cooler 35 can be effectively utilized and cooling efficiency is improved.

**[0024]** In the conventional refrigerator shown in FIG. 27, by suppressing the interior inflow of the air warmed up by defrosting heater 27 at the time of defrosting so as to reduce the heat energy, there is an effect of achieving energy saving. However, since a temperature increase of warm air inflow space 28 itself cannot be avoided, a temperature of

the interior back surface side in particular is influenced by heat transfer from warm air inflow space 28 having the increased temperature to the interior. Since food stored on the interior back surface side is subjected to a temperature change, a nearly frozen state and a nearly melt state are repeated inside of the food upon every defrosting, and there is a problem that freshness is deteriorated.

**[0025]** In the conventional refrigerator shown in FIG. 28, by changing a flowing way of the return cool air flowing in cooler compartment 33 so as to improve efficiency of cooler 35, there is an effect of achieving energy saving. However, ventilation resistance of an intake part is increased by gutter 40 provided for changing the flow-direction of the return cool air, so that the whole wind amount is lowered. As a result, an amount of circulation wind passing through cooler 35 is lowered, and consequently, there is a problem that a sufficient cooling effect cannot be exerted.

**[0026]** Since gutter 40 is disposed up to the vicinity of a front surface of defrosting heater 37, a temperature is influenced by heat generation of defrosting heater 37 at the time of defrosting. Due to the heat generation of defrosting heater 37 at the time of defrosting, a temperature of a surface of defrosting heater 37 is increased to about 300°C. As a result, a temperature of a surface of gutter 40 provided in the vicinity of defrosting heater 37 is also increased to substantially 100°C or more. Thus, in order to prevent deformation due to heat, a member made of metal such as an aluminum foil for covering the surface is required, and there is a problem that material cost and cost of the man-hour are increased.

**[0027]** The present invention is to provide a large capacity refrigerator in which cooling efficiency and efficiency at the time of defrosting are enhanced so as to achieve a high energy saving performance, and an invalid space is suppressed.

#### Citation List

#### Patent Literatures

#### **[0028]**

PTL 1: Unexamined Japanese Patent Publication No. 2007-71487

PTL 2: Unexamined Japanese Patent Publication No. 2011-127850

PTL 3: Unexamined Japanese Patent Publication No. 2010-60188

PTL 4: Unexamined Japanese Patent Publication No. 2011-89718

#### SUMMARY OF THE INVENTION

**[0029]** A refrigerator of the present invention has a refrigerator body, and a freezing compartment of a freezing temperature zone in the refrigerator. The refrigerator also has a cooler compartment including a cooler provided on a back surface side of the freezing compartment, the cooler for generating cool air, a defrosting heater provided below the cooler, and a drain pan provided below the defrosting heater, the drain pan for receiving defrosted water dropped after frost formed on the cooler is melted. Further, the refrigerator includes a cooler cover including a cool air return port through which the cool air after cooling the freezing compartment is returned to the cooler, the cooler cover covering the cooler. Center of the defrosting heater is set above a lower surface of the freezing compartment in a horizontal direction, a projection member protruding into an interior side is disposed on the lower surface of the freezing compartment, and a lower end of the cool air return port and an upper end of the projection member are overlapped with each other in a height direction.

**[0030]** Thereby, since the overlapping part between the lower end of the cool air return port and the projection member is provided in the present invention, red heat from the defrosting heater at the time of defrosting can be prevented from being leaked out to the exterior. Since a gap is created between the lower end of the cool air return port and the projection member, the return cool air from the interior to the cooler can ensure convection not only on a front surface of the return port but also from the lower side of the cooler. Therefore, a large heat exchange area in the cooler can be obtained, and a circulation wind amount can be increased by lowering ventilation resistance of the return cool air. A heat exchange amount in the cooler is increased and an evaporation temperature is increased, so that energy saving can be achieved by improvement of freezing cycle efficiency.

**[0031]** By the improvement of the heat exchange amount of the cooler and the increase in the circulation wind amount, a time for cooling the interior can be reduced. Thus, a frost formation amount onto the cooler due to shortening of a cooling operation time can also be reduced. Thereby, a regular defrosting period for melting frost of the cooler can be extended. The input number of the defrosting heater can be decreased and a power input required for cooling the interior after an interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0032]** Obtaining a large heat exchange area in the cooler by improvement of a wind passage means increasing an area where frost can be formed in the cooler. At this time, since a flow from the interior to the cooler can be improved and frost can be uniformly formed on the cooler, deterioration of a cooling ability at the time of frost formation can be suppressed. Thereby, the defrosting period serving as an operation time of the refrigerator until defrosting is required

can be extended. Thus, the input number of the defrosting heater can be decreased and the input required for cooling the interior after the interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0033]** A refrigerator of the present invention includes a cooler provided on a back surface side of the refrigerator, the cooler for generating cool air, a defrosting heater provided below the cooler, and a cooler cover covering the cooler and having a cool air return port through which the cool air after cooling a freezing compartment is returned to the cooler. The cooler cover includes a cooler front side cover on an interior side and a cooler rear side cover in a direction to the cooler, a heat transfer suppression space by the cooler front side cover and the cooler rear side cover is provided in front of the cooler, and a defrosting warm air guide member is provided in the cool air return port.

**[0034]** Thereby, by an effect of the defrosting warm air guide member, convection due to heat of the defrosting heater easily flows to the cooler. Thus, defrosting efficiency can be enhanced and energy saving due to shortening of a defrosting time can be achieved. Further, by suppressing a temperature increase due to shortening of a non-cooling operation time at the time of defrosting and preventing a warm air inflow to the interior, not only energy saving due to reduction of a cooling load amount can be achieved but also a temperature change in food can be reduced. Thus, freshness deterioration can be suppressed and long term storage can be achieved.

**[0035]** Even in the case where a temperature of a cooler periphery is increased at the time of defrosting, heat transfer to the interior can be suppressed by the heat transfer suppression space. Thus, since a temperature influence on food particularly stored in a deep interior can be reduced, freshness deterioration can be suppressed and long term storage can be achieved.

## BRIEF DESCRIPTION OF DRAWINGS

### **[0036]**

FIG. 1 is a perspective view of a refrigerator in a first exemplary embodiment of the present invention.

FIG. 2 is a vertically sectional view of the refrigerator in the first exemplary embodiment of the present invention.

FIG. 3 is a vertically sectional view of a cooler periphery of the refrigerator in the first exemplary embodiment of the present invention.

FIG. 4 is a detailed vertically sectional view of the cooler periphery of the refrigerator in the first exemplary embodiment of the present invention.

FIG. 5 is a curve resistance image diagram of a cool air blower fan of the refrigerator in the first exemplary embodiment of the present invention.

FIG. 6 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a second exemplary embodiment of the present invention.

FIG. 7 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a third exemplary embodiment of the present invention.

FIG. 8 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a fourth exemplary embodiment of the present invention.

FIG. 9 is a perspective view of a refrigerator in a fifth exemplary embodiment of the present invention.

FIG. 10 is a vertically sectional view of the refrigerator in the fifth exemplary embodiment of the present invention.

FIG. 11 is a vertically sectional view of a cooler periphery of the refrigerator in the fifth exemplary embodiment of the present invention.

FIG. 12 is a detailed vertically sectional view of the cooler periphery of the refrigerator in the fifth exemplary embodiment of the present invention.

FIG. 13 is a curve resistance image diagram of a cool air blower fan of the refrigerator in the fifth exemplary embodiment of the present invention.

FIG. 14 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a sixth exemplary embodiment of the present invention.

FIG. 15 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a seventh exemplary embodiment of the present invention.

FIG. 16 is a detailed vertically sectional view of a cooler periphery of a refrigerator in an eighth exemplary embodiment of the present invention.

FIG. 17 is a perspective view of a refrigerator in a ninth exemplary embodiment of the present invention.

FIG. 18 is a vertically sectional view of the refrigerator in the ninth exemplary embodiment of the present invention.

FIG. 19 is a vertically sectional view of a cooler periphery of the refrigerator in the ninth exemplary embodiment of the present invention.

FIG. 20 is a detailed vertically sectional view of the cooler periphery of the refrigerator in the ninth exemplary embodiment of the present invention.

FIG. 21 is a curve resistance image diagram of a cool air blower fan of the refrigerator in the ninth exemplary embodiment of the present invention.

FIG. 22 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a tenth exemplary embodiment of the present invention.

FIG. 23 is a back view of a cooler cover of the refrigerator in the tenth exemplary embodiment of the present invention.

FIG. 24 is an illustrative view of a basic heat exchanger of a cooler of the refrigerator in the tenth exemplary embodiment of the present invention.

FIG. 25 is a detailed side cross sectional view of a cooler periphery of a refrigerator for illustrating a refrigerator according to a conventional technique.

FIG. 26A is a detailed side cross sectional view of a cooler periphery of a refrigerator for illustrating a refrigerator according to a conventional technique.

FIG. 26B is a detailed side cross sectional view of the cooler periphery of the refrigerator for illustrating the refrigerator according to the conventional technique.

FIG. 27 is a detailed side cross sectional view of a cooler periphery of a refrigerator for illustrating a refrigerator according to a conventional technique.

FIG. 28 is a detailed side cross sectional view of a cooler periphery of a refrigerator for illustrating a refrigerator according to a conventional technique.

## DESCRIPTION OF EMBODIMENTS

**[0037]** Hereinafter, exemplary embodiments of the present invention will be described with reference to the drawings. It should be noted that the present invention is not limited by the exemplary embodiments.

## FIRST EXEMPLARY EMBODIMENT

**[0038]** Hereinafter, the exemplary embodiments of the present invention will be described in detail with reference to the drawings.

**[0039]** FIG. 1 is a perspective view of a refrigerator in a first exemplary embodiment of the present invention. FIG. 2 is a vertically sectional view of the refrigerator in the first exemplary embodiment of the present invention. FIG. 3 is a vertically sectional view of a cooler periphery of the refrigerator in the first exemplary embodiment of the present invention. FIG. 4 is a detailed vertically sectional view of the cooler periphery of the refrigerator in the first exemplary embodiment of the present invention.

**[0040]** As shown in FIGS. 1 to 4, refrigerator body 101 has forward-opened outer box 124 made of metal (such as an iron plate), inner box 125 made of rigid resin (such as ABS), and heat insulating body 126 made of rigid urethane foams which are foamed and charged between outer box 124 and inner box 125. Refrigerator body 101 includes refrigerating compartment 102 provided in an upper part, upper level freezing compartment 103 provided below refrigerating compartment 102, and ice-making compartment 104 provided below refrigerating compartment 102 in parallel with upper level freezing compartment 103. Further, refrigerator body 101 includes vegetable compartment 106 provided in a lower part of the body, and lower level freezing compartment 105 provided between upper level freezing compartment 103 and ice-making compartment 104 which are installed in parallel to each other and vegetable compartment 106. Front surface parts of upper level freezing compartment 103, ice-making compartment 104, lower level freezing compartment 105, and vegetable compartment 106 are openably closed by upper level freezing compartment door 103a, ice-making compartment door 104a, lower level freezing compartment door 105a, and vegetable compartment door 106a of a pull-out type. A front surface of refrigerating compartment 102 is openably closed by double-door type refrigerating compartment door 102a.

**[0041]** A temperature of refrigerating compartment 102 is generally set in a range from 1°C to 5°C with an unfreezable temperature as a lower limit for refrigerating storage. A temperature of vegetable compartment 106 is often in a range from 2°C to 7°C of a temperature setting equal to or slightly higher than refrigerating compartment 102. With a low temperature, freshness of green vegetables can be maintained for a long time.

**[0042]** Temperatures of upper level freezing compartment 103 and lower level freezing compartment 105 are generally set in a range from -22°C to -18°C for freezing storage. However, for improving a freezing storage state, the temperatures are sometimes set in, for example, a low-temperature range from -30°C to -25°C.

**[0043]** Since refrigerating compartment 102 and vegetable compartment 106 are set at a temperature above zero in interiors thereof, the compartments are called a refrigerating temperature zone. Since upper level freezing compartment 103, lower level freezing compartment 105, and ice-making compartment 104 are set at a temperature below zero in interiors thereof, the compartments are called a freezing temperature zone. By using a damper mechanism or the like, upper level freezing compartment 103 may serve as a switching compartment for which the refrigerating temperature zone or the freezing temperature zone can be selected.

**[0044]** A top surface portion of refrigerator body 101 is formed by first top surface portion 108 and second top surface portion 109 by providing a step-like concave part toward the back surface direction of the refrigerator. Machine compartment 119 is provided in second top surface portion 109 where the step-like concave part is provided. By enclosing a cooling medium into a freezing cycle formed by successively connecting compressor 117 disposed in machine compartment 119 in the step-like concave part, a dryer (not shown) for removing water contents, a capacitor (not shown), a heat-radiation pipe (not shown) for heat radiation, capillary tube 118, and cooler 107 in a circular form, a cooling operation is performed. In recent years, as the cooling medium, a combustible cooling medium is often used for environmental protection. It should be noted that in a case of a freezing cycle in which a three-way valve and a switching valve are used, those functional parts can be disposed in machine compartment 119.

**[0045]** Refrigerating compartment 102, ice-making compartment 104, and upper level freezing compartment 103 are partitioned by first heat insulating partition portion 110. Ice-making compartment 104 and upper level freezing compartment 103 are partitioned by second heat insulating partition portion 111. Ice-making compartment 104 and upper level freezing compartment 103, and lower level freezing compartment 105 are partitioned by third heat insulating partition portion 112.

**[0046]** Since second heat insulating partition portion 111 and third heat insulating partition portion 112 are parts assembled after forming refrigerator body 101 by foaming, expanded polystyrene is generally used as a heat insulating material. However, rigid urethane foams may be used for improving a heat insulating performance and rigidity. Further, by inserting a vacuum heat insulating material having a high heat-insulating property as second heat insulating partition portion 111 and third heat insulating partition portion 112, thickness of a partition structure may be further reduced.

**[0047]** By ensuring an operating part of a door frame so as to reduce thickness of shapes of second heat insulating partition portion 111 and third heat insulating partition portion 112 or to eliminate the heat insulating partition portions, a cooling wind passage can be ensured and a cooling ability can also be improved. By hollowing out second heat insulating partition portion 111 and third heat insulating partition portion 112 so as to make a wind passage, materials are consequently reduced and cost can be reduced.

**[0048]** Lower level freezing compartment 105 and vegetable compartment 106 are partitioned by fourth heat insulating partition portion 113.

**[0049]** Next, a configuration of the cooler periphery in the present exemplary embodiment will be described.

**[0050]** Cooler compartment 123 is provided on a back surface of refrigerator body 101. In cooler compartment 123, as a representative part, fin-and-tube type cooler 107 for generating the cool air is disposed so as to extend in the up and down direction on a back surface of lower level freezing compartment 105 including rear regions of second heat insulating partition portion 111 and third heat insulating partition portion 112 which serve as heat insulating partition walls.

**[0051]** Cooler cover 120 made of aluminum or copper, the cooler cover covering cooler 107 is disposed on a front surface of cooler compartment 123. Cool air return port 135 through which the cool air after cooling lower level freezing compartment 105 is returned to the cooler is provided in cooler cover 120.

**[0052]** Flow-direction guide portions 122 are provided in cool air return port 135 provided in a lower part of cooler cover 120. An interval of flow-direction guide portions 122 is 5 mm or more in consideration with prevention of finger invasion and ensuring of strength of a mold and cooler cover 120.

**[0053]** In the vicinity of cooler 107 (such as an upper space), cool air blower fan 116 for blowing the cool air generated in cooler 107 to the storage compartments of refrigerating compartment 102, ice-making compartment 104, upper level freezing compartment 103, lower level freezing compartment 105, and vegetable compartment 106 by a forced-convection method is disposed. Defrosting heater 132 formed by a glass tube heater for removing frost formed on cooler 107 and to cool air blower fan 116 at the time of cooling is provided below cooler 107. Above defrosting heater 132 formed by the glass tube heater, cover heater 133 covering defrosting heater 132 is disposed. Cover heater 133 has size equal to or more than a diameter and width of the glass tube of defrosting heater 132 in such a manner that hissing sounds are not generated when waterdrops dropped from cooler 107 at the time of defrosting directly fall down to a surface of the glass tube whose temperature is increased by defrosting.

**[0054]** Drain pan 134 integrated with an upper surface of fourth heat insulating partition portion 113, the drain pan serving as a lower surface of the freezing compartment for receiving defrosted water dropped after the frost formed on cooler 107 is melted is disposed below defrosting heater 132.

**[0055]** In drain pan 134 integrated with the upper surface of fourth heat insulating partition portion 113, projection member 136 protruding toward the interior side is disposed on the lower surface of the freezing compartment. Further, projection member 136 is disposed between a lower end of cool air return port 135 and defrosting heater 132. Thereby, red heat is not visible from the interior, and projection member 136 is hidden by the lower end of the cool air return port of cooler cover 120 when seen from the interior side. Thus, it looks good and outer appearance quality is consequently improved.

**[0056]** Center of defrosting heater 132 is disposed at a position on the upper side of the upper surface of fourth heat insulation partition portion 113. Thereby, a shape of drain pan 134 integrated with the lower surface of the freezing compartment can be substantially horizontal, so that an invalid space created by installment of defrosting heater 132

can be reduced and an interior capacity can be increased. Since depth of drain pan 134 can be shallow, mold cost at the time of molding constituent parts can be suppressed. Thus, cost is consequently reduced. Deformation at the time of foaming heat insulation body 126 formed by the rigid urethane foams which are closely attached to inside of outer box 124 and inner box 125 of refrigerator body 101 can be suppressed, so that a product yield ratio is improved and disposal cost is reduced. In addition, workability at the time of attachment is also improved. Thus, the refrigerator with favorable outer appearance quality can be provided.

**[0057]** As a recent cooling medium of the freezing cycle, isobutane serving as a combustible cooling medium having a low global warming potential is used from a viewpoint of global environmental conservation. Isobutane of carbon hydrate has a specific gravity about twice more than the air at a normal temperature at atmospheric pressure (2.04, 300 K). Thereby, a cooling medium charging amount can be reduced in comparison to the conventional examples and cost is low. In addition, a leakage amount in the case where the combustible cooling medium is leaked out by any possibility is reduced, so that safety can be more improved.

**[0058]** In the present exemplary embodiment, isobutane is used as the cooling medium, and a maximum temperature of the surface of the glass tube serving as an outer shell of defrosting heater 132 at the time of defrosting is regulated as explosion protection. In order to reduce the temperature of the surface of the glass tube, a double glass tube heater in which glass tubes are doubly formed is adopted as defrosting heater 132. In addition to this, as a means for reducing the temperature of the surface of the glass tube, a member having a high heat radiation property (such as an aluminum fin) can be wound around the surface of the glass tube. At this time, with a single glass tube, outer size of defrosting heater 132 can be reduced.

**[0059]** As a means for improving efficiency at the time of defrosting, in addition to defrosting heater 132 formed by the glass tube heater, a pipe heater closely attached to cooler 107 may also be used. In this case, cooler 107 can be efficiently defrosted by heat transfer directly from the pipe heater. At the same time, frost formed on drain pan 134 and cool air blower fan 116 in the periphery of cooler 107 can be melted by defrosting heater 132. Thus, a defrosting time can be shortened, so that energy saving can be achieved and an interior temperature increase during the defrosting time can be suppressed.

**[0060]** It should be noted that in the case where defrosting heater 132 formed by the glass tube heater is combined with the pipe heater, by properly matching heater capacities with each other, the capacity of defrosting heater 132 can be lowered. When the heater capacity is lowered, a temperature of the outer shell of defrosting heater 132 at the time of defrosting can also be lowered. Thus, red heat at the time of defrosting can be suppressed.

**[0061]** Next, cooling of the refrigerator will be described. For example, in the case where an interior temperature of lower level freezing compartment 105 is increased by invading heat from the external air, opening/closing of the door, and the like, and a temperature of a freezing compartment sensor (not shown) becomes a start-up temperature or more, compressor 117 is started up and cooling is started. A high-temperature and high-pressure cooling medium discharged from compressor 117 is cooled and liquefied particularly in the heat-radiation pipe (not shown) installed in outer box 124 by heat exchange with the air outside outer box 124 and with heat insulating body 126 formed by the rigid urethane foams in the interior before reaching the dryer (not shown) disposed in machine compartment 119 at the end.

**[0062]** Next, the liquefied cooling medium is decompressed in capillary tube 118, flows into cooler 107, and exchanges heat with the interior cool air in the periphery of cooler 107. The cool air after heat exchange is blown into the interior by cool air blower fan 116 in the vicinity thereof, and cools the interior. After that, the cooling medium is heated, gasified, and returned to compressor 117. In the case where the interior is cooled and the temperature of the freezing compartment sensor (not shown) becomes a stop temperature or less, an operation of compressor 117 is stopped.

**[0063]** Cool air blower fan 116 may be directly disposed in inner box 125. However, by arranging the cool air blower fan in second heat insulating partition portion 111 assembled after foaming and performing block processing of the parts, manufacturing cost can be reduced.

**[0064]** Next, the time of defrosting of the refrigerator will be described.

**[0065]** When a cooling operation of the refrigerator is performed, as the time elapses, due to water contents in the air invading at the time of opening/closing the door, water contents attached to food brought into the interior, further, water contents from vegetables stored in vegetable compartment 106, and the like, frost is formed on cooler 107. When the frost grows, heat exchange efficiency between cooler 107 and the circulation cool air is lowered, so that the interior cannot be sufficiently cooled and brought into a non-cooled state at the end. Therefore, in the refrigerator, there is a need for regularly removing the frost formed on the cooler.

**[0066]** In the refrigerator in the present exemplary embodiment, after the refrigerator is operated and a fixed time elapses, defrosting is automatically performed. At the time of defrosting, an operation of compressor 117 and cool air blower fan 116 is stopped, and power is supplied to defrosting heater 132 formed by the glass tube heater. By the cooling medium remaining inside cooler 107 and melting of the frost formed on cooler 107, a temperature of cooler 107 is increased substantially through a sensible heat change from -30°C to 0°C, a latent heat change at 0°C, and a sensible heat change from 0°C to higher. A defrosting sensor (not shown) is attached to cooler 107 so as to stop power supply to defrosting heater 132 at a predetermined temperature. In the present exemplary embodiment, at a time point when

the defrosting sensor detects 10°C, the power supply to defrosting heater 132 is stopped.

**[0067]** At this time, the temperature of the surface of the glass tube becomes high by the power supply to defrosting heater 132, and by melting the frost formed on cooler 107, and drain pan 134 and cool air blower fan 116 in the periphery of cooler 107 by radiation heat, cooler 107 is refreshed.

**[0068]** It should be noted that in the low-temperature external air of about 5°C for example, even when the frost of cooler 107 is sufficiently removed, a temperature of the defrosting sensor is not easily sufficiently increased at the time of defrosting due to an influence of the external air. Thus, the defrosting time tends to be extended. In this case, when a state of the sensible heat change from 0°C to higher is checked and a fixed time or longer elapses, control of finishing defrosting can be combined. Thereby, a temperature increase due to an unnecessary heater input and radiation heat to the interior caused by a situation that even when the frost is sufficiently removed, the defrosting time is extended due to an insufficient temperature increase of cooler 107 with the low-temperature external air, and further, a temperature increase due to cooling stop at the time of defrosting can be suppressed.

**[0069]** Hereinafter, actions and operations of the refrigerator with the above configuration will be described.

**[0070]** As in the present exemplary embodiment, the layout configuration of the refrigerator in which vegetable compartment 106 is installed on the lower side, lower level freezing compartment 105 is installed in the middle, and refrigerating compartment 102 is installed on the upper side is frequently used from a viewpoint of usability and energy saving. From a viewpoint of usability, a refrigerator with a configuration of a fully-open mechanism in which interior drawer parts of lower level freezing compartment 105 and vegetable compartment 106 are large is also provided.

**[0071]** At this time, when the drawer part of lower level freezing compartment 105 is fully opened, cooler cover 120 and cool air return port 135 in the lower part of cooler cover 120 conventionally not easily seen behind a back surface of an interior case are visible.

**[0072]** Thus, in the present exemplary embodiment, projection member 136 protruding toward the interior side is disposed on the lower surface of the freezing compartment. The configuration will be described with FIGS. 3 and 4. From the upper surface of fourth heat insulating partition portion 113, a distance to the lower end of cool air return port 135 is A, a height to an upper surface of projection member 136 is B, and a distance to the center of defrosting heater 132 is C. An overlapping part in the height direction of the lower end of cool air return port 135 and projection member 136 is 0 mm or more, that is, in a relationship of  $A \leq B$ . At this time, with a relationship of  $A \geq C$  and  $B \geq A \geq C$ , red heat from defrosting heater 132 formed by the glass tube heater at the time of defrosting is not visible. Thus, even in the case where the freezing compartment door is opened at the time of defrosting the refrigerator, a user does not feel anxiety given by red heat of defrosting heater 132.

**[0073]** When a space distance between the lower end of cool air return port 135 and projection member 136 is D, a relationship is  $B \leq D$  in the present exemplary embodiment. Thereby, the return cool air from the interior to cooler 107 can ensure convection not only in the part of flow-direction guide portions 122 on a front surface of cool air return port 135 but also from the lower side of the interior. Therefore, a large area for the return cool air passing can be obtained, and ventilation resistance can be further lowered. As a result, a circulation wind amount can be increased, a heat exchange amount in cooler 107 is increased, and an evaporation temperature is increased, so that energy saving can be achieved by improvement of freezing cycle efficiency.

**[0074]** By the improvement of the heat exchange amount of cooler 107 and the increase in the circulation wind amount, a time for cooling the interior can be reduced. Thus, a frost formation amount onto cooler 107 due to shortening of a cooling operation time can also be reduced. Thereby, a defrosting period of cooler 107 can be extended. The input number of defrosting heater 132 can be decreased and an input required for cooling the interior after an interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0075]** Obtaining a large heat exchange area in cooler 107 by improvement of a wind passage means increasing an area where frost is formed in cooler 107. Thus, deterioration of a cooling ability at the time of frost formation can be suppressed. Thereby, an operation time of the refrigerator until defrosting is required can be extended. Thus, the input number of defrosting heater 132 can be decreased and the input required for cooling the interior after the interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0076]** It should be noted that when ventilation resistance is reduced, the circulation wind amount of cool air blower fan 116 is increased in a case of the same fan voltage. FIG. 5 shows a characteristic image diagram of ventilation resistance and the wind amount. As shown in FIG. 5, in a cooling performance of the refrigerator, from a characteristic of a fan, when ventilation resistance is reduced from Point 1 (P1) to Point 2 (P2), the circulation wind amount is increased from Q1 to Q2.

**[0077]** Further, in the case where the performance can be ensured with the same wind amount, by decreasing the rotation number of the fan of cool air blower fan 116, the same wind amount can be obtained. In this case, the characteristic is moved from Point 2 to Point 3, and the input is reduced by a decrease amount of the rotation number of the fan, so that energy saving in terms of a power input can be achieved. Further, by the decrease in the rotation number of the fan, wind noises of cool air blower fan 116 can be reduced. Thus, even in a quiet environment where peripheral noises are low during nighttime or the like, noises do not have to be cared.

**[0078]** Further, in the present exemplary embodiment, for the purpose of regulating a shape of cool air return port 135 and ensuring an opening area, projection member 136 is in contact with an outer periphery of cooler cover 120 forming the lower end of cool air return port 135.

**[0079]** Thereby, the outer periphery of cool air return port 135 easily deformed in the case where cool air return port 135 is largely opened can be fixed. Thus, size of cool air return port 135 is regulated and the area of the opening part can be ensured, so that a sufficient cooling effect can be exerted. At the time of attachment, an operator works such that cooler cover 120 abuts with projection member 136 while projection member 136 is taken as a mark. Thus, workability is improved and a working time is shortened. Therefore, a yield ratio can be improved and product variation can be suppressed, so that a stable cooling performance can be ensured.

**[0080]** It should be noted that when projection member 136 is formed by the upper surface of fourth heat insulating partition portion 113, material cost and mold cost for making projection member 136 can be reduced, and the man-hour in a manufacturing step can also be reduced. Management of two parts including projection member 136 and the upper surface of fourth heat insulating partition portion 113 is changed to management of one part. Thus, management cost can be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0081]** In this case, regarding a part of projection member 136 in contact with the outer periphery of cooler cover 120, when a height of the outer periphery of cooler cover 120 is E, red heat is not visible from the interior with  $B \leq E$ . At this time, width of projection member 136 or projection member 136 formed by the upper surface of fourth heat insulating partition portion 113 does not require large width in the interior but a few points. Thereby, material cost can be reduced and a yield ratio at the time of manufacturing parts can be improved.

**[0082]** Further, a shape of flow-direction guide portions 122 in cool air return port 135 in the present exemplary embodiment will be described.

**[0083]** Flow-direction guide portions 122 extend from the interior side to the side of the back surface cooler. Flow-direction guide portion 122 of a return lower part is longer than flow-direction guide portion 122 of a return upper part on the side of defrosting heater 132.

**[0084]** Thereby, ventilation resistance of cool air return port 135 can be reduced so as to improve a cooling ability. In addition, there is an effect of easily suppressing a warm air inflow to the interior due to the radiation heat from defrosting heater 132 at the time of defrosting. When the warm air inflow can be reduced, the interior temperature increase at the time of defrosting can be suppressed. Thus, in cooling after finishing defrosting, the interior temperature can be restored with a low input for a short time, so that long term storage can be achieved by suppressing deterioration of food quality due to suppression of a food temperature change. Further, energy saving can also be realized.

**[0085]** A far end of each of the flow-direction guide portions 122 is located at a higher position than a line connecting between a far end of another one of the flow-direction guide portions 122 provided below the each of the flow-direction guide portions and the center of the defrosting heater 132.

**[0086]** Thereby, when seen from the interior, flow-direction guide portions 122 are seen as overlapping with respect to defrosting heater 132. Thus, even in the case where the freezing compartment door is opened at the time of defrosting the refrigerator, red heat of defrosting heater 132 is not visible. There is an effect of suppressing an interior inflow of the radiation heat from defrosting heater 132 at the time of defrosting, so that the interior temperature increase is suppressed. At this time, the warm air due to the heat at the time of defrosting flows to the side of the cooler by flow-direction guide portions 122. Thus, defrosting efficiency can be improved and an energy saving effect due to shortening of the defrosting time can be obtained.

**[0087]** In addition, suppression of the warm air inflow to the interior is also effective for preventing frost formation on the interior. When the warm air inflow to the interior is great, frost formation is remarkably generated particularly in a part communicating with the interior and on a top surface of the interior. As the time elapses at the time of the long term use, there is a possibility that the frost formation part is dropped and brought down to the interior case upon every defrosting. With the shape of the present exemplary embodiment, the warm air inflow to the interior can be suppressed. Thus, even when the refrigerator is used for substantially 10 years or more, frost formation can be prevented, so that a high quality refrigerator can be provided.

**[0088]** A line connecting interior side end surfaces of flow-direction guide portion 122 of the cool air return port upper part through to flow-direction guide portion 122 of the cool air return port lower part is parallel with a draft of the back surface of the interior case. Thus, an interval between the interior case and cool air return port 135 can be a fixed value or more without a locally narrow part, and the wind amount is not lowered due to an increase in ventilation resistance of a wind passage. Therefore, a cooling ability is not lowered.

**[0089]** In a recent trend of large capacity, a large interior case to a maximum extent leads to sales improvement. The draft at the time of molding the interior case is parallel with the line connecting the interior side end surfaces of flow-direction guide portions 122. Therefore, at the time of molding the interior case, a maximum actual interior capacity with an invalid space being reduced can be realized. In addition, since flow-direction guide portions 122 does not abut with the interior case even in a case of large capacity, cracking and contact noises due to abutment between the interior

case and flow-direction guide portions 122 at the time of actual use are eliminated.

[0090] Further, the shortest distance between end surfaces of flow-direction guide portions 122 on the side of defrosting heater 132 and the outer shell of the glass tube of defrosting heater 132 is 60 mm or more. From this, a temperature increase of cooler cover 120 itself forming cool air return port 135 due to the radiation heat from defrosting heater 132 at the time of defrosting can be suppressed. Thus, even in the case where the defrosting time is excessively extended at the time of frost formation or the like, deformation or the like due to a temperature influence of the radiation heat is not generated. Since the shortest distance is 60 mm or more, the warm air from defrosting heater 132 at the time of defrosting flows to the side of the cooler, so that there is an effect of easily suppressing the inflow to the interior.

[0091] It should be noted that in the present exemplary embodiment, a type of the cooling medium is isobutane. Thus, the temperature of the surface of the glass tube of defrosting heater 132 at the time of defrosting is regulated to be 394°C or less. Inexpensive PP (polypropylene) is used as a material of cooler cover 120 and flow-direction guide portions 122 used in the present exemplary embodiment, and a heatproof melting temperature of PP is about 200°C, and an ignition temperature thereof is about 440°C. However, in consideration with the time of actual use, the heatproof temperature is set to be 135°C. That is, considering as the worst condition, with the temperature of the surface of the glass tube of 394°C and PP as the material, size is calculated so as to obtain the heatproof temperature of 135°C or less, so that the shortest distance is 60 mm or more as described above. The Stefan-Boltzmann law is used in the above calculation.

## SECOND EXEMPLARY EMBODIMENT

[0092] FIG. 6 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a second exemplary embodiment of the present invention.

[0093] As shown in FIG. 6, the refrigerator has cooler 157 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 182 formed by a glass tube heater which is provided below cooler 157. Drain pan 184 integrated with a lower surface of a freezing compartment for receiving defrosted water dropped after frost formed on cooler 157 is melted is provided below defrosting heater 182. Cool air return port 185 through which the cool air after cooling freezing compartment 155 is returned to cooler 157 is provided in a lower part of cooler cover 170 covering cooler 157. Center of defrosting heater 182 is disposed on the upper side of an upper surface of fourth heat insulating partition portion 163 on a lower surface of freezing compartment 155.

[0094] In the present exemplary embodiment, projection member 186 protruding toward the interior side is disposed on the lower surface of freezing compartment 155. From an upper surface of fourth heat insulating partition portion 163, a distance to a lower end of cool air return port 185 is A, a height to an upper surface of projection member 186 is B, and a distance to the center of defrosting heater 182 is C1. An overlapping part in the height direction of the lower end of cool air return port 185 and projection member 186 is 0 mm or more, that is, in a relationship of  $A \leq B$ . At this time, with a relationship of  $A \leq C1$  and  $C1 \geq B \geq A$ , red heat from defrosting heater 182 at the time of defrosting is not visible. Thus, even in the case where a freezing compartment door is opened at the time of defrosting the refrigerator, a user does not feel anxiety given by red heat of defrosting heater 182 formed by the glass tube heater.

## THIRD EXEMPLARY EMBODIMENT

[0095] FIG. 7 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a third exemplary embodiment of the present invention.

[0096] As shown in FIG. 7, the refrigerator has cooler 207 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 232 formed by a glass tube heater which is provided below cooler 207. Drain pan 234 integrated with a lower surface of a freezing compartment for receiving defrosted water dropped after frost formed on cooler 207 is melted is provided below defrosting heater 232. Cool air return port 235 through which the cool air after cooling freezing compartment 205 is returned to cooler 207 is provided in a lower part of cooler cover 220 covering cooler 207. Flow-direction guide portions 222 are provided in cool air return port 235, and center of defrosting heater 232 is disposed on the upper side of an upper surface of fourth heat insulating partition portion 213. Projection member 236 protruding toward the interior side is disposed on the lower surface of freezing compartment 205.

[0097] In the present exemplary embodiment, projection member 236 is integrated with cooler cover 220 and fixed in contact with a contact part (not shown) with the lower surface of freezing compartment 205, so that red heat is not visible from the interior. Further, an outer periphery of cool air return port 235 easily deformed in the case where cool air return port 235 is largely opened can be fixed. Thus, size of cool air return port 235 is regulated and an area of an opening part can be ensured, so that a sufficient cooling effect can be exerted. At the time of attachment, the operator works in such a manner that the contact part abuts therewith while the contact part is taken as a mark. Thus, workability is improved and the working time is shortened. Therefore, a yield ratio can be improved and product variation can be suppressed, so that a stable cooling performance can be ensured.

## FOURTH EXEMPLARY EMBODIMENT

**[0098]** FIG. 8 is a detailed sectional view of a cooler compartment of a refrigerator in a fourth exemplary embodiment of the present invention.

**[0099]** As shown in FIG. 8, the refrigerator has cooler 257 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 282 formed by a glass tube heater which is provided below cooler 257. Drain pan 284 integrated with a lower surface of a freezing compartment for receiving defrosted water dropped after frost formed on cooler 257 is melted is provided below defrosting heater 282. Cool air return port 285 through which the cool air after cooling freezing compartment 255 is returned to cooler 257 is provided in a lower part of cooler cover 270 covering cooler 257. Flow-direction guide portions 272 are provided in cool air return port 285, and center of defrosting heater 282 is disposed on the upper side of an upper surface of fourth heat insulating partition portion 263. Projection member 286 protruding toward the interior side is disposed on the lower surface of freezing compartment 255.

**[0100]** Above defrosting heater 282, cover heater 283 covering defrosting heater 282 is disposed. Cover heater 283 has size equal to or more than a diameter and width of the glass tube in such a manner that hissing sounds are not generated when waterdrops dropped from cooler 257 at the time of defrosting directly fall down to a surface of the glass tube forming defrosting heater 282 whose temperature is increased by defrosting.

**[0101]** In the present exemplary embodiment, cover heater 283 is inclined in the front and rear direction, and an end surface of cover heater 283 on the back surface side is lifted with respect to the interior side. Cooler 257 has a zigzag pipe pattern, and cooler 257 is attached in such a manner that a cooling pipe is inclined on the interior side.

**[0102]** At the time of a cooling operation, the cool air returned from cool air return port 285 to cooler 257 via flow-direction guide portions 272 easily flows to the side of cooler 257 along an inclination of cover heater 283. Therefore, the cool air does not easily become a rolled flow around defrosting heater 282. Thus, since the return cool air smoothly and efficiently flows to cooler 257, heat exchange efficiency is improved and a cooling ability is improved. As a result, the refrigerator excellent in an energy saving property can be provided.

**[0103]** At the time of defrosting, a frost formation amount onto the front surface side of cooler 257 is increased, and upon defrosting mainly on the back surface side due to the inclination of cover heater 283, defrosting of the front surface side of the cooler where the frost formation amount is great is delayed. Thus, there is a problem that the defrosting time is extended.

**[0104]** In the present exemplary embodiment, cooler 257 having not the conventional inline pipe pattern but the zigzag pipe pattern is used. Since cooler 257 having the zigzag pipe pattern is attached in such a manner that the pipe is inclined on the interior side, the warm air at the time of defrosting becomes a flow toward the interior side by inclination of the pipe. Further, the size of cover heater 283 is equal to or more than the diameter and the width of the glass tube forming defrosting heater 282. Thus, the cover heater does not cover defrosting heater 282 on the interior side, and the warm air of defrosting heater 282 flows toward cooler 257 also from the interior side.

**[0105]** Thereby, without partly defrosting cooler 257, the whole cooler can be efficiently defrosted. Thus, defrosting is not partly delayed or the whole defrosting time is not extended. As a result, an interior temperature is not excessively increased due to a heat influence on the interior by defrosting heater 282 at the time of defrosting.

**[0106]** That is, the defrosting time is not extended due to unevenly formed frost on cooler 257, so that a highly energy saving refrigerator due to improvement of a cooling performance can be provided.

**[0107]** It should be noted that by inclining the back surface side of cover heater 283 upward, defrosting efficiency is improved.

## FIFTH EXEMPLARY EMBODIMENT

**[0108]** Hereinafter, a fifth exemplary embodiment of the present invention will be described in detail with reference to the drawings.

**[0109]** FIG. 9 is a perspective view of a refrigerator in the fifth exemplary embodiment of the present invention. FIG. 10 is a vertically sectional view of the refrigerator in the fifth exemplary embodiment of the present invention. FIG. 11 is a vertically sectional view of a cooler periphery of the refrigerator in the fifth exemplary embodiment of the present invention. FIG. 12 is a detailed vertically sectional view of the cooler periphery of the refrigerator in the fifth exemplary embodiment of the present invention.

**[0110]** As shown in FIGS. 9 to 12, refrigerator body 301 has forward-opened outer box 324 made of metal (such as an iron plate), inner box 325 made of rigid resin (such as ABS), and heat insulating body 326 made of rigid urethane foams which are foamed and charged between outer box 324 and inner box 325. Refrigerator body 301 includes refrigerating compartment 302 provided in an upper part, upper level freezing compartment 303 provided below refrigerating compartment 302, and ice-making compartment 304 provided below refrigerating compartment 302 in parallel with upper level freezing compartment 303. Further, refrigerator body 301 includes vegetable compartment 306 provided in a lower part of the body, and lower level freezing compartment 305 provided between upper level freezing compartment 303

and ice-making compartment 304 which are installed in parallel with each other and vegetable compartment 306. Front surface parts of upper level freezing compartment 303, ice-making compartment 304, lower level freezing compartment 305, and vegetable compartment 306 are openably closed by upper level freezing compartment door 303a, ice-making compartment door 304a, lower level freezing compartment door 305a, and vegetable compartment door 306a of a pull-out type. A front surface of refrigerating compartment 302 is openably closed by double-door type refrigerating compartment door 302a.

**[0111]** A temperature of refrigerating compartment 302 is generally set in a range from 1°C to 5°C with an unfreezable temperature as a lower limit for refrigerating storage. A temperature of vegetable compartment 306 is often in a range from 2°C to 7°C of a temperature setting equal to or slightly higher than refrigerating compartment 302. With a low temperature, freshness of green vegetables can be maintained for a long time.

**[0112]** Temperatures of upper level freezing compartment 303 and lower level freezing compartment 305 are generally set in a range from -22°C to -18°C for freezing storage. However, for improving a freezing storage state, the temperatures are sometimes set in, for example, a low-temperature range from -30°C to -25°C.

**[0113]** Since refrigerating compartment 302 and vegetable compartment 306 are set at a temperature above zero in interiors thereof, the compartments are called a refrigerating temperature zone. Since upper level freezing compartment 303, lower level freezing compartment 305, and ice-making compartment 304 are set at a temperature below zero in interiors thereof, the compartments are called a freezing temperature zone. By using a damper mechanism or the like, upper level freezing compartment 303 may serve as a switching compartment for which the refrigerating temperature zone or the freezing temperature zone can be selected.

**[0114]** A top surface portion of refrigerator body 301 is formed by first top surface portion 308 and second top surface portion 309 by providing a step-like concave part toward the back surface direction of the refrigerator. Machine compartment 319 is provided in second top surface portion 309 where the step-like concave part is provided. By enclosing a cooling medium into a freezing cycle formed by successively connecting compressor 317 disposed in machine compartment 319 in the step-like concave part, a dryer (not shown) for removing water contents, a capacitor (not shown), a heat-radiation pipe (not shown) for heat radiation, capillary tube 318, and cooler 307 in a circular form, a cooling operation is performed. In recent years, as the cooling medium, a combustible cooling medium is often used for environmental protection. It should be noted that in a case of a freezing cycle in which a three-way valve and a switching valve are used, those functional parts can be disposed in machine compartment 319.

**[0115]** Refrigerating compartment 302, ice-making compartment 304, and upper level freezing compartment 303 are partitioned by first heat insulating partition portion 310. Ice-making compartment 304 and upper level freezing compartment 303 are partitioned by second heat insulating partition portion 311. Ice-making compartment 304 and upper level freezing compartment 303, and lower level freezing compartment 305 are partitioned by third heat insulating partition portion 312.

**[0116]** Since second heat insulating partition portion 311 and third heat insulating partition portion 312 are parts assembled after forming refrigerator body 301 by foaming, expanded polystyrene is generally used as a heat insulating material. However, rigid urethane foams may be used for improving a heat insulating performance and rigidity. Further, by inserting a vacuum heat insulating material having a high heat-insulating property as second heat insulating partition portion 311 and third heat insulating partition portion 312, thickness of a partition structure may be further reduced.

**[0117]** By ensuring an operating part of a door frame so as to reduce thickness of shapes of second heat insulating partition portion 311 and third heat insulating partition portion 312 or to eliminate the heat insulating partition portions, a cooling wind passage can be ensured and a cooling ability can also be improved. By hollowing out second heat insulating partition portion 311 and third heat insulating partition portion 312 so as to make a wind passage, materials are consequently reduced and cost can be reduced.

**[0118]** Lower level freezing compartment 305 and vegetable compartment 306 are partitioned by fourth heat insulating partition portion 313.

**[0119]** Next, a configuration of the cooler periphery in the present exemplary embodiment will be described.

**[0120]** Cooler compartment 323 is provided on a back surface of refrigerator body 301. In cooler compartment 323, as a representative part, fin-and-tube type cooler 307 for generating the cool air is disposed so as to extend in the up and down direction on a back surface of lower level freezing compartment 305 including rear regions of second heat insulating partition portion 311 and third heat insulating partition portion 312 which serve as heat insulating partition walls.

**[0121]** Cooler cover 320 made of aluminum or copper, the cooler cover covering cooler 307 is disposed on a front surface of cooler compartment 323. Cool air return port 335 through which the cool air after cooling lower level freezing compartment 305 is returned to cooler 307 is provided in cooler cover 320.

**[0122]** Cooler cover 320 includes cooler front side cover 337 on the interior side and cooler rear side cover 338 on the side of the cooler, and heat transfer suppression space 339 formed by cooler front side cover 337 and cooler rear side cover 338 is provided in front of cooler 307. Heat transfer suppression space 339 is formed between an upper end of cool air return port 335 provided in a lower part of cooler cover 320 and a lower end of a discharge port to lower level freezing compartment 305. When a height of heat transfer suppression space 339 is up to an upper end of cooler 307,

there is an effect of suppressing heat transfer. However, a position may be decided based on a balance with an interior capacity or case size. In the present exemplary embodiment, the height of heat transfer suppression space 339 is substantially up to the lower end of the discharge port to lower level freezing compartment 305 on the third step from the lower side of cooler 307 close to defrosting heater 332 in consideration with a flow of the warm air at the time of defrosting. Inside of heat transfer suppression space 339 serves as an air layer.

**[0123]** Metal heat transfer facilitating member 340 is disposed on the side of cooler 307 of cooler rear side cover 338. In the present exemplary embodiment, in consideration with cost, for facilitating heat transfer at the time of defrosting, an aluminum foil with  $t = 8 \mu\text{m}$  is attached from a lower end to the upper end of cooler 307 in the up and down direction by larger size of about 15 mm from a part between fins of cooler 307 in the left and right direction. From this, heat transfer at the time of defrosting is facilitated, and due to improvement of defrosting efficiency, an effect of shortening the defrosting time is obtained. It should be noted that in order to obtain a further effect, an aluminum foil may be disposed in inner box 325 on the back surface side of cooler 307. Further, when an aluminum plate thicker than an aluminum foil or a material having higher heat conductivity than aluminum (such as copper) is used, the effect of facilitating heat transfer is further exerted.

**[0124]** Defrosting warm air guide member 341 is provided in cool air return port 335 of cooler cover 320. Defrosting warm air guide member 341 forms an upward angle from the interior side toward the side of cooler 307. In the present exemplary embodiment, the angle is substantially  $45^\circ$  with respect to the horizon. At this time, defrosting warm air guide portion upper end 343 serving as an upper end of defrosting warm air guide member 341 is disposed at a higher position than cooler lower end 344. Thereby, the return cool air circulated in the interior can take a large heat exchange area in cooler 307. Thus, a heat exchange amount in cooler 307 is increased, so that an ability of cooler 307 can be improved.

**[0125]** Further, flow-direction guide portions 322 are provided in cool air return port 335. An interval of flow-direction guide portions 322 is 5 mm in consideration with prevention of finger invasion and ensuring of strength of a mold and cooler cover 320. It should be noted that a part of flow-direction guide portions 322 also forms an upward angle from the interior side toward the side of cooler 307 in the same direction as defrosting warm air guide member 341.

**[0126]** In the vicinity of cooler 307 (such as an upper space), cool air blower fan 316 for blowing the cool air generated in cooler 307 to the storage compartments of refrigerating compartment 302, ice-making compartment 304, upper level freezing compartment 303, lower level freezing compartment 305, and vegetable compartment 306 by a forced-convection method is disposed. Defrosting heater 332 formed by a glass tube heater of a glass tube for removing frost formed on cooler 307 and cool air blower fan 316 at the time of cooling is provided below cooler 307.

**[0127]** Above defrosting heater 332 formed by the glass tube heater, cover heater 333 covering defrosting heater 332 is disposed. Cover heater has size equal to or more than a diameter and width of the glass tube in such a manner that hissing sounds are not generated when waterdrops dropped from cooler 307 at the time of defrosting directly fall down to a surface of the glass tube forming defrosting heater 332 whose temperature is increased by defrosting.

**[0128]** Drain pan 334 integrated with an upper surface of fourth heat insulating partition portion 313, the drain pan serving as a lower surface of lower level freezing compartment 305 for receiving defrosted water dropped after the frost formed on cooler 307 is melted is disposed below defrosting heater 332.

**[0129]** A diffuser (not shown) formed by cooler front side cover 337 is disposed in front of cool air blower fan 316. Wind having increased static pressure from cool air blower fan 316 is discharged to the interior straightaway without any losses.

**[0130]** In drain pan 334 integrated with the upper surface of fourth heat insulating partition portion 313, projection member 336 toward the interior side is disposed on the lower surface of lower level freezing compartment 305, so as to suspend and fix the lower part of cooler cover 320. Since projection member 336 is disposed between a lower end of cool air return port 335 and defrosting heater 332, red heat is not visible from the interior, and projection member 336 is hidden by the lower end of cool air return port 335 of cooler cover 320 when seen from the interior side. Thus, it looks good and outer appearance quality is consequently improved.

**[0131]** As a recent cooling medium of the freezing cycle, isobutane serving as a combustible cooling medium having a low global warming potential is used from a viewpoint of global environmental conservation. Isobutane of carbon hydrate has a specific gravity about twice more than the air at a normal temperature at atmospheric pressure (2.04, 300 K). Thereby, a cooling medium charging amount can be reduced in comparison to the conventional examples and cost is low. In addition, a leakage amount in the case where the combustible cooling medium is leaked out by any possibility is reduced, so that safety can be more improved.

**[0132]** In the present exemplary embodiment, isobutane is used as the cooling medium, and a maximum temperature of the surface of the glass tube serving as an outer shell of defrosting heater 332 formed by the glass tube heater at the time of defrosting is regulated as explosion protection. Therefore, in order to reduce the temperature of the surface of the glass tube, a double glass tube heater in which glass tubes are doubly formed is adopted. In addition to this, as a means for reducing the temperature of the surface of the glass tube, a member having a high heat radiation property (such as an aluminum fin) can be wound around the surface of the glass tube. At this time, with a single glass tube, outer size of defrosting heater 332 can be reduced.

**[0133]** As a means for improving efficiency at the time of defrosting, in addition to defrosting heater 332, a pipe heater closely attached to cooler 307 may also be used. In this case, cooler 307 can be efficiently defrosted by heat transfer directly from the pipe heater. Further, frost formed on drain pan 334 and cool air blower fan 316 in the periphery of cooler 307 can be melted by defrosting heater 332. Thus, the defrosting time can be shortened, so that energy saving can be achieved and an interior temperature increase during the defrosting time can be suppressed.

**[0134]** It should be noted that in the case where defrosting heater 332 formed by the glass tube heater is combined with the pipe heater, by properly matching heater capacities with each other, the capacity of defrosting heater 332 can be lowered. When the heater capacity is lowered, a temperature of the outer shell of defrosting heater 332 at the time of defrosting can also be lowered. Thus, red heat at the time of defrosting can be suppressed.

**[0135]** Next, cooling of the refrigerator will be described. For example, in the case where an interior temperature of lower level freezing compartment 305 is increased by invading heat from the external air, opening/closing of the door, and the like, and a temperature of a freezing compartment sensor (not shown) becomes a start-up temperature or more, compressor 317 is started up and cooling is started. A high-temperature and high-pressure cooling medium discharged from compressor 317 is cooled and liquefied particularly in the heat-radiation pipe (not shown) installed in outer box 324 by heat exchange with the air outside outer box 324 and with heat insulating body 326 formed by the rigid urethane foams in the interior before reaching the dryer (not shown) disposed in machine compartment 319 at the end.

**[0136]** Next, the liquefied cooling medium is decompressed in capillary tube 318, flows into cooler 307, and exchanges heat with the interior cool air in the periphery of cooler 307. The cool air after heat exchange is blown into the interior by cool air blower fan 316 in the vicinity thereof, and cools the interior. After that, the cooling medium is heated, gasified, and returned to compressor 317. In the case where the interior is cooled and the temperature of the freezing compartment sensor (not shown) becomes a stop temperature or less, an operation of compressor 317 is stopped.

**[0137]** Cool air blower fan 316 may be directly disposed in inner box 325. However, by arranging the cool air blower fan in second heat insulating partition portion 311 assembled after foaming and performing block processing of the parts, manufacturing cost can be reduced.

**[0138]** Next, the time of defrosting of the refrigerator will be described.

**[0139]** When a cooling operation of the refrigerator is performed, as the time elapses, due to water contents in the air invading at the time of opening/closing the door, water contents attached to food brought into the interior, further, water contents from vegetables stored in vegetable compartment 306, and the like, frost is formed on cooler 307. When the frost is grown, heat exchange efficiency between cooler 307 and the circulation cool air is lowered, so that the interior cannot be sufficiently cooled and brought into a fully-cooled or non-cooled state at the end. Therefore, in the refrigerator, there is a need for regularly removing the frost formed on cooler 307.

**[0140]** In the refrigerator in the present exemplary embodiment, after the refrigerator is operated and a fixed time elapses, defrosting is automatically performed. At the time of defrosting, an operation of compressor 317 and cool air blower fan 316 is stopped, and power is supplied to defrosting heater 332 formed by the glass tube heater. By the cooling medium remaining inside cooler 307 and melting of the frost formed on cooler 307, a temperature of cooler 307 is increased substantially through a sensible heat change from  $-30^{\circ}\text{C}$  to  $0^{\circ}\text{C}$ , a latent heat change at  $0^{\circ}\text{C}$ , and a sensible heat change from  $0^{\circ}\text{C}$  to higher. A defrosting sensor (not shown) is attached to cooler 307 so as to stop power supply to defrosting heater 332 at a predetermined temperature. In the present exemplary embodiment, at a time point when the defrosting sensor detects  $10^{\circ}\text{C}$ , the power supply to defrosting heater 332 is stopped.

**[0141]** At this time, the temperature of the surface of the glass tube becomes high by the power supply to defrosting heater 332, and by melting the frost formed on cooler 307, and drain pan 334 and cool air blower fan 316 in the periphery of cooler 307 by radiation heat, cooler 307 is refreshed.

**[0142]** It should be noted that in the low-temperature external air of about  $5^{\circ}\text{C}$  for example, even when the frost of cooler 307 is sufficiently removed, a temperature of the defrosting sensor (not shown) is not easily sufficiently increased at the time of defrosting due to an influence of the external air. Thus, the defrosting time tends to be extended. In this case, when a state of the sensible heat change from  $0^{\circ}\text{C}$  to higher is checked and a fixed time or longer elapses, control of finishing defrosting can be combined. Thereby, a temperature increase due to an unnecessary heater input and radiation heat to the interior caused by a situation that even when the frost is sufficiently removed, the defrosting time is extended due to an insufficient temperature increase of cooler 307 with the low-temperature external air, and further, a temperature increase due to cooling stop at the time of defrosting can be suppressed.

**[0143]** Hereinafter, actions and operations of the refrigerator with the above configuration will be described.

**[0144]** As in the present exemplary embodiment, the layout configuration of the refrigerator in which vegetable compartment 306 is installed on the lower side, lower level freezing compartment 305 is installed in the middle, and refrigerating compartment 302 is installed on the upper side is frequently used from a viewpoint of usability and energy saving. From a viewpoint of interior capacity, following a tendency of the increasing used amount of frozen food, a refrigerator in which interior case size of lower level freezing compartment 305 is increased and a capacity is improved is also provided.

**[0145]** At this time, the interior case is large, size of cooler cover 320 on the back surface is reduced. By a temperature increase in cooler 307 and cooler compartment 323 at the time of defrosting and further, the radiation heat from defrosting

heater 332 and convection, a temperature of frozen food stored in the freezing compartment is influenced. Therefore, in the present exemplary embodiment, a heat influence on the interior at the time of defrosting is suppressed by heat transfer suppression space 339 formed by cooler front side cover 337 and cooler rear side cover 338, and defrosting warm air guide member 341 provided in cool air return port 335. In the present exemplary embodiment, the inside of heat transfer suppression space 339 serves as the air layer, and heat transfer to the interior can be suppressed even upon a temperature increase in the periphery of cooler 307 due to the radiation heat from defrosting heater 332. Therefore, since a temperature influence on food stored in the interior, particularly, on the side of the cooler can be reduced, deterioration of food can be suppressed and long term storage can be achieved. Heat conductivity of the air layer is substantially 0.03 W/mK. For example, even in the case where an interior temperature is -25°C and a cooler compartment inside temperature at the time of defrosting is increased to 20°C, the interior temperature is increased only to -17°C due to heat insulation of the air layer. At this time, thickness of the air layer, that is, internal size of heat transfer suppression space 339 is 13.4 mm. Therefore, even at the time of defrosting, a temperature increase is -12°C or less at which frozen food and ice cream are melted and quality thereof is deteriorated. Thus, quality deterioration can be suppressed even upon long term storage.

**[0146]** Not only a temperature influence on food in the interior but also a point where the temperature is locally lowered in the interior can be eliminated. Thus, there is an effect of preventing water contents from being attached to cooler cover 320 as frost, the water contents being sublimed from water contents and the like which are attached to food at the time of opening/closing the door or at the time of installing food. Thereby, a dehumidification performance of cooler 307 can be ensured, and an auxiliary heater for preventing frost formation is not required to be used.

**[0147]** Since a temperature influence on the interior at the time of defrosting can be reduced, there is an effect of reducing an interior load amount at the time of defrosting. Therefore, since a cooling load amount after the defrosting time is reduced, an energy saving effect can be obtained by a decrease in the operation rotation number of compressor 317 required for cooling the interior after the defrosting time and shortening of an operation time.

**[0148]** Defrosting warm air guide member 341 is disposed and inclined at the upward angle of 45° from the interior side toward the side of cooler 307. Thus, convection due to the radiation heat from defrosting heater 332 at the time of defrosting easily flows to cooler 307, and the frost formed on cooler 307 can be efficiently melted. Thus, a power supply time of defrosting heater 332 can be reduced, so that energy saving due to reduction of a power input is achieved. At this time, with shortening of the defrosting time, by suppression of a temperature increase due to shortening of a non-cooling operation time and suppression of a temperature increase due to heat generation of defrosting heater 332 itself, since the cooling load amount after the defrosting time is reduced, an energy saving effect can be obtained by a decrease in the operation rotation number of compressor 317 required for cooling the interior after the defrosting time and shortening of the operation time.

**[0149]** Further, since convection due to the radiation heat from defrosting heater 332 at the time of defrosting easily flows to cooler 307 by defrosting warm air guide member 341, there is an effect of suppressing an interior inflow of the heat, so that the interior temperature increase is suppressed. Frozen food stored in the interior is deteriorated due to an influence of frostbite or a heat change by an interior inflow of the warm air at the time of defrosting. However, by the effect of defrosting warm air guide member 341, even in a case of long term storage, deterioration of food can be suppressed.

**[0150]** In the present exemplary embodiment, the angle of defrosting warm air guide member 341 is upward of 45°. However, the upward angle may be decided in consideration with a flowing way of the return cool air, a flowing way of the warm air at the time of defrosting, an interior capacity, and easiness of manufacturing a mold and the like.

**[0151]** Since defrosting warm air guide member 341 is integrated with cooler rear side cover 338, material cost and mold cost for making defrosting warm air guide member 341 can be reduced, and the man-hour in a manufacturing step can also be reduced. By making with cooler rear side cover 338, a shape including draft of the mold can be simplified. Thus, mold cost is consequently further reduced. Management of two parts including defrosting warm air guide member 341 and cooler rear side cover 338 is changed to management of one part. Thus, management cost can be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0152]** Meanwhile, defrosting warm air guide member 341 can also be integrated with cooler front side cover 337. In this case, the same effect as a case where the defrosting warm air guide member is integrated with cooler rear side cover 338 can also be obtained. In the present exemplary embodiment, defrosting warm air guide member 341 is integrated with cooler rear side cover 338. However, the best mode is desirably implemented in consideration with a configuration mode of cooler cover 320, easiness of manufacturing, a mold configuration, cost, and the like.

**[0153]** A part of flow-direction guide portions 322 provided in cool air return port 335 below cooler cover 320 is inclined in the same direction as defrosting warm air guide member 341, and disposed at an upward angle from the interior side toward the side of the cooler. Thereby, when seen from the interior, the flow-direction guide portions are seen as overlapping with respect to defrosting heater 332. Thus, even in the case where the freezing compartment door is opened at the time of defrosting the refrigerator, red heat of defrosting heater 332 is not visible. In the present exemplary embodiment, the angle of flow-direction guide portions 322 is the same as the draft of the mold. However, the angle

may be decided in consideration with the flowing way of the return cool air and the flowing way of the warm air at the time of defrosting.

**[0154]** Further, convection due to the radiation heat from defrosting heater 332 at the time of defrosting easily flows to cooler 307 via defrosting warm air guide member 341. Thus, the warm air inflow to the interior can be further suppressed, and efficiency at the time of defrosting can be improved.

**[0155]** Since a part of flow-direction guide portions 322 and defrosting warm air guide member 341 are inclined in the same upward direction, suction ventilation resistance of the return cool air at the time of cooling can be suppressed. Thus, a circulation wind amount can be increased, a heat exchange amount in cooler 307 is increased, and an evaporation temperature is increased, so that energy saving can be achieved by improvement of freezing cycle efficiency. It should be noted that by the improvement of the heat exchange amount of cooler 307 and the increase in the circulation wind amount, a time for cooling the interior can be reduced. Thus, a frost formation amount onto cooler 307 due to shortening of a cooling operation time can also be reduced. Thereby, a defrosting period of cooler 307 can be extended. The input number of defrosting heater 332 can be decreased and an input required for cooling the interior after an interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0156]** Defrosting warm air guide member 341 is disposed between the upper end of cool air return port 335 of cooler rear side cover 338 or a lower end on a basic sectional shape and cooler lower end 344, that is, defrosting warm air guide portion upper end 343 is placed at a higher position than cooler lower end 344. Thus, a large heat exchange area of the return cool air and cooler 307 can be obtained. Therefore, an area where frost is formed in cooler 307 is increased. Thus, deterioration of a cooling ability at the time of frost formation can be suppressed. Thereby, an operation time of the refrigerator until defrosting is required can be extended. Thus, the input number of defrosting heater 332 can be decreased and the input required for cooling the interior after the interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0157]** It should be noted that when ventilation resistance is reduced, the circulation wind amount of cool air blower fan 316 is increased in a case of the same fan voltage. FIG. 13 shows a characteristic image diagram of ventilation resistance and the wind amount. As shown in FIG. 13, in a cooling performance of the refrigerator, from a characteristic of a fan, when ventilation resistance is reduced from Point 1 (P1) to Point 2 (P2), the circulation wind amount is increased from Q1 to Q2.

**[0158]** Further, in the case where the performance can be ensured with the same wind amount, by decreasing the rotation number of the fan of cool air blower fan 316, the same wind amount can be obtained. In this case, the characteristic is moved from Point 2 to Point 3, and the input is reduced by a decrease amount of the rotation number of the fan, so that energy saving in terms of a power input can be achieved. Further, by the decrease in the rotation number of the fan, wind noises of cool air blower fan 316 can be reduced. Thus, even in a quiet environment where ambient noises are low during nighttime or the like, noises do not have to be cared.

**[0159]** In addition, suppression of the warm air inflow to the interior by flow-direction guide portions 322 and defrosting warm air guide member 341 is also effective for preventing frost formation on the interior. When the warm air inflow to the interior is great, frost formation is remarkably generated particularly in a part communicating with the interior and on a top surface of the interior. As the time elapses at the time of long term use, there is a possibility that the frost formation part is dropped and brought down to the interior case upon every defrosting. With the shape of the present exemplary embodiment, the warm air inflow to the interior can be suppressed. Thus, even when the refrigerator is used for substantially 10 years or more, frost formation can be prevented, so that a high quality refrigerator can be provided.

**[0160]** By properly forming heat transfer suppression space 339, defrosting warm air guide member 341, and flow-direction guide portions 322, a further energy saving effect due to reduction of an interior heat influence at the time of defrosting and improvement of defrosting efficiency can be exerted.

**[0161]** It should be noted that in the present exemplary embodiment, the inside of the formed heat transfer suppression space serves as the air layer. However, for example, by making rigid urethane foams, expanded polystyrene (foamed polystyrene), and expanded polyethylene having a high heat insulating performance and low heat conductivity a heat insulating member, a temperature influence can be further reduced. Thus, a further effect can be exerted.

**[0162]** A shortest distance between end surfaces of flow-direction guide portions 322 on the side of defrosting heater 332 and the outer shell of the glass tube of defrosting heater 332 is 60 mm or more. From this, a temperature increase of cooler cover 320 itself forming cool air return port 335 due to the radiation heat from defrosting heater 332 at the time of defrosting can be suppressed. Therefore, even in the case where the defrosting time is excessively extended at the time of frost formation or the like, deformation or the like due to a temperature influence of the radiation heat is not generated. Since the shortest distance is 60 mm or more, the warm air from defrosting heater 332 at the time of defrosting flows to the side of the cooler, so that there is an effect of easily suppressing the inflow to the interior.

**[0163]** It should be noted that in the present exemplary embodiment, a type of the cooling medium is isobutane. Thus, the temperature of the surface of the glass tube of defrosting heater 332 at the time of defrosting is regulated to be 394°C or less. Inexpensive PP (polypropylene) is used as a material of cooler cover 320 and flow-direction guide portions 322 used in the present exemplary embodiment, and a heatproof melting temperature of PP is about 200°C, and an

ignition temperature thereof is about 440°C. However, in consideration with the time of actual use, the heatproof temperature is set to be 135°C. That is, considering as the worst condition, with the temperature of the surface of the glass tube of defrosting heater 332 of 394°C and PP as the material, size is calculated so as to obtain the heatproof temperature of 135°C or less, so that the shortest distance is 60 mm or more as described above. The Stefan-Boltzmann law is used in the above calculation.

#### SIXTH EXEMPLARY EMBODIMENT

**[0164]** FIG. 14 is a detailed vertically sectional view of a cooler periphery of a refrigerator in a sixth exemplary embodiment of the present invention.

**[0165]** As shown in FIG. 14, the refrigerator has cooler 357 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 382 formed by a glass tube heater which is provided below cooler 357. Drain pan 384 integrated with a lower surface of lower level freezing compartment 355 for receiving defrosted water dropped after frost formed on cooler 357 is melted is provided below defrosting heater 382. Cooler cover 370 including cool air return port 385 through which the cool air after cooling lower level freezing compartment 355 is returned to cooler 357 and covering cooler 357 is disposed.

**[0166]** Defrosting warm air guide member 391 is provided in cool air return port 385 of cooler cover 370. Defrosting warm air guide member 391 forms an upward angle from the interior side toward the side of cooler 357. In the present exemplary embodiment, the angle is substantially 45°. Flow-direction guide portions 372 are provided in cool air return port 385 provided in a lower part of cooler cover 370. A part of flow-direction guide portions 372 also forms an upward angle from the interior side toward the side of cooler 357 in the same direction as defrosting warm air guide member 391.

**[0167]** In the present exemplary embodiment, center of defrosting heater 382 is disposed at a position on the upper side of a bottom basic surface of lower level freezing compartment 355 serving as an upper surface of fourth heat insulating partition portion 363. Thereby, a shape of drain pan 384 integrated with the lower surface of the lower level freezing compartment can be substantially horizontal. Thus, an invalid space created by installment of defrosting heater 382 can be reduced and an interior capacity can be increased.

**[0168]** Since depth of drain pan 384 can be shallow, mold cost at the time of molding constituent parts can be suppressed. Thus, cost is consequently reduced. Deformation at the time of foaming the rigid urethane foams closely attached to inside of the outer box and the inner box of the refrigerator body can be suppressed, so that a product yield ratio is improved and disposal cost is reduced. In addition, workability at the time of attachment is also improved. Thus, the refrigerator with favorable outer appearance quality can be provided.

**[0169]** At this time, a part of flow-direction guide portions 372 provided in cool air return port 385 below cooler cover 370 is inclined in the same direction as defrosting warm air guide member 391, and disposed at an upward angle from the interior side toward the side of cooler 357. Thereby, when seen from the interior, flow-direction guide portions 372 are seen as overlapping with respect to defrosting heater 382. Thus, even in the case where a freezing compartment door is opened at the time of defrosting the refrigerator, red heat of defrosting heater 382 at the time of defrosting is not visible, so that a user does not feel anxiety.

#### SEVENTH EXEMPLARY EMBODIMENT

**[0170]** FIG. 15 is a detailed sectional view of a cooler compartment of a refrigerator in a seventh exemplary embodiment of the present invention.

**[0171]** As shown in FIG. 15, the refrigerator has cooler 407 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 432 formed by a glass tube heater which is provided below cooler 407. Drain pan 434 integrated with a lower surface of lower level freezing compartment 405 for receiving defrosted water dropped after frost formed on cooler 407 is melted is provided below defrosting heater 432. Cooler cover 420 including cool air return port 435 through which the cool air after cooling lower level freezing compartment 405 is returned to cooler 407, the cooler cover covering cooler 407, is disposed.

**[0172]** Defrosting warm air guide member 441 is provided in cool air return port 435 of cooler cover 420. Defrosting warm air guide member 441 forms an upward angle from the interior side toward the side of cooler 407. In the present exemplary embodiment, the angle is substantially 45°. Flow-direction guide portions 422 are provided in cool air return port 435 provided in a lower part of cooler cover 420. A part of flow-direction guide portions 422 also forms an upward angle from the interior side toward the side of cooler 407 in the same direction as defrosting warm air guide member 441.

**[0173]** In the present exemplary embodiment, cover heater 433 covering an upper part of defrosting heater 432 is inclined in the front and rear direction, and an end surface of cover heater 433 on the back surface side is lifted with respect to the interior side. Cooler 407 has a zigzag pipe pattern, and cooler 407 is attached in such a manner that a cooling pipe is inclined on the interior side.

**[0174]** Thereby, at the time of defrosting, a flow of the warm air firstly and mainly flows on the back surface side of

cooler 407, and then goes toward the interior side by inclination of the pipe. Therefore, the warm air does not easily flow to cool air return port 435, and a warm air inflow to the interior is suppressed by defrosting warm air guide member 441 and flow-direction guide portions 422. Thus, an effect is exerted for reducing an interior temperature increase.

**[0175]** It should be noted that by setting an inlet pipe of cooler 407 on the back surface side, convection of defrosting warm air can be generated mainly in a low-temperature part where frost is easily formed. Thus, defrosting can be efficiently performed.

**[0176]** It should be noted that by inclining the back surface side of cover heater 433 upward, defrosting efficiency can be further improved.

## EIGHTH EXEMPLARY EMBODIMENT

**[0177]** FIG. 16 is a detailed sectional view of a cooler compartment of a refrigerator in an eighth exemplary embodiment of the present invention.

**[0178]** As shown in FIG. 16, the refrigerator has cooler 457 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 482 formed by a glass tube heater which is provided below cooler 457. Drain pan 484 integrated with a lower surface of lower level freezing compartment 455 for receiving defrosted water dropped after frost formed on cooler 457 is melted is provided below defrosting heater 482. Cooler cover 470 including cool air return port 485 through which the cool air after cooling lower level freezing compartment 455 is returned to cooler 457, the cooler cover covering cooler 457, is disposed.

**[0179]** Defrosting warm air guide member 491 is provided in cool air return port 485 of cooler cover 470. Defrosting warm air guide member 491 forms an upward angle from the interior side toward the side of cooler 457. In the present exemplary embodiment, the angle is substantially 45°. Flow-direction guide portions 472 are provided in cool air return port 485 provided in a lower part of cooler cover 470. Flow-direction guide portions 472 also form an upward angle from the interior side toward the side of cooler 457 in the same direction as defrosting warm air guide member 491.

**[0180]** In the present exemplary embodiment, flow-direction guide portions 472 are coupled to defrosting warm air guide member 491, so as to form coupled flow-direction guide 495 serving as a large flow-direction guide portion. Thereby, convection due to radiation heat from defrosting heater 482 at the time of defrosting further easily flows to cooler 457, and the frost formed on cooler 457 can be efficiently melted. Thus, a power supply time of defrosting heater 482 can be reduced, so that energy saving due to reduction of a power input is achieved.

**[0181]** An effect of suppressing an interior inflow of the radiation heat from defrosting heater 482 at the time of defrosting is enhanced, so that an interior temperature increase is further suppressed.

**[0182]** By integrating coupled flow-direction guide 495 with cooler front side cover 487 or cooler rear side cover 488, material cost and mold cost can be reduced and the man-hour in a manufacturing step can also be reduced.

## NINTH EXEMPLARY EMBODIMENT

**[0183]** Hereinafter, a ninth exemplary embodiment of the present invention will be described in detail with reference to the drawings.

**[0184]** FIG. 17 is a perspective view of a refrigerator in the ninth exemplary embodiment of the present invention. FIG. 18 is a vertically sectional view of the refrigerator in the ninth exemplary embodiment of the present invention. FIG. 19 is a vertically sectional view of a cooler periphery of the refrigerator in the ninth exemplary embodiment of the present invention. FIG. 20 is a detailed vertically sectional view of the cooler periphery of the refrigerator in the ninth exemplary embodiment of the present invention.

**[0185]** As shown in FIGS. 17 to 20, refrigerator body 501 has forward-opened outer box 524 made of metal (such as an iron plate), inner box 525 made of rigid resin (such as ABS), and heat insulating body 526 made of rigid urethane foams which are foamed and charged between outer box 524 and inner box 525. Refrigerator body 501 includes refrigerating compartment 502 provided in an upper part, upper level freezing compartment 503 provided below refrigerating compartment 502, and ice-making compartment 504 provided below refrigerating compartment 502 in parallel with upper level freezing compartment 503. Further, refrigerator body 501 includes vegetable compartment 506 provided in a lower part of the body, and lower level freezing compartment 505 provided between upper level freezing compartment 503 and ice-making compartment 504 which are installed in parallel with each other and vegetable compartment 506. Front surface parts of upper level freezing compartment 503, ice-making compartment 504, lower level freezing compartment 505, and vegetable compartment 506 are openably closed by upper level freezing compartment door 503a, ice-making compartment door 504a, lower level freezing compartment door 505a, and vegetable compartment door 506a of a pull-out type. A front surface of refrigerating compartment 502 is openably closed by, for example, double-door type refrigerating compartment door 502a.

**[0186]** A temperature of refrigerating compartment 502 is generally set in a range from 1°C to 5°C with an unfreezable temperature as a lower limit for refrigerating storage. A temperature of vegetable compartment 506 is often in a range

from 2°C to 7°C of a temperature setting equal to or slightly higher than refrigerating compartment 502. With a low temperature, freshness of green vegetables can be maintained for a long time.

[0187] Temperatures of upper level freezing compartment 503 and lower level freezing compartment 505 are generally set in a range from -22°C to -18°C for freezing storage. However, for improving a freezing storage state, the temperatures are sometimes set in for example a low-temperature range from -30°C to -25°C.

[0188] Since refrigerating compartment 502 and vegetable compartment 506 are set at a temperature above zero in interiors thereof, the compartments are called a refrigerating temperature zone. Since upper level freezing compartment 503, lower level freezing compartment 505, and ice-making compartment 504 are set at a temperature below zero in interiors thereof, the compartments are called a freezing temperature zone. By using a damper mechanism or the like, upper level freezing compartment 503 may serve as a switching compartment for which the refrigerating temperature zone or the freezing temperature zone can be selected.

[0189] A top surface portion of refrigerator body 501 is formed by first top surface portion 508 and second top surface portion 509 by providing a step-like concave part toward the back surface direction of the refrigerator. Machine compartment 519 is provided in second top surface portion 509 where the step-like concave part is provided. By enclosing a cooling medium into a freezing cycle formed by successively connecting compressor 517 disposed in machine compartment 519 in the step-like concave part, a dryer (not shown) for removing water contents, a capacitor (not shown), a heat-radiation pipe (not shown) for heat radiation, capillary tube 518, and cooler 507 in a circular form, a cooling operation is performed. In recent years, as the cooling medium, a combustible cooling medium is often used for environmental protection. It should be noted that in a case of a freezing cycle in which a three-way valve and a switching valve are used, those functional parts can be disposed in machine compartment 519.

[0190] Refrigerating compartment 502, ice-making compartment 504, and upper level freezing compartment 503 are partitioned by first heat insulating partition portion 510. Ice-making compartment 504 and upper level freezing compartment 503 are partitioned by second heat insulating partition portion 511. Ice-making compartment 504 and upper level freezing compartment 503, and lower level freezing compartment 505 are partitioned by third heat insulating partition portion 512.

[0191] Since second heat insulating partition portion 511 and third heat insulating partition portion 512 are parts assembled after forming refrigerator body 501 by foaming, expanded polystyrene is generally used as a heat insulating material. However, rigid urethane foams may be used for improving a heat insulating performance and rigidity. Further, by inserting a vacuum heat insulating material having a high heat-insulating property as second heat insulating partition portion 511 and third heat insulating partition portion 512, thickness of a partition structure may be further reduced.

[0192] By ensuring an operating part of a door frame so as to reduce thickness of shapes of second heat insulating partition portion 511 and third heat insulating partition portion 512 or to eliminate the heat insulating partition portions, a cooling wind passage can be ensured and a cooling ability can also be improved. By hollowing out second heat insulating partition portion 511 and third heat insulating partition portion 512 so as to make a wind passage, materials are consequently reduced and cost can be reduced.

[0193] Lower level freezing compartment 505 and vegetable compartment 506 are partitioned by fourth heat insulating partition portion 513.

[0194] Next, a configuration of the cooler periphery in the present exemplary embodiment will be described.

[0195] Cooler compartment 523 is provided on a back surface of refrigerator body 501. In cooler compartment 523, as a representative part, fin-and-tube type cooler 507 for generating the cool air is disposed so as to extend in the up and down direction on a back surface of lower level freezing compartment 505 including rear regions of second heat insulating partition portion 511 and third heat insulating partition portion 512 which serve as heat insulating partition walls.

[0196] Cooler cover 520 including cool air return port 535 through which the cool air after cooling the freezing compartment is returned to the cooler and covering cooler 507 is disposed on the interior side on a front surface of cooler compartment 523. Aluminum or copper is used as a material of cooler 507. Cooler cover 520 includes cooler front side cover 537 on the interior side and cooler rear side cover 538 on the side of the cooler, and heat transfer suppression space 539 formed by cooler front side cover 537 and cooler rear side cover 538 is provided in front of cooler 507. Heat transfer suppression space 539 is formed between an upper end of cool air return port 535 provided in a lower part of cooler cover 520 and a lower end of a discharge port to lower level freezing compartment 505. When a height of heat transfer suppression space 539 is up to an upper end of cooler 507, there is an effect of suppressing heat transfer. However, a position may be decided based on a balance with an interior capacity or case size. In the present exemplary embodiment, the height of heat transfer suppression space 539 is substantially up to the lower end of the discharge port to lower level freezing compartment 505 on the third step from the lower side of cooler 507 close to defrosting heater 532 in consideration with a flow of the warm air at the time of defrosting. Inside of heat transfer suppression space 539 serves as an air layer.

[0197] Metal heat transfer facilitating member 540 is disposed on the side of cooler 507 of cooler rear side cover 538. In the present exemplary embodiment, in consideration with cost, for facilitating heat transfer at the time of defrosting, an aluminum foil with  $t = 8 \mu\text{m}$  is attached from a lower end of cooler 507 to the upper end in the up and down direction

by larger size of about 15 mm from a part between fins of cooler 507 in the left and right direction. From this, heat transfer at the time of defrosting is facilitated, and due to improvement of defrosting efficiency, an effect of shortening the defrosting time is obtained. It should be noted that in order to obtain a further effect, an aluminum foil may be disposed in inner box 525 on the back surface side of cooler 507. Further, when an aluminum plate thicker than an aluminum foil or a material having higher heat conductivity than aluminum (such as copper) is used, the effect of facilitating heat transfer is further exerted.

**[0198]** Defrosting warm air guide member 541 is provided in cool air return port 535 of cooler cover 520. Defrosting warm air guide member 541 forms an upward angle from the interior side toward the side of cooler 507. In the present exemplary embodiment, the angle is substantially 45° with respect to the horizon. At this time, defrosting warm air guide portion upper end 543 serving as an upper end of defrosting warm air guide member 541 is disposed at a higher position than cooler lower end 544. Thereby, the return cool air circulated in the interior can take a large heat exchange area in cooler 507. Thus, a heat exchange amount in cooler 507 is increased, so that an ability of cooler 507 can be improved.

**[0199]** Further, flow-direction guide portions 522 are provided in cool air return port 535. An interval of flow-direction guide portions 522 is 5 mm in consideration with prevention of finger invasion and ensuring of strength of a mold and cooler cover 520. It should be noted that a part of flow-direction guide portions 522 also forms an upward angle from the interior side toward the side of cooler 507 in the same direction as defrosting warm air guide member 541.

**[0200]** In the vicinity of cooler 507 (such as an upper space), cool air blower fan 516 for blowing the cool air generated in cooler 507 to the storage compartments of refrigerating compartment 502, ice-making compartment 504, upper level freezing compartment 503, lower level freezing compartment 505, and vegetable compartment 506 by a forced-convection method is disposed. Defrosting heater 532 formed by a glass tube heater of a glass tube for removing frost formed on cooler 507 and cool air blower fan 516 at the time of cooling is provided below cooler 507.

**[0201]** Above defrosting heater 532 formed by the glass tube heater, cover heater 533 covering defrosting heater 532 is disposed. Cover heater has size equal to or more than a diameter and width of the glass tube in such a manner that hissing sounds are not generated when waterdrops dropped from cooler 507 at the time of defrosting directly fall down to a surface of the glass tube forming defrosting heater 532 whose temperature is increased by defrosting.

**[0202]** Drain pan 534 integrated with an upper surface of fourth heat insulating partition portion 513, the drain pan serving as a lower surface of lower level freezing compartment 505 for receiving defrosted water dropped after the frost formed on cooler 507 is melted is disposed below defrosting heater 532.

**[0203]** A diffuser (not shown) formed by cooler front side cover 537 is disposed in front of cool air blower fan 516. Wind having increased static pressure from cool air blower fan 516 is discharged to the interior straightaway without any losses.

**[0204]** In drain pan 534 integrated with the upper surface of fourth heat insulating partition portion 513, projection member 536 toward the interior side is disposed on the lower surface of lower level freezing compartment 505, so as to suspend and fix the lower part of cooler cover 520. Since projection member 536 is disposed between a lower end of cool air return port 535 and defrosting heater 532, red heat is not visible from the interior, and projection member 536 is hidden by the lower end of cool air return port 535 of cooler cover 520 when seen from the interior side. Thus, it looks good and outer appearance quality is consequently improved.

**[0205]** As a recent cooling medium of the freezing cycle, isobutane serving as a combustible cooling medium having a low global warming potential is used from a viewpoint of global environmental conservation. Isobutane of carbon hydrate has a specific gravity about twice more than the air at a normal temperature at atmospheric pressure (2.04, 300 K). Thereby, a cooling medium charging amount can be reduced in comparison to the conventional examples and cost is low. In addition, a leakage amount in the case where the combustible cooling medium is leaked out by any possibility is reduced, so that safety can be more improved.

**[0206]** In the present exemplary embodiment, isobutane is used as the cooling medium, and a maximum temperature of the surface of the glass tube serving as an outer shell of defrosting heater 532 formed by the glass tube heater at the time of defrosting is regulated as explosion protection. Therefore, in order to reduce the temperature of the surface of the glass tube, a double glass tube heater in which glass tubes are doubly formed is adopted. In addition to this, as a means for reducing the temperature of the surface of the glass tube, a member having a high heat radiation property (such as an aluminum fin) can be wound around the surface of the glass tube. At this time, with a single glass tube, outer size of defrosting heater 532 can be reduced.

**[0207]** As a means for improving efficiency at the time of defrosting, in addition to defrosting heater 532, a pipe heater closely attached to cooler 507 may also be used. In this case, cooler 507 can be efficiently defrosted by heat transfer directly from the pipe heater. Further, frost formed on drain pan 534 and cool air blower fan 516 in the periphery of cooler 507 can be melted by defrosting heater 532. Thus, the defrosting time can be shortened, so that energy saving can be achieved and an interior temperature increase during the defrosting time can be suppressed.

**[0208]** It should be noted that in the case where defrosting heater 532 formed by the glass tube heater is combined with the pipe heater, by properly matching heater capacities with each other, the capacity of defrosting heater 532 can be lowered. When the heater capacity is lowered, a temperature of the outer shell of defrosting heater 532 at the time

of defrosting can also be lowered. Thus, red heat at the time of defrosting can be suppressed.

**[0209]** Next, cooling of the refrigerator will be described. For example, in the case where an interior temperature of lower level freezing compartment 505 is increased by invading heat from the external air, opening/closing of the door, and the like, and a temperature of a freezing compartment sensor (not shown) becomes a start-up temperature or more, compressor 517 is started up and cooling is started. A high-temperature and high-pressure cooling medium discharged from compressor 517 is cooled and liquefied particularly in the heat-radiation pipe (not shown) installed in outer box 524 by heat exchange with the air outside outer box 524 and with heat insulating body 526 formed by the rigid urethane foams in the interior before reaching the dryer (not shown) disposed in machine compartment 519 at the end.

**[0210]** Next, the liquefied cooling medium is decompressed in capillary tube 518, flows into cooler 507, and exchanges heat with the interior cool air in the periphery of cooler 507. The cool air after heat exchange is blown into the interior by cool air blower fan 516 in the vicinity thereof, and cools the interior. After that, the cooling medium is heated, gasified, and returned to compressor 517. In the case where the interior is cooled and the temperature of the freezing compartment sensor (not shown) becomes a stop temperature or less, an operation of compressor 517 is stopped.

**[0211]** Cool air blower fan 516 may be directly disposed in inner box 525. However, by arranging the cool air blower fan in second heat insulating partition portion 511 assembled after foaming and performing block processing of the parts, manufacturing cost can be reduced.

**[0212]** Next, the time of defrosting of the refrigerator will be described.

**[0213]** When a cooling operation of the refrigerator is performed, as the time elapses, due to water contents in the air invading at the time of opening/closing the door, water contents attached to food brought into the interior, further, water contents from vegetables stored in vegetable compartment 506, and the like, frost is formed on cooler 507. When the frost grows, heat exchange efficiency between cooler 507 and the circulation cool air is lowered, so that the interior cannot be sufficiently cooled and brought into a fully-cooled or non-cooled state at the end. Therefore, in the refrigerator, there is a need for regularly removing the frost formed on cooler 507.

**[0214]** In the refrigerator in the present exemplary embodiment, after the refrigerator is operated and a fixed time elapses, defrosting is automatically performed. At the time of defrosting, an operation of compressor 517 and cool air blower fan 516 is stopped, and power is supplied to defrosting heater 532 formed by the glass tube heater. By the cooling medium remaining inside cooler 507 and melting of the frost formed on cooler 507, a temperature of cooler 507 is increased substantially through a sensible heat change from  $-30^{\circ}\text{C}$  to  $0^{\circ}\text{C}$ , a latent heat change at  $0^{\circ}\text{C}$ , and a sensible heat change from  $0^{\circ}\text{C}$  to higher. A defrosting sensor (not shown) is attached to cooler 507 so as to stop power supply to defrosting heater 532 at a predetermined temperature. In the present exemplary embodiment, at a time point when the defrosting sensor detects  $10^{\circ}\text{C}$ , the power supply to defrosting heater 532 is stopped.

**[0215]** At this time, the temperature of the surface of the glass tube becomes high by the power supply to defrosting heater 532, and by melting the frost formed on cooler 507, and drain pan 534 and cool air blower fan 516 in the periphery of cooler 507 by radiation heat, cooler 507 is refreshed.

**[0216]** It should be noted that in the low-temperature external air of about  $5^{\circ}\text{C}$  or lower for example, even when the frost of cooler 507 is sufficiently removed, a temperature of the defrosting sensor (not shown) is not easily sufficiently increased at the time of defrosting due to an influence of the external air. Thus, the defrosting time tends to be extended. In this case, when a state of the sensible heat change from  $0^{\circ}\text{C}$  to higher is checked and a fixed time or longer elapses, control of finishing defrosting can be combined. Thereby, a temperature increase due to an unnecessary heater input and radiation heat to the interior caused by a situation that even when the frost is sufficiently removed, the defrosting time is extended due to an insufficient temperature increase of cooler 507 with the low-temperature external air, and further, a temperature increase due to cooling stop at the time of defrosting can be suppressed.

**[0217]** Hereinafter, actions and operations of the refrigerator with the above configuration will be described.

**[0218]** As in the present exemplary embodiment, the layout configuration of the refrigerator in which vegetable compartment 506 is installed on the lower side, lower level freezing compartment 505 is installed in the middle, and refrigerating compartment 502 is installed on the upper side is frequently used from a viewpoint of usability and energy saving. From a viewpoint of interior capacity, following a tendency of the increasing used amount of frozen food, a refrigerator in which interior case size of lower level freezing compartment 505 is increased and a capacity is improved is also released.

**[0219]** At this time, the interior case is large, size of cooler cover 520 on the back surface is reduced. By a temperature increase in cooler 507 and cooler compartment 523 at the time of defrosting and further, the radiation heat from defrosting heater 532 and convection, a temperature of frozen food stored in the freezing compartment is influenced. Therefore, in the present exemplary embodiment, a heat influence on the interior at the time of defrosting is suppressed by heat transfer suppression space 539 formed by cooler front side cover 537 and cooler rear side cover 538, and defrosting warm air guide member 541 provided in cool air return port 535. In the present exemplary embodiment, the inside of heat transfer suppression space 539 serves as the air layer, and heat transfer to the interior can be suppressed even upon a temperature increase in the periphery of cooler 507 due to the radiation heat from defrosting heater 532. Therefore, since a temperature influence on food stored in the interior, particularly, on the side of the cooler can be reduced, deterioration of food can be suppressed and long term storage can be achieved. Heat conductivity of the air layer is

substantially 0.03 W/mK. For example, even in the case where an interior temperature is -25°C and a cooler compartment inside temperature at the time of defrosting is increased to 20°C, the interior temperature is increased only to -17°C due to heat insulation of the air layer. At this time, thickness of the air layer, that is, internal size of heat transfer suppression space 539 is 13.4 mm. Therefore, even at the time of defrosting, a temperature increase is -12°C or less at which frozen food and ice cream are melted and quality thereof is deteriorated. Thus, quality deterioration can be suppressed even upon long term storage.

**[0220]** Not only a temperature influence on food in the interior but also a point where the temperature is locally lowered in the interior can be eliminated. Thus, there is an effect of preventing water contents from being attached to cooler cover 520 as frost, the water contents being sublimed from water contents and the like which are attached to food at the time of opening/closing the door or at the time of installing food. Thereby, a dehumidification performance of cooler 507 can be ensured, and an auxiliary heater for preventing frost formation is not required to be used.

**[0221]** Since a temperature influence on the interior at the time of defrosting can be reduced, there is an effect of reducing an interior load amount at the time of defrosting. Therefore, since a cooling load amount after the defrosting time is reduced, an energy saving effect can be obtained by a decrease in the operation rotation number of compressor 517 required for cooling the interior after the defrosting time and shortening of an operation time.

**[0222]** Defrosting warm air guide member 541 is disposed and inclined at the upward angle of 45° from the interior side toward the side of cooler 507. Thus, convection due to the radiation heat from defrosting heater 532 at the time of defrosting easily flows to cooler 507, and the frost formed on cooler 507 can be efficiently melted. Thus, a power supply time of defrosting heater 532 can be reduced, so that energy saving due to reduction of a power input is achieved. At this time, with shortening of the defrosting time, by suppression of a temperature increase due to shortening of a non-cooling operation time and suppression of a temperature increase due to heat generation of defrosting heater 532 itself, since the cooling load amount after the defrosting time is reduced, an energy saving effect can be obtained by a decrease in the operation rotation number of compressor 517 required for cooling the interior after the defrosting time and shortening of the operation time.

**[0223]** Further, since convection due to the radiation heat from defrosting heater 532 at the time of defrosting easily flows to cooler 507 by defrosting warm air guide member 541, there is an effect of suppressing an interior inflow of the heat, so that the interior temperature increase is suppressed. Frozen food stored in the interior is deteriorated due to an influence of frostbite or a heat change by an interior inflow of the warm air at the time of defrosting. However, by the effect of defrosting warm air guide member 541, even in a case of long term storage, deterioration of food can be suppressed.

**[0224]** In the present exemplary embodiment, the angle of defrosting warm air guide member 541 is upward of 45°. However, the upward angle may be decided in consideration with a flowing way of the return cool air, a flowing way of the warm air at the time of defrosting, an interior capacity, and easiness of manufacturing a mold and the like.

**[0225]** Since defrosting warm air guide member 541 is integrated with cooler rear side cover 538, material cost and mold cost for making defrosting warm air guide member 541 can be reduced, and the man-hour in a manufacturing step can also be reduced. By making with cooler rear side cover 538, a shape including draft of the mold can be simplified. Thus, mold cost is consequently further reduced. Management of two parts including defrosting warm air guide member 541 and cooler rear side cover 538 is changed to management of one part. Thus, management cost can be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0226]** It should be noted that defrosting warm air guide member lower end 531 serving as a lower end of defrosting warm air guide member 541 is placed on the side of cooler 507 with respect to drain pan interior side end surface 530 serving as an interior side end surface of drain pan 534. Thereby, in the case where the frost formed on cooler 507 is melted at the time of defrosting, defrosted water dropped through cooler rear side cover 538 can reliably fall down into drain pan 534. In the present exemplary embodiment, a distance between drain pan interior side end surface 530 and defrosting warm air guide member lower end 531 is 15.8 mm. This is size by which waterdrops of defrosted water are dropped into drain pan 534 even in the case where the refrigerator is inclined forward by 15° due to an installment situation of the refrigerator. In the case where the refrigerator is actually inclined forward by 15° due to an installment state of the refrigerator, the refrigerator itself falls down with the size. Even in consideration with size variation of parts forming the periphery of cooler 507, defrosted water which is dropping can reliably fall down into drain pan 534 in the present exemplary embodiment. Thus, water does not invade the interior side, so that a high quality refrigerator can be provided as a product.

**[0227]** Meanwhile, defrosting warm air guide member 541 can also be integrated with cooler front side cover 537. In this case, the same effect as a case where the defrosting warm air guide member is integrated with cooler rear side cover 538 can also be obtained. In the present exemplary embodiment, defrosting warm air guide member 541 is integrated with cooler rear side cover 538. However, the best mode is desirably implemented in consideration with a configuration mode of cooler cover 520, easiness of manufacturing, a mold configuration, cost, and the like.

**[0228]** A part of flow-direction guide portions 522 provided in cool air return port 535 below cooler cover 520 is inclined in the same direction as defrosting warm air guide member 541, and disposed at an upward angle from the interior side

toward the side of the cooler. Thereby, when seen from the interior, the flow-direction guide portions are seen as overlapping with respect to defrosting heater 532 formed by the glass tube heater. Thus, even in the case where the freezing compartment door is opened at the time of defrosting the refrigerator, red heat of defrosting heater 532 is not visible. In the present exemplary embodiment, the upward angle of a part of flow-direction guide portions 522 is the same as the draft of the mold. However, the angle may be decided in consideration with the flowing way of the return cool air and the flowing way of the warm air at the time of defrosting.

**[0229]** Further, convection due to the radiation heat from defrosting heater 532 at the time of defrosting easily flows to cooler 507 via defrosting warm air guide member 541. Thus, the warm air inflow to the interior can be further suppressed, and efficiency at the time of defrosting can be improved.

**[0230]** Since a part of flow-direction guide portions 522 and defrosting warm air guide member 541 are inclined in the same upward direction, suction ventilation resistance of the return cool air at the time of cooling can be suppressed. Thus, a circulation wind amount can be increased, a heat exchange amount in cooler 507 is increased, and an evaporation temperature is increased, so that energy saving can be achieved by improvement of freezing cycle efficiency. It should be noted that by the improvement of the heat exchange amount of cooler 507 and the increase in the circulation wind amount, a time for cooling the interior can be reduced. Thus, a frost formation amount onto cooler 507 due to shortening of a cooling operation time can also be reduced. Thereby, a defrosting period of cooler 507 can be extended. The input number of defrosting heater 532 can be decreased and an input required for cooling the interior after an interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0231]** Defrosting warm air guide member 541 is disposed between the upper end of cool air return port 535 of cooler rear side cover 538 or a lower end on a basic sectional shape and cooler lower end 544, that is, defrosting warm air guide portion upper end 543 is placed at a higher position than cooler lower end 544. Thus, a large heat exchange area of the return cool air and cooler 507 can be obtained. Therefore, an area where frost is formed in cooler 507 is increased. Thus, deterioration of a cooling ability at the time of frost formation can be suppressed. Thereby, an operation time of the refrigerator until defrosting is required can be extended. Thus, the input number of defrosting heater 532 can be decreased and the input required for cooling the interior after the interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0232]** It should be noted that when ventilation resistance is reduced, the circulation wind amount of cool air blower fan 516 is increased in a case of the same fan voltage. FIG. 21 shows a characteristic image diagram of ventilation resistance and the wind amount. As shown in FIG. 21, in a cooling performance of the refrigerator, from a characteristic of a fan, when ventilation resistance is reduced from Point 1 (P1) to Point 2 (P2), the circulation wind amount is increased from Q1 to Q2.

**[0233]** Further, in the case where the performance can be ensured with the same wind amount, by decreasing the rotation number of the fan of cool air blower fan 516, the same wind amount can be obtained. In this case, the characteristic is moved from Point 2 to Point 3, and the input is reduced by a decrease amount of the rotation number of the fan, so that energy saving in terms of a power input can be achieved. Further, by the decrease in the rotation number of the fan, wind noises of cool air blower fan 516 can be reduced. Thus, even in a quiet environment where ambient noises are low during nighttime or the like, noises do not have to be cared.

**[0234]** In addition, suppression of the warm air inflow to the interior by flow-direction guide portions 522 and defrosting warm air guide member 541 is also effective for preventing frost formation on the interior. When the warm air inflow to the interior is great, frost formation is remarkably generated particularly in a part communicating with the interior and on a top surface of the interior. As the time elapses at the time of long term use, there is a possibility that the frost formation part is dropped and brought down to the interior case upon every defrosting. With the shape of the present exemplary embodiment, the warm air inflow to the interior can be suppressed. Thus, even when the refrigerator is used for substantially 10 years or more, frost formation can be prevented, so that a high quality refrigerator can be provided.

**[0235]** By properly forming heat transfer suppression space 539, defrosting warm air guide member 541, and flow-direction guide portions 522, a further energy saving effect due to reduction of an interior heat influence at the time of defrosting and improvement of defrosting efficiency can be exerted.

**[0236]** It should be noted that in the present exemplary embodiment, the inside of the formed heat transfer suppression space serves as the air layer. However, for example, by making rigid urethane foams, expanded polystyrene (foamed polystyrene), and expanded polyethylene having a high heat insulating performance and low heat conductivity heat insulating member 542, a temperature influence can be further reduced. Thus, a further effect can be exerted.

**[0237]** A shortest distance between end surfaces of flow-direction guide portions 522 on the side of defrosting heater 532 and the outer shell of the glass tube of defrosting heater 532 is 60 mm or more. From this, a temperature increase of cooler cover 520 itself forming cool air return port 535 due to the radiation heat from defrosting heater 532 at the time of defrosting can be suppressed. Therefore, even in the case where the defrosting time is excessively extended at the time of frost formation or the like, deformation or the like due to a temperature influence of the radiation heat is not generated. Since the shortest distance is 60 mm or more, the warm air from defrosting heater 532 at the time of defrosting flows to the side of the cooler, so that there is an effect of easily suppressing the inflow to the interior.

[0238] It should be noted that in the present exemplary embodiment, a type of the cooling medium is isobutane. Thus, the temperature of the surface of the glass tube of defrosting heater 532 at the time of defrosting is regulated to be 394°C or less. Inexpensive PP (polypropylene) is used as a material of cooler cover 520 and flow-direction guide portions 522 used in the present exemplary embodiment, and a heatproof melting temperature of PP is about 200°C, and an ignition temperature thereof is about 440°C. However, in consideration with the time of actual use, the heatproof temperature is set to be 135°C. That is, considering as the worst condition, with the temperature of the surface of the glass tube of defrosting heater 532 of 394°C and PP as the material, size is calculated so as to obtain the heatproof temperature of 135°C or less, so that the shortest distance is 60 mm or more as described above. The Stefan-Boltzmann law is used in the above calculation.

#### TENTH EXEMPLARY EMBODIMENT

[0239] FIG. 22 is a detailed sectional view of a cooler compartment of a refrigerator in a tenth exemplary embodiment of the present invention.

[0240] FIG. 23 is a back view of a cooler cover of the refrigerator in the tenth exemplary embodiment of the present invention. FIG. 24 is an illustrative view of a basic heat exchanger of a cooler of the refrigerator in the tenth exemplary embodiment of the present invention.

[0241] As shown in FIGS. 22 to 24, the refrigerator has cooler 607 provided on a back surface of a refrigerator body, the cooler for generating the cool air, and defrosting heater 632 formed by a glass tube heater which is provided below cooler 607. Drain pan 634 integrated with a lower surface of lower level freezing compartment 605 for receiving defrosted water dropped after frost formed on cooler 607 is melted is provided below defrosting heater 632. Cooler cover 620 including cool air return port 635 through which the cool air after cooling lower level freezing compartment 605 is returned to cooler 607 and covering cooler 607 is disposed.

[0242] Cooler cover 620 includes cooler front side cover 637 on the interior side and cooler rear side cover 638 on the side of cooler 607, and heat transfer suppression space 639 formed by cooler front side cover 637 and cooler rear side cover 638 is provided in front of cooler 607. Heat transfer suppression space 639 is formed between an upper end of cool air return port 635 provided in a lower part of cooler cover 620 and a lower end of a discharge port to lower level freezing compartment 605. When a height of heat transfer suppression space 639 is up to an upper end of cooler 607, there is an effect of suppressing heat transfer. However, a position may be decided based on a balance with an interior capacity or case size. In the present exemplary embodiment, the height is substantially up to the lower end of the discharge port to lower level freezing compartment 605 on the third step from the lower side of cooler 607 in consideration with a flow of the warm air at the time of defrosting. Inside of heat transfer suppression space 639 serves as an air layer.

[0243] Therefore, the frost formed on cooler 607 is melted by radiation heat from defrosting heater 632 at the time of defrosting so as to become the highly-humid warm air and rise in the cooler compartment by natural convection. At this time, although a part of the warm air flows into the interior, an inflow to the interior can be suppressed by heat transfer suppression space 639, so that the warm air can flow into the space. Particularly in a case of Japan in a highly humid environment, frost is easily formed on cooler 607 and frost is most frequently formed in a lower part of cooler 607 where heat is firstly exchanged between the return cool air from the freezing compartment and a refrigerating compartment and cooler 607, and dehumidification is performed. Therefore, at an initial stage of the time of defrosting, the warm air after defrosting easily flows to the periphery of cooler 607 and easily flows into the interior. However, the inflow to the interior can be suppressed by heat transfer suppression space 639. Further, even upon a temperature increase in the periphery of cooler 607 due to the radiation heat from defrosting heater 632, heat transfer to the interior can be suppressed by heat transfer suppression space 639. Thus, a temperature influence on food on the far side stored in the interior, particularly on the side of cooler 607 can be reduced, so that deterioration of food can be suppressed and long term storage can be achieved.

[0244] In the present exemplary embodiment, in order to provide communication between the inside of heat transfer suppression space 639 and cooler compartment 623, warm air collection holes 646 are formed in cooler rear side cover 638. In general, a space inlet part of cooler front side cover 637 and cooler rear side cover 638 forming heat transfer suppression space 639 has basic size of 3 mm or less. With an effect of defrosting warm air guide member 641, although the warm air does not invade heat transfer suppression space 639 by convection due to the radiation heat from defrosting heater 632 at the time of defrosting, by molding size variation of the part itself or fitting variation at the time of assembling the product, the warm air sometimes comes into heat transfer suppression space 639. However, in the case where the warm air coming into heat transfer suppression space 639 or the warm air existing in heat transfer suppression space 639 due to the radiation heat from defrosting heater 632 is expanded to have a spatial volume or more, the warm air is discharged to the side of cooler compartment 623 through warm air collection holes 646. This suppresses the warm air inflow to the interior side.

[0245] It should be noted that warm air collection holes 646 are placed so as to provide communication on the outer side of a projection surface from the front side of fin-and-tube type cooler basic heat exchanger 648. Thereby, the warm

air collection holes are out of a major flow of the cool air even at the time of a cooling operation. Thus, short circuit caused by re-junction between the discharge cool air and the return cool air through warm air collection holes 646 after heat is exchanged between the return cool air and cooler 607 and the return cool air becomes the discharge cool air can be prevented, and a decrease in heat exchange efficiency of cooler 607 can be prevented.

**[0246]** An area ( $S_k$ ) of warm air collection holes 646 is smaller than a basic section area ( $S_d$ ) of heat transfer suppression space 639, that is, in a relationship of  $S_d > S_k$ . In the present exemplary embodiment, the plurality of warm air collection holes 646 are disposed in heat transfer suppression space 639, so that the warm air remaining in the heat transfer suppression space can be discharged to the side of the cooler compartment at the time of defrosting without stagnation. In the present exemplary embodiment, warm air collection holes 646 are disposed in both end parts of cooler 607. At this time, with "n" warm air collection holes, the area of warm air collection holes 646 is expressed as  $S_{kn}$  in a relationship of  $S_d > \sum S_{kn}$ . In warm air collection from warm air collection holes 646 to cooler compartment 623, pressure of the warm air flowing in by the radiation heat from defrosting heater 632 at the time of defrosting is boosted by a temperature increase in the space so as to be higher than pressure on the side of the cooler compartment having a larger volume. Therefore, a part of the warm air in the heat transfer suppression space flows to the side of the cooler compartment from warm air collection holes 646 by a pressure difference, and the warm air in the heat transfer suppression space does not flow out to the interior side, so that the interior temperature increase can be suppressed. Thus, the refrigerator excellent in an energy saving property can be provided. Further, since a temperature change due to the warm air inflow to the interior can be reduced, deterioration of food such as frozen food susceptible to the temperature change can be suppressed and long term storage can be achieved.

**[0247]** It should be noted that as in the present exemplary embodiment, by arranging the plurality of warm air collection holes 646 so as to maintain a pressure balance (for example, evenly on the left and right sides), the warm air can be efficiently collected and stagnation can be reduced. Thus, even in the case where size of cooler 607 is large particularly in a large-capacity and wide refrigerator, an effect can be obtained.

**[0248]** It should be noted that by arranging heat transfer member 647 inside heat transfer suppression space 639, the warm air remaining inside the heat transfer suppression space can be dehumidified. A metal material may be used as heat transfer member 647. In the present exemplary embodiment, in consideration with cost, an aluminum foil with  $t = 8 \mu\text{m}$  is attached. However, when an aluminum plate thicker than an aluminum foil or a material having higher heat conductivity than aluminum (such as copper) is used, the effect for heat transfer is further exerted. A heat storage material may be used as heat transfer member 647. In that case, not only dehumidification is performed but also a temperature in the heat transfer suppression space is not easily increased even at the time of defrosting by the heat storage material cooled at the time of a cooling operation. Thus, the interior temperature increase can be remarkably suppressed, so that deterioration of food can be suppressed, further long term storage can be achieved, and the refrigerator excellent in an energy saving property can be provided.

**[0249]** It should be noted that in the present exemplary embodiment, upper ends of warm air collection holes 646 are inclined on the side of the heat transfer suppression space, and lower ends are inclined on the side of the cooler compartment. Thereby, the warm air remaining in the heat transfer suppression space at the time of defrosting flows to an upper part by an upward airflow of natural convection. However, since the upper ends and the lower ends of warm air collection holes 646 are inclined, ventilation resistance is reduced, so that the warm air can be discharged to the side of the cooler compartment without stagnation. Since the upper ends and the lower ends of warm air collection holes 646 are inclined, a yield ratio at the time of molding the constituent parts is improved, and cost is consequently reduced by suppressing mold cost.

**[0250]** A refrigerator of the present invention includes a refrigerator body, a freezing compartment of a freezing temperature zone in the refrigerator, and a cooler compartment including a cooler provided on a back surface side of the freezing compartment, the cooler for generating cool air, a defrosting heater provided below the cooler, and a drain pan provided below the defrosting heater, the drain pan for receiving defrosted water dropped after frost formed on the cooler is melted. A cooler cover including a cool air return port through which the cool air after cooling the freezing compartment is returned to the cooler, the cooler cover covering the cooler, is provided. Center of the defrosting heater is set above a lower surface of the freezing compartment in a horizontal direction, a projection member protruding into an interior side is disposed on the lower surface of the freezing compartment, and a lower end of the cool air return port and an upper end of the projection member are overlapped with each other in a height direction.

**[0251]** Thereby, red heat from the defrosting heater at the time of defrosting is not easily visible. Thus, even in the case where a freezing compartment door is opened at the time of defrosting the refrigerator, a user does not feel anxiety given by red heat of the defrosting heater.

**[0252]** Since a gap is created between the lower end of the cool air return port and the projection member, the return cool air from the interior to the cooler can ensure convection not only on a front surface of the return port but also from the lower side of the cooler. Therefore, a large heat exchange area in the cooler can be obtained. In addition, a circulation wind amount can be increased by lowering ventilation resistance of the return cool air. A heat exchange amount in the cooler is increased and an evaporation temperature is increased, so that energy saving can be achieved by improvement

of freezing cycle efficiency.

**[0253]** By the improvement of the heat exchange amount of the cooler and the increase in the circulation wind amount, a time for cooling the interior can be reduced. Thus, a frost formation amount onto the cooler due to shortening of a cooling operation time can also be reduced. Thereby, a defrosting period of the cooler can be extended. The input number of the defrosting heater can be decreased and an input required for cooling the interior after an interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0254]** Obtaining a large heat exchange area in the cooler by improvement of a wind passage means increasing an area where frost can be formed in the cooler. Thus, deterioration of a cooling ability at the time of frost formation can be suppressed. Thereby, an operation time of the refrigerator until defrosting is required can be extended. Thus, the input number of the defrosting heater can be decreased and the input required for cooling the interior after the interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0255]** In the present invention, a space distance between the projection member and the lower end of the cool air return port is larger than a height of the projection member.

**[0256]** Thereby, an opening area of the return cool air from the interior to the cooler can be large, and ventilation resistance can be further lowered. Thus, in a case of the same fan voltage, the circulation wind amount is increased and a heat exchange amount in the cooler is increased, so that further energy saving can be achieved.

**[0257]** In the present invention, the projection member is disposed between the lower end of the cool air return port and the defrosting heater.

**[0258]** Thereby, in addition to an energy saving effect due to improvement of a wind passage and improvement of frost formation resistance, red heat is not visible from the interior, and the projection member is hidden by the lower end of the cool air return port of the cooler cover when seen from the interior side. Thus, it looks good and outer appearance quality is consequently improved.

**[0259]** In the present invention, the projection member is in contact with a part of the cooler cover forming the lower end of the cool air return port.

**[0260]** Thereby, an outer periphery of the cool air return port easily deformed in the case where the cool air return port is largely opened can be fixed. Thus, size of the cool air return port is regulated and an area of the opening part can be ensured, so that a sufficient cooling effect can be exerted. At the time of attachment, an operator works in such a manner that the projection member abuts therewith while the projection member is taken as a mark. Thus, workability is improved and a working time is shortened. Therefore, a yield ratio can be improved and product variation can be suppressed, so that a stable cooling performance can be ensured.

**[0261]** In the present invention, the lower surface of the freezing compartment is integrated with the drain pan.

**[0262]** Thereby, material cost and mold cost for making the projection member can be reduced, and the man-hour in a manufacturing step can also be reduced. Management of two parts including the projection member and the drain pan is changed to management of one part. Thus, management cost can be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0263]** In the present invention, a plurality of flow-direction guide portions are provided in the cool air return port, and a far end of each of the flow-direction guide portions is located at a higher position than a line connecting between a far end of another one of the flow-direction guide portions provided below the each of the flow-direction guide portions and the center of the defrosting heater.

**[0264]** Thereby, when seen from the interior, the flow-direction guide portions are seen as overlapping with respect to the defrosting heater. Thus, even in the case where the freezing compartment door is opened at the time of defrosting the refrigerator, red heat of the defrosting heater is not visible. There is an effect of suppressing an interior inflow of radiation heat from the defrosting heater at the time of defrosting, so that the interior temperature increase is suppressed. At this time, the warm air due to the radiation heat at the time of defrosting flows to the side of the cooler by the flow-direction guide portions. Thus, defrosting efficiency can be improved and an energy saving effect due to shortening of a defrosting time can be obtained.

**[0265]** In the present invention, a plurality of flow-direction guide portions are provided in the cool air return port, and in the flow-direction guide portions, a lower flow-direction guide portion is longer than an upper flow-direction guide portion in a direction to the defrosting heater.

**[0266]** Thereby, ventilation resistance of the cool air return port can be reduced so as to improve a cooling ability. In addition, a warm air inflow to the interior by the radiation heat from the defrosting heater at the time of defrosting is easily suppressed.

**[0267]** In the present invention, a plurality of flow-direction guide portions are provided in the cool air return port, and a line connecting interior side end surfaces of the flow-direction guide portions is substantially parallel with a back surface of an interior case.

**[0268]** Thereby, an interval between the interior case and the cool air return port can be ensured to be a fixed value or more without a locally narrow part. Thus, a wind amount is not lowered due to an increase in ventilation resistance of a wind passage. Therefore, a cooling ability is not lowered. Circulation of the cool air is not prevented. Thus, even

when frost is formed on the surface by invasion of the highly-humid external air, sublimation is easily generated without stagnation. In a recent trend of an increase in actual interior capacity, as a large interior case as possible leads to sales improvement. Draft at the time of molding the interior case is parallel with the line connecting the interior side end surfaces of the flow-direction guide portions. Thus, a maximum actual interior capacity with an invalid space being reduced is realized.

**[0269]** In the present invention, a shortest distance between the cool air return port in a direction to the defrosting heater and an outer shell of the defrosting heater is 60 mm or more.

**[0270]** Thereby, a temperature increase of the cooler cover itself forming the cool air return port due to the radiation heat from the defrosting heater at the time of defrosting can be suppressed. Thus, even in the case where the defrosting time is excessively extended at the time of frost formation or the like, deformation or the like due to a temperature influence of the radiation heat is not generated. Since the shortest distance is 60 mm or more, the warm air from the heater at the time of defrosting flows to the side of the cooler, so that there is an effect of easily suppressing the inflow to the interior.

**[0271]** In the present invention, the projection member is integrated with the cooler cover.

**[0272]** Thereby, material cost and mold cost for making the projection member can be reduced, and the man-hour in a manufacturing step can also be reduced. Management cost can also be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0273]** In the present invention, the projection member is integrated with the lower surface of the freezing compartment.

**[0274]** Thereby, material cost and mold cost for making the projection member can be reduced, and the man-hour in a manufacturing step can also be reduced. Management cost can also be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0275]** A refrigerator of the present invention includes a cooler provided on a back surface side of the refrigerator, the cooler for generating cool air, a defrosting heater provided below the cooler, and a cooler cover covering the cooler and having a cool air return port through which the cool air after cooling a freezing compartment is returned to the cooler. The cooler cover includes a cooler front side cover on an interior side and a cooler rear side cover in a direction to the cooler, a heat transfer suppression space by the cooler front side cover and the cooler rear side cover is provided in front of the cooler, and a defrosting warm air guide member is provided in the cool air return port.

**[0276]** Since the defrosting warm air guide member is provided in the cool air return port, convection due to radiation heat from the defrosting heater at the time of defrosting easily flows to the cooler, and frost formed on the cooler can be efficiently melted. Thus, a power supply time of the defrosting heater can be reduced, so that energy saving due to reduction of a power input is achieved. At this time, with shortening of the defrosting time, by suppression of a temperature increase due to shortening of a non-cooling operation time and suppression of a temperature increase due to heat generation of the defrosting heater itself, since a cooling load amount after the defrosting time is reduced, an energy saving effect can be obtained by a decrease in the operation rotation number of a compressor required for cooling the interior after the defrosting time and shortening of the operation time.

**[0277]** Further, since convection due to the radiation heat from the defrosting heater at the time of defrosting easily flows to the cooler by the defrosting warm air guide member, there is an effect of suppressing the interior inflow of the heat, so that the interior temperature increase is suppressed. Frozen food stored in the interior is deteriorated due to an influence of frostbite or a heat change by an interior inflow of the warm air at the time of defrosting. However, by the effect of the defrosting warm air guide member, even in a case of long term storage, deterioration of food can be suppressed.

**[0278]** Even upon a temperature increase in a periphery of the cooler due to the radiation heat from the defrosting heater at the time of defrosting, heat transfer to the interior can be suppressed by the heat transfer suppression space formed by the cooler front side cover and the cooler rear side cover. Thus, a temperature influence on food on the far side stored in the interior, particularly on the side of the cooler can be reduced, so that deterioration of food can be suppressed and long term storage can be achieved.

**[0279]** Since the heat transfer suppression space is provided, a heat influence from the low-temperature cooler can be suppressed and a temperature difference between the surface of the cooler cover and the interior can be reduced. Thus, even upon a humidity inflow due to sublimation of water contents attached to food in the case where the door is opened/closed or at the time of bringing food into the interior, frost formation can be suppressed.

**[0280]** In the present invention, a heat insulating member is disposed inside the heat transfer suppression space.

**[0281]** Thereby, a temperature of the cooler periphery is increased by the radiation heat from the defrosting heater at the time of defrosting. However, heat transfer from the cooler periphery having the increased temperature to the interior can be suppressed to a large extent. Therefore, a temperature influence on food stored in the interior, particularly on the side of the cooler can be eliminated, so that deterioration of food can be suppressed and further long term storage can be achieved.

**[0282]** Since the heat transfer from the cooler periphery having the increased temperature to the interior can be suppressed, the radiation heat from the defrosting heater remains in a cooler compartment. A temperature of the cooler

itself can be efficiently increased, so that with suppression of a temperature increase due to shortening of the defrosting time and shortening of a non-cooling operation time, further energy saving can be realized.

**[0283]** Since the heat insulating member is disposed inside the heat transfer suppression space so as to reduce a temperature influence from the cooler, there is no point where the temperature is locally low in the interior and frost attachment due to water contents invading into the interior by opening/closing of the door or the like can be prevented. Thus, quality of the product is improved.

**[0284]** In the present invention, an upper end of the defrosting warm air guide member is disposed at a higher position than a lower end of the cooler.

**[0285]** Thereby, a large heat exchange area of the return cool air in the cooler can be obtained, and a circulation wind amount can be increased by lowering ventilation resistance of the return cool air. A heat exchange amount in the cooler is increased and an evaporation temperature is increased, so that energy saving can be achieved by improvement of freezing cycle efficiency.

**[0286]** By the improvement of the heat exchange amount of the cooler and the increase in the circulation wind amount, a time for cooling the interior can be reduced. Thus, a frost formation amount onto the cooler due to shortening of a cooling operation time can also be reduced. Thereby, a defrosting period of the cooler can be extended. The input number of the defrosting heater can be decreased and an input required for cooling the interior after an interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0287]** Obtaining a large heat exchange area in the cooler by improvement of a wind passage means increasing an area where frost is formed in the cooler. Thus, deterioration of a cooling ability at the time of frost formation can be suppressed. Thereby, an operation time of the refrigerator until defrosting is required can be extended. The input number of the defrosting heater can be decreased and the input required for cooling the interior after the interior temperature increase due to defrosting can be reduced, so that further energy saving can be achieved.

**[0288]** In the present invention, the defrosting warm air guide member is integrated with the cooler front side cover.

**[0289]** Thereby, material cost and mold cost for making the defrosting warm air guide member can be reduced, and the man-hour in a manufacturing step can also be reduced. Management cost can also be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0290]** In the present invention, the defrosting warm air guide member is integrated with the cooler rear side cover.

**[0291]** Thereby, material cost and mold cost for making the defrosting warm air guide member can be reduced, and the man-hour in a manufacturing step can also be reduced. By making with the cooler rear side cover, a shape including draft of a mold can be simplified. Thus, mold cost is consequently further reduced. Management of two parts including the defrosting warm air guide member and the cooler rear side cover is changed to management of one part. Thus, management cost can be reduced, cost can be reduced as a product, and a selling price is consequently lowered, so that a sale rate can be improved.

**[0292]** In the present invention, flow-direction guide portions are provided on the side of the cooler of the cool air return port, and the flow-direction guide portions are inclined in an upward direction with respect to an inlet of the cool air return port.

**[0293]** Thereby, when seen from the interior side, the flow-direction guide portions are seen as overlapping with respect to the defrosting heater. Thus, even in the case where the freezing compartment door is opened at the time of defrosting the refrigerator, red heat of the defrosting heater is not visible. There is an effect of suppressing the interior inflow of the radiation heat from the defrosting heater at the time of defrosting, so that the interior temperature increase is suppressed. At this time, the warm air due to the radiation heat at the time of defrosting flows to the side of the cooler by the flow-direction guide portions. Thus, defrosting efficiency can be improved and an energy saving effect due to shortening of the defrosting time can be obtained.

**[0294]** The flow-direction guide portions and the defrosting warm air guide member are inclined in the upward direction. Thus, in addition to reduction of suction ventilation resistance of a suction wind passage of the return cool air, a flow can be uniformized, so that further energy saving can be achieved by improvement of cooling efficiency.

**[0295]** In the present invention, the shortest distance between a defrosting heater side of the cooler cover and an outer shell of the defrosting heater is 60 mm or more.

**[0296]** Thereby, a temperature increase of the cooler cover itself forming the cool air return port due to the radiation heat from the defrosting heater at the time of defrosting can be suppressed. Thus, even in the case where the defrosting time is excessively extended at the time of frost formation or the like, deformation or the like due to a temperature influence of the radiation heat is not generated. Since the shortest distance is 60 mm or more, the warm air from the heater at the time of defrosting flows to the side of the cooler, so that there is an effect of easily suppressing the inflow to the interior.

**[0297]** In the present invention, center of the defrosting heater is placed above a bottom base surface of the freezing compartment.

**[0298]** Thereby, a shape of the drain pan integrated with the bottom base surface of the freezing compartment can be substantially horizontal, so that an invalid space created by installment of the defrosting heater can be reduced. Thus,

an interior capacity can be increased. Since depth of the drain pan can be shallow, mold cost at the time of molding constituent parts can be suppressed. Thus, cost is consequently reduced.

**[0299]** In the present invention, a metal heat transfer facilitating member is provided on the side of the cooler of the cooler rear side cover.

**[0300]** Thereby, the radiation heat of the defrosting heater at the time of defrosting can be transferred to an upper part of the cooler. Thus, the defrosting time can be further shortened. Since the metal heat transfer facilitating member has high heat conductivity, the heat from the defrosting heater can be uniformly transferred. Therefore, the heat is uniformly transferred to the cooler, not only defrosting efficiency is improved but also there is no fear that frost remains.

**[0301]** In the present invention, the flow-direction guide portions are coupled to the defrosting warm air guide member.

**[0302]** Thereby, the defrosting warm air guide member and the flow-direction guide portions formed in the same upward direction are integrated to form a coupled flow-direction guide. Thus, convection due to the radiation heat from the defrosting heater at the time of defrosting further easily flows to the cooler, and the frost formed on the cooler can be efficiently melted. Thus, a power supply time of the defrosting heater can be reduced, so that energy saving due to reduction of a power input is achieved.

**[0303]** An effect of suppressing the interior inflow of the radiation heat from the defrosting heater at the time of defrosting is enhanced, so that the interior temperature increase is further suppressed.

**[0304]** In the present invention, a warm air collection hole providing communication between the heat transfer suppression space and a cooler compartment in which the cooler is accommodated is provided.

**[0305]** Thereby, a space inlet part of the cooler front side cover and the cooler rear side cover forming the heat transfer suppression space has basic size of 3 mm or less. With an effect of the defrosting warm air guide member, although the warm air does not invade the heat transfer suppression space by convection due to the radiation heat from the defrosting heater at the time of defrosting, by molding size variation of the part itself or fitting variation at the time of assembling the product, the warm air sometimes comes into the heat transfer suppression space. At this time, in the case where the warm air coming into the heat transfer suppression space or the warm air existing in the heat transfer suppression space due to the radiation heat from the defrosting heater is expanded to have a spatial volume or more, the warm air can be prevented from flowing into the interior side. An excessive temperature increase in the space due to the radiation heat can also be suppressed. Therefore, a temperature influence on food stored in the interior, particularly on the side of the cooler can be eliminated, so that deterioration of food can be suppressed and further long term storage can be achieved.

**[0306]** In the present invention, the warm air collection hole is disposed on an outer side of a basic heat exchanger of the cooler.

**[0307]** Thereby, short circuit caused by re-junction between the cool air after exchanging heat with the cooler and invading the heat transfer suppression space through the warm air collection hole and the return cool air from the interior can be prevented, and a decrease in heat exchange efficiency of the cooler can be prevented.

**[0308]** In the present invention, an area of the warm air collection hole is smaller than a basic section area of the heat transfer suppression space.

**[0309]** Thereby, pressure of the warm air invading the heat transfer suppression space by convection due to the radiation heat from the defrosting heater at the time of defrosting by molding size variation of the part itself or fitting variation at the time of assembling the product is boosted by a temperature increase in the space so as to be higher than pressure on the side of the cooler compartment having a larger volume. Thus, a part of the warm air in the heat transfer suppression space flows to the side of the cooler compartment from the warm air collection hole by a pressure difference. Therefore, the warm air in the heat transfer suppression space does not flow out to the interior side, so that the interior temperature increase can be suppressed.

**[0310]** In the present invention, a plurality of warm air collection holes are provided.

**[0311]** Thereby, the warm air remaining in the heat transfer suppression space at the time of defrosting flows to the side of the cooler compartment from the plurality of warm air collection holes by the pressure difference. Thus, even in a particularly wide refrigerator, the pressure in the heat transfer suppression space is maintained to be balanced and stagnation is reduced, so that the warm air inflow to the interior and the temperature increase can be suppressed.

**[0312]** In the present invention, a heat transfer member is disposed inside the heat transfer suppression space.

**[0313]** Thereby, even in the case where the highly-humid warm air remains in the heat transfer suppression space at the time of defrosting, dehumidification at the time of defrosting can be performed by the heat transfer member cooled at the time of cooling operation, and the warm air inflow to the cooler compartment and the interior through the warm air collection holes can be suppressed. Therefore, frost or ice does not partially remain, so that a refrigerator having high quality in terms of product reliability can be provided.

**[0314]** In the present invention, an upper end of the warm air collection hole is inclined downward in a direction to the heat transfer suppression space.

**[0315]** Thereby, the warm air remaining in the heat transfer suppression space at the time of defrosting is easily guided to the side of the cooler compartment by a guide shape inclined on the side of the upper end.

**[0316]** In the present invention, a lower end of the warm air collection hole is inclined upward in a direction to the cooler compartment.

**[0317]** Thereby, the warm air remaining in the heat transfer suppression space at the time of defrosting is easily guided to the side of the cooler compartment by a guide shape inclined on the side of the lower end.

# INDUSTRIAL APPLICABILITY

**[0318]** As described above, the present invention can be utilized for a domestic refrigerator or the like for the purpose of space saving and large capacity by reducing an invalid volume and increasing an interior capacity, and improvement of an energy saving property.

# REFERENCE MARKS IN THE DRAWINGS

## [0319]

|                                        |                                          |
|----------------------------------------|------------------------------------------|
| 1, 11, 21, 35                          | cooler                                   |
| 2, 15, 22, 32                          | freezing compartment                     |
| 3, 23, 33                              | cooler compartment                       |
| 4, 12, 24, 31                          | cooler cover                             |
| 5, 25, 41                              | inner box                                |
| 6, 26                                  | cool air return port                     |
| 7, 27                                  | defrosting heater                        |
| 8                                      | vegetable compartment                    |
| 9                                      | partition portion                        |
| 10                                     | guide portion                            |
| 13, 37                                 | defrosting heater                        |
| 14, 36                                 | cover heater                             |
| 28                                     | warm air inflow space                    |
| 34                                     | fan                                      |
| 38                                     | water receiving portion                  |
| 39                                     | cooler compartment inlet                 |
| 40                                     | gutter                                   |
| 42                                     | guide                                    |
| 101, 301, 501                          | refrigerator body                        |
| 102, 302, 502                          | refrigerating compartment                |
| 102a, 302a, 502a                       | refrigerating compartment door           |
| 103, 303, 503                          | upper level freezing compartment         |
| 103a, 303a, 503a                       | upper level freezing compartment door    |
| 104, 304, 504                          | ice-making compartment                   |
| 104a, 304a, 504a                       | ice-making compartment door              |
| 105, 305, 355, 405, 455, 505, 605      | lower level freezing compartment         |
| 105a, 305a, 505a                       | lower level freezing compartment door    |
| 106, 306, 506                          | vegetable compartment                    |
| 106a, 306a, 506a                       | vegetable compartment door               |
| 107, 307, 407, 507                     | cooler                                   |
| 108, 308, 508                          | first top surface portion                |
| 109, 309, 509                          | second top surface portion               |
| 110, 310, 510                          | first heat insulating partition portion  |
| 111, 311, 511                          | second heat insulating partition portion |
| 112, 312, 512                          | third heat insulating partition portion  |
| 113, 163, 213, 263, 313, 363, 513      | fourth heat insulating partition portion |
| 116, 316, 516                          | cool air blower fan                      |
| 117, 317, 517                          | compressor                               |
| 118, 318, 518                          | capillary tube                           |
| 119, 319, 519                          | machine compartment                      |
| 120, 170, 270, 320, 470, 520           | cooler cover                             |
| 122, 222, 272, 322, 372, 422, 472, 522 | flow-direction guide portion             |
| 123, 323, 523, 623                     | cooler compartment                       |

|                                                  |                                             |
|--------------------------------------------------|---------------------------------------------|
| 124, 324, 524                                    | outer box                                   |
| 125, 325, 525                                    | inner box                                   |
| 126, 326, 526                                    | heat insulating body                        |
| 132, 182, 232, 282, 332, 382, 432, 482, 532, 632 | defrosting heater                           |
| 5 133, 283, 333, 433, 533                        | cover heater                                |
| 134, 184, 234, 284, 334, 384, 484, 434, 534, 634 | drain pan                                   |
| 135, 185, 235, 285, 335, 385, 435, 485, 535, 635 | cool air return port                        |
| 136, 186, 236, 286, 336, 536                     | projection member                           |
| 155, 205, 255                                    | freezing compartment                        |
| 10 157, 257, 207, 357, 457, 607                  | cooler                                      |
| 220, 370, 420, 620                               | cooler cover                                |
| 337, 487, 537, 637                               | cooler front side cover                     |
| 338, 488, 538, 638                               | cooler rear side cover                      |
| 339, 539, 639                                    | heat transfer suppression space             |
| 15 340, 540                                      | heat transfer facilitating member           |
| 343, 543                                         | defrosting warm air guide portion upper end |
| 344, 544                                         | cooler lower end                            |
| 341, 391, 441, 491, 541, 641                     | defrosting warm air guide member            |
| 495                                              | flow-direction guide                        |
| 20 530                                           | drain pan interior side end surface         |
| 531                                              | defrosting warm air guide member lower end  |
| 646                                              | warm air collection hole                    |
| 647                                              | heat transfer member                        |
| 648                                              | cooler basic heat exchanger                 |

## Claims

### 1. A refrigerator comprising:

a refrigerator body;  
a freezing compartment of a freezing temperature zone in the refrigerator;  
a cooler compartment including a cooler provided on a back surface side of the freezing compartment, the cooler for generating cool air, a defrosting heater provided below the cooler, and a drain pan provided below the defrosting heater, the drain pan for receiving defrosted water that drops when frost formed on the cooler is melted; and  
a cooler cover covering the cooler and having a cool air return port for the cool air to return to the cooler after having cooled the freezing compartment,  
wherein  
a center of the defrosting heater is set above a lower surface of the freezing compartment in a horizontal direction,  
a projection member protruding into an interior side is disposed on the lower surface of the freezing compartment, and  
a lower end of the cool air return port and an upper end of the projection member are overlapped each other in a height direction.

### 2. The refrigerator according to claim 1, wherein

a space distance between the projection member and the lower end of the cool air return port is larger than a height of the projection member.

### 3. The refrigerator according to claim 1 or 2, wherein

the projection member is disposed between the lower end of the cool air return port and the defrosting heater.

### 4. The refrigerator according to claim 1 or 2, wherein

the projection member is in contact with a part of the cooler cover forming the lower end of the cool air return port.

### 5. The refrigerator according to claim 1 or 2, wherein

the lower surface of the freezing compartment is integrated with the drain pan.

6. The refrigerator according to claim 1 or 2, wherein  
a plurality of flow-direction guide portions are provided in the cool air return port, and  
a far end of each of the flow-direction guide portions is located at a higher position than a line connecting between  
a far end of another one of the flow-direction guide portions provided below the each of the flow-direction guide  
portions and the center of the defrosting heater.
7. The refrigerator according to claim 1 or 2, wherein  
a plurality of flow-direction guide portions are provided in the cool air return port, and  
among the plurality of flow-direction guide portions, a lower one of the flow-direction guide portions is longer than  
an upper one of the flow-direction guide portions at one side confronting the defrosting heater.
8. The refrigerator according to claim 1 or 2, wherein  
a plurality of flow-direction guide portions are provided in the cool air return port, and  
a line connecting interior side end surfaces of the flow-direction guide portions is parallel with a back surface of an  
interior case.
9. The refrigerator according to claim 1 or 2, wherein  
a shortest distance between the cool air return port at one side confronting the defrosting heater and an outer shell  
of the defrosting heater is 60 mm or more.
10. The refrigerator according to claim 1 or 2, wherein  
the projection member is integrated with the cooler cover.
11. The refrigerator according to claim 1 or 2, wherein  
the projection member is integrated with the lower surface of the freezing compartment.
12. A refrigerator comprising:  
a refrigerator body;  
a freezing compartment of a freezing temperature zone in the refrigerator;  
a cooler provided on a back surface side of the freezing compartment, the cooler for generating cool air;  
a defrosting heater disposed below the cooler; and  
a cooler cover covering the cooler and having a cool air return port for the cool air to return to the cooler after  
having cooled the freezing compartment, wherein  
the cooler cover includes a cooler front side cover on an interior side and a cooler rear side cover on another  
side confronting the cooler,  
a heat transfer suppression space is formed between the cooler front side cover and the cooler rear side cover  
in front of the cooler, and  
a defrosting warm air guide member is provided in the cool air return port.
13. The refrigerator according to claim 12, wherein  
a heat insulating member is disposed inside the heat transfer suppression space.
14. The refrigerator according to claim 12 or 13, wherein  
an upper end of the defrosting warm air guide member is placed at a higher position than a lower end of the cooler.
15. The refrigerator according to claim 12 or 13, wherein  
the defrosting warm air guide member is integrated with the cooler front side cover.
16. The refrigerator according to claim 12 or 13, wherein  
the defrosting warm air guide member is integrated with the cooler rear side cover.
17. The refrigerator according to claim 12 or 13, wherein  
a flow-direction guide portion is provided in the cool air return port at one side confronting the cooler, and  
the flow-direction guide portion is inclined in an upward direction with respect to an inlet of the return port.
18. The refrigerator according to claim 12 or 13, wherein  
a shortest distance between a defrosting heater side of the cooler cover and an outer shell of the defrosting heater

is 60 mm or more.

19. The refrigerator according to claim 12 or 13, wherein  
a center of the defrosting heater is placed above a bottom base surface of the freezing compartment.

20. The refrigerator according to claim 12 or 13, wherein  
a metal heat transfer facilitating member is provided on the cooler rear side cover at one side confronting the cooler.

21. The refrigerator according to claim 17, wherein  
the flow-direction guide portion is coupled to the defrosting warm air guide member.

22. The refrigerator according to claim 12, wherein  
a warm air collection hole is provided for communication between the heat transfer suppression space and a cooler  
compartment in which the cooler is accommodated.

23. The refrigerator according to claim 22, wherein  
the warm air collection hole is disposed on an outer side of a basic heat exchanger of the cooler.

24. The refrigerator according to claim 22 or 23, wherein  
an area of the warm air collection hole is smaller than a basic sectional area of the heat transfer suppression space.

25. The refrigerator according to claim 22 or 23, wherein  
a plurality of warm air collection holes are provided.

26. The refrigerator according to claim 22 or 23, wherein  
a heat transfer member is disposed inside the heat transfer suppression space.

27. The refrigerator according to claim 22 or 23, wherein  
an upper end of the warm air collection hole is inclined downward in a direction to the heat transfer suppression space.

28. The refrigerator according to claim 22 or 23, wherein  
a lower end of the warm air collection hole is inclined upward in a direction to the cooler compartment.

FIG. 1

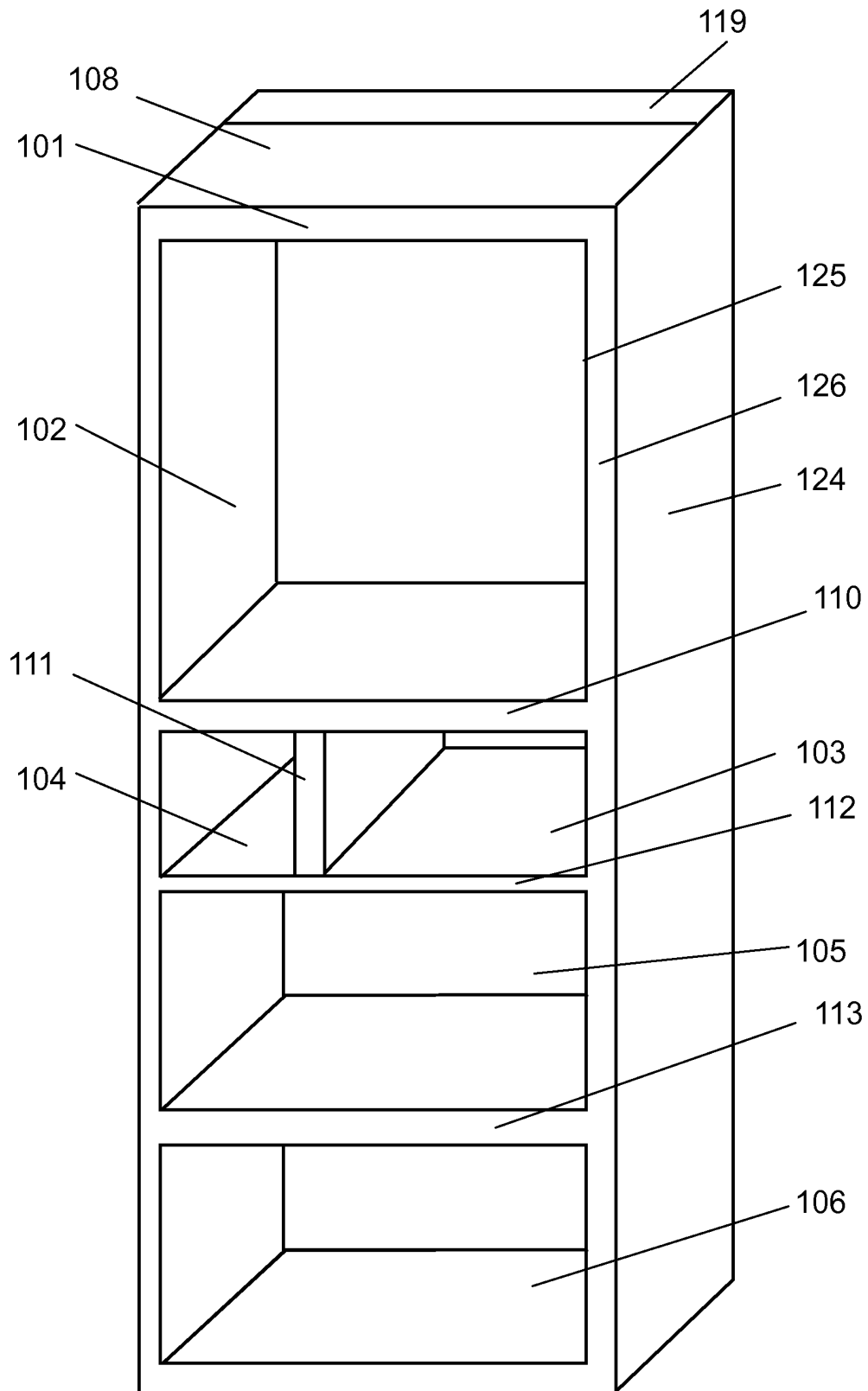


FIG. 2

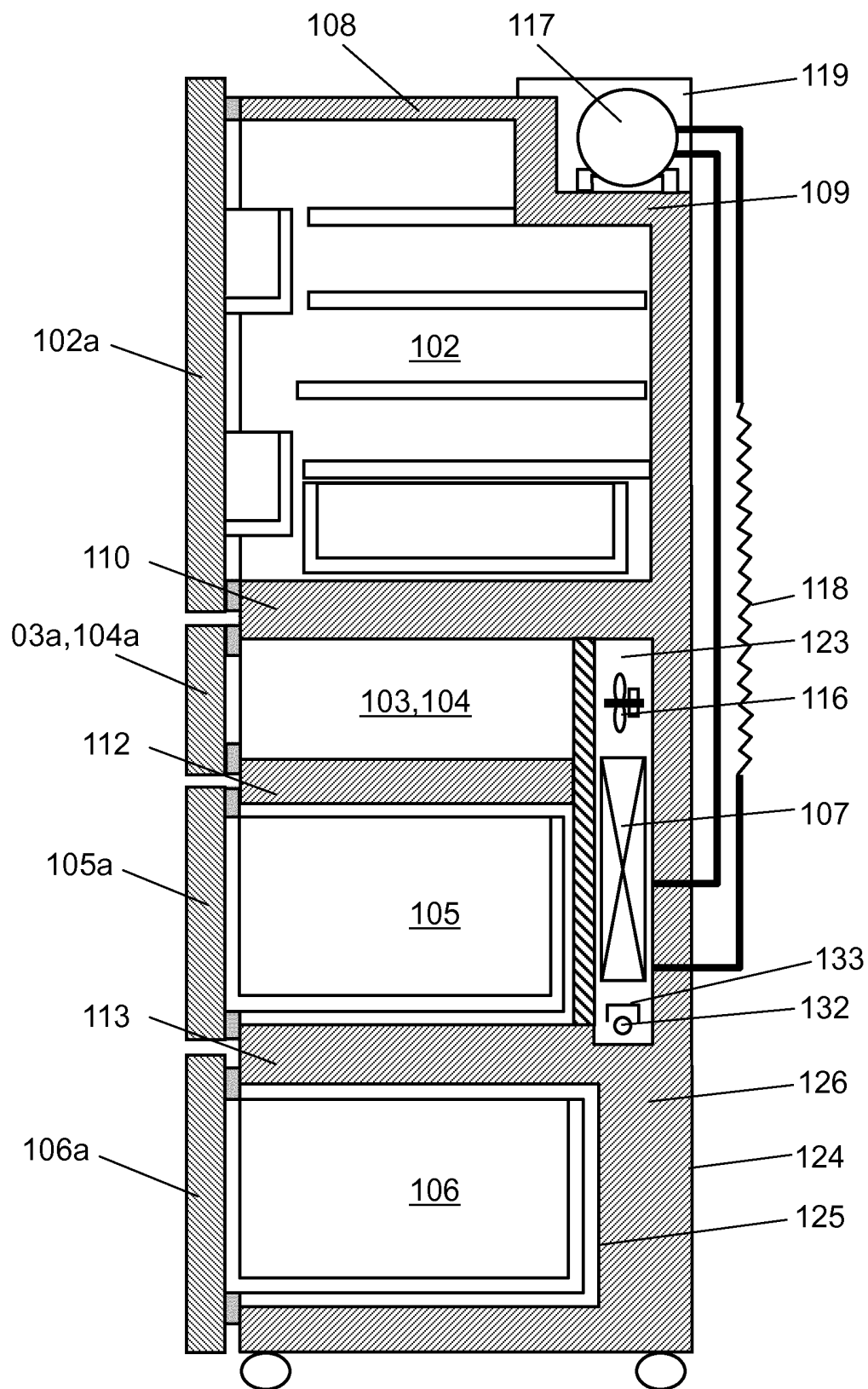


FIG. 3

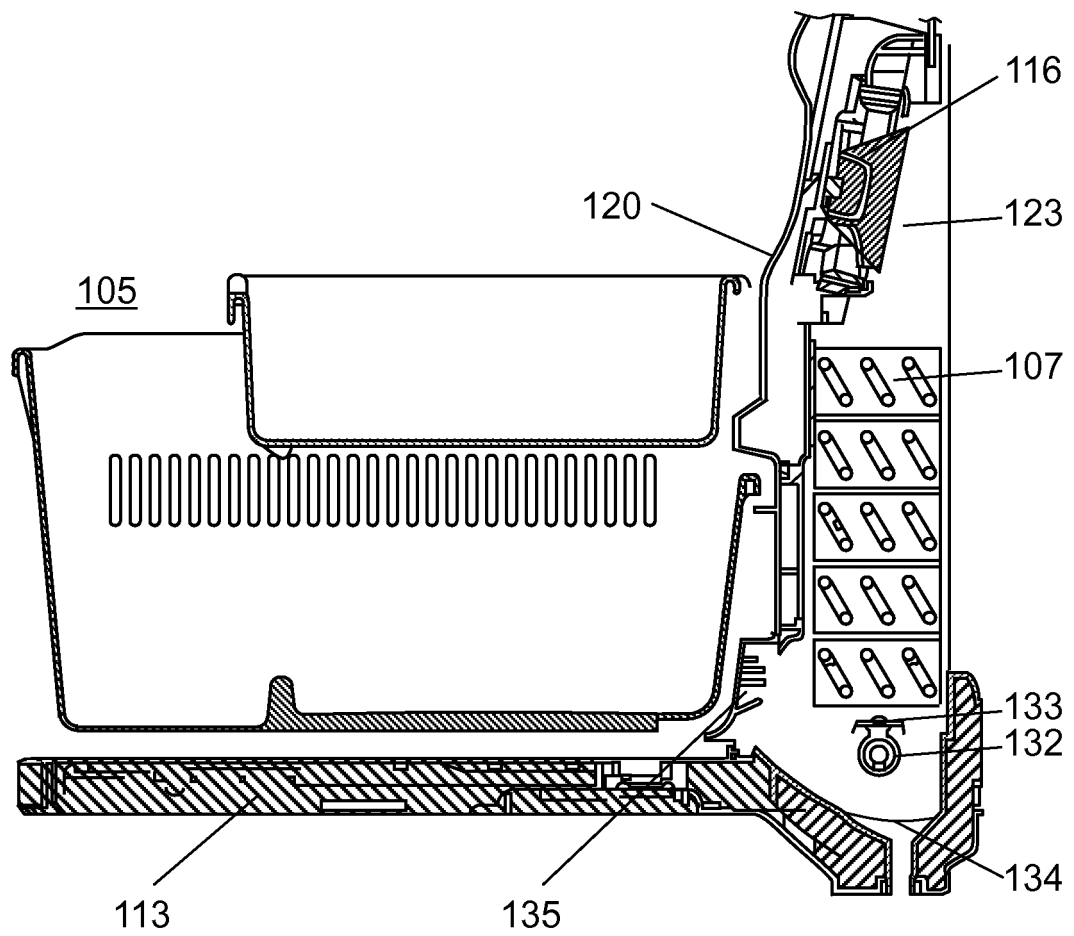


FIG. 4

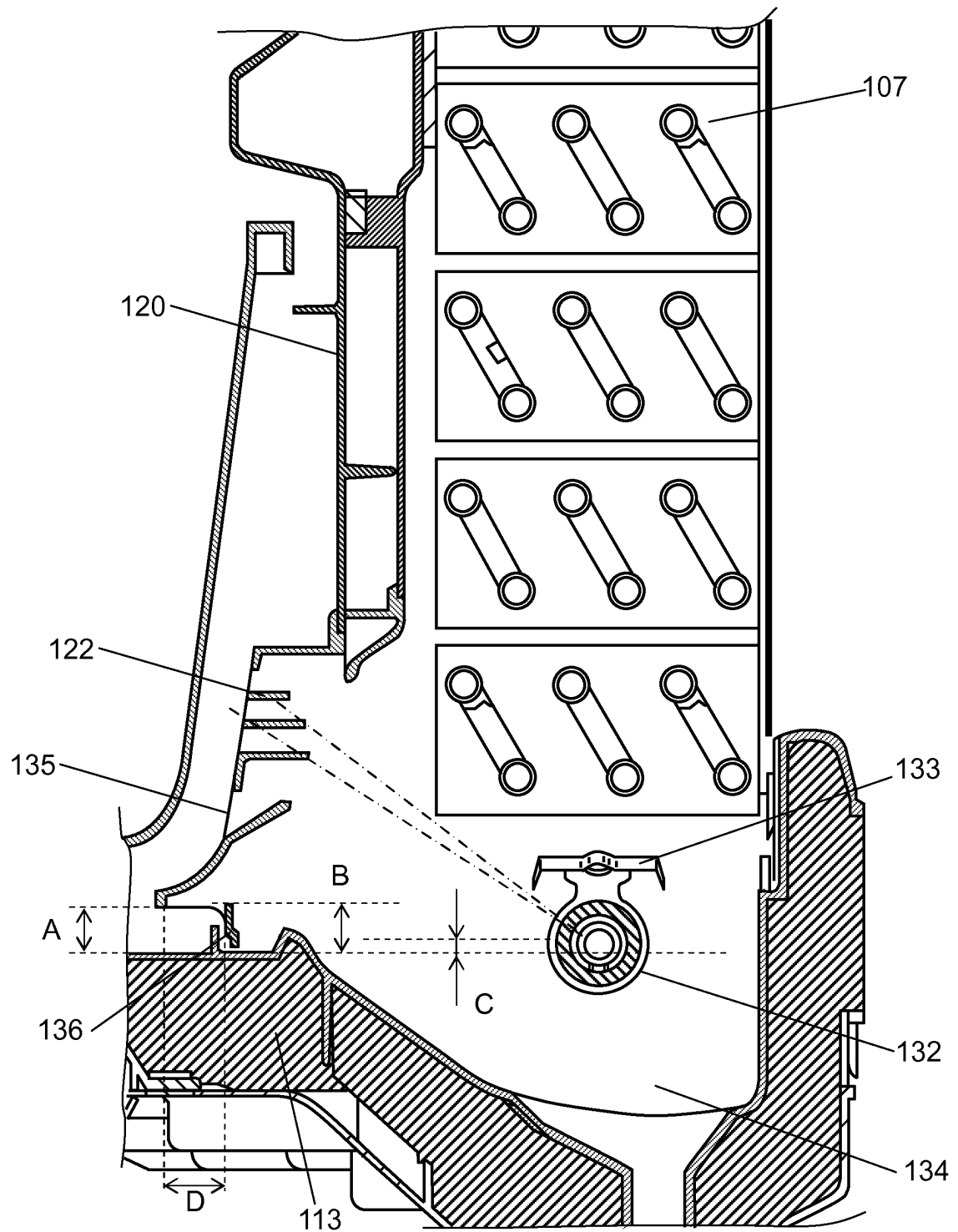


FIG. 5

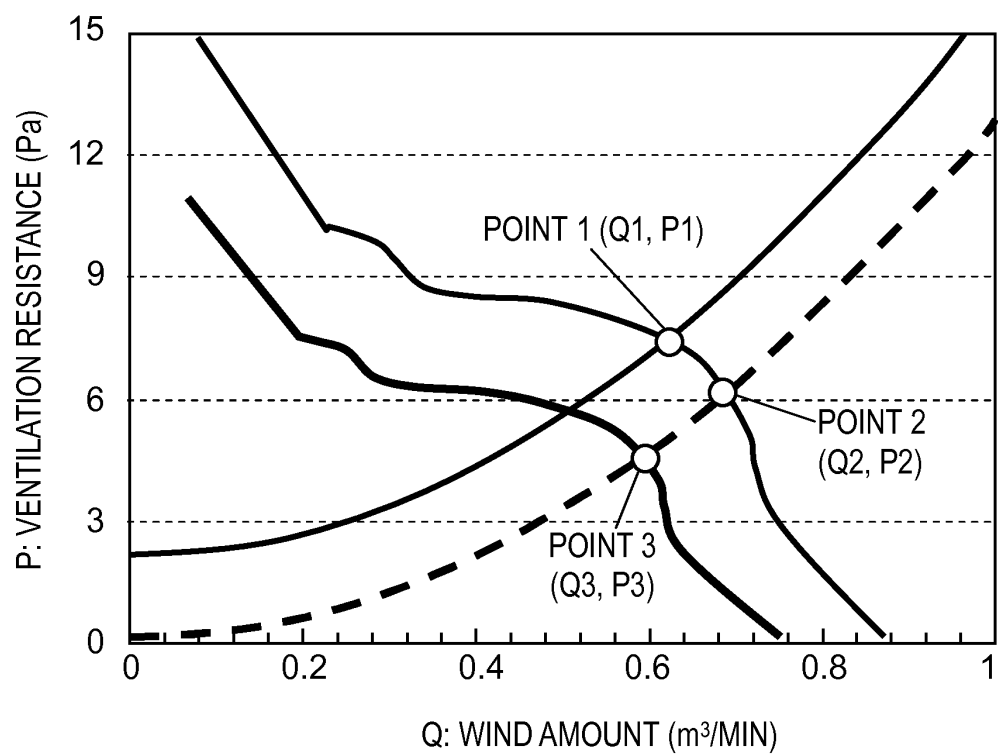


FIG. 6

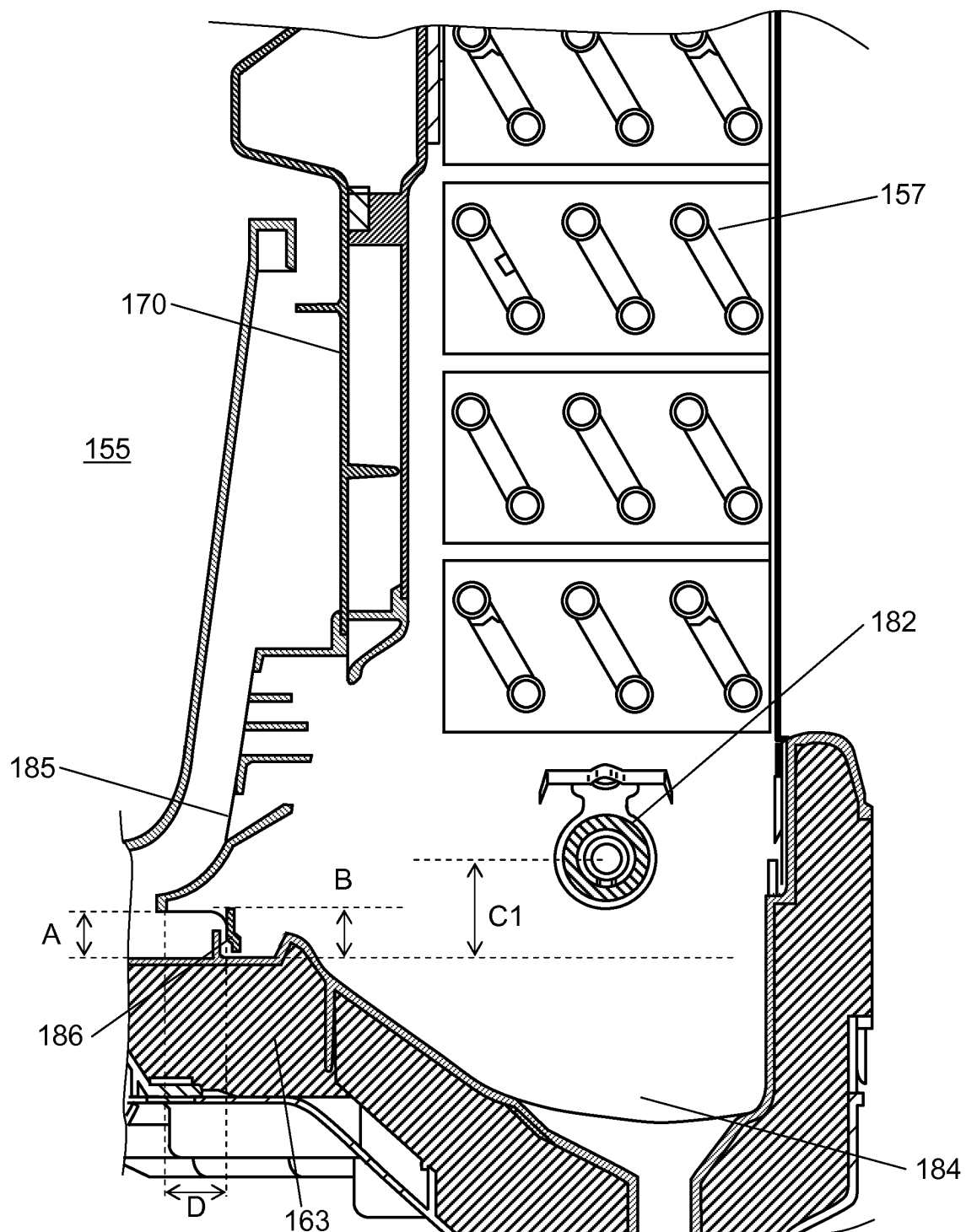


FIG. 7

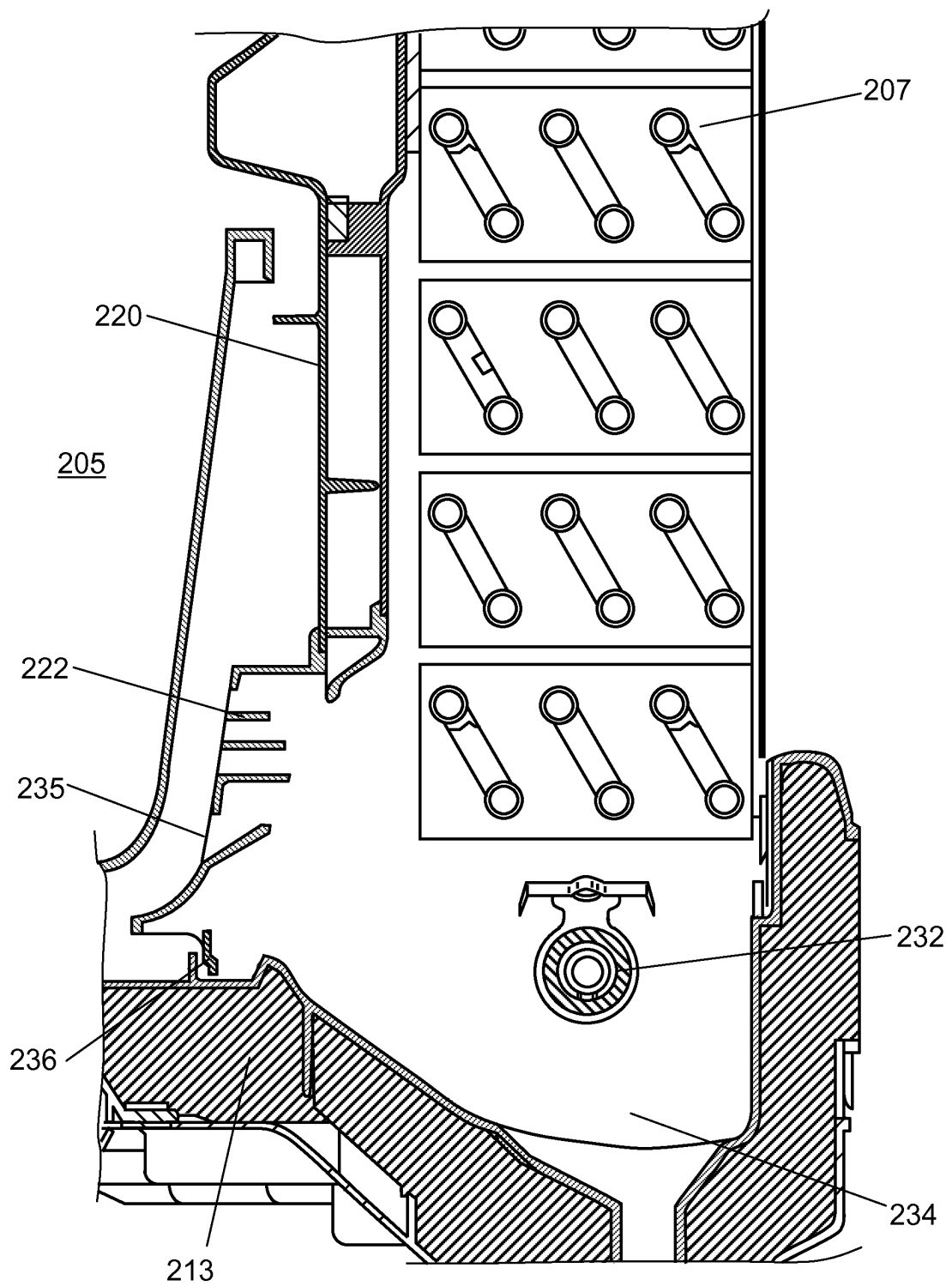


FIG. 8

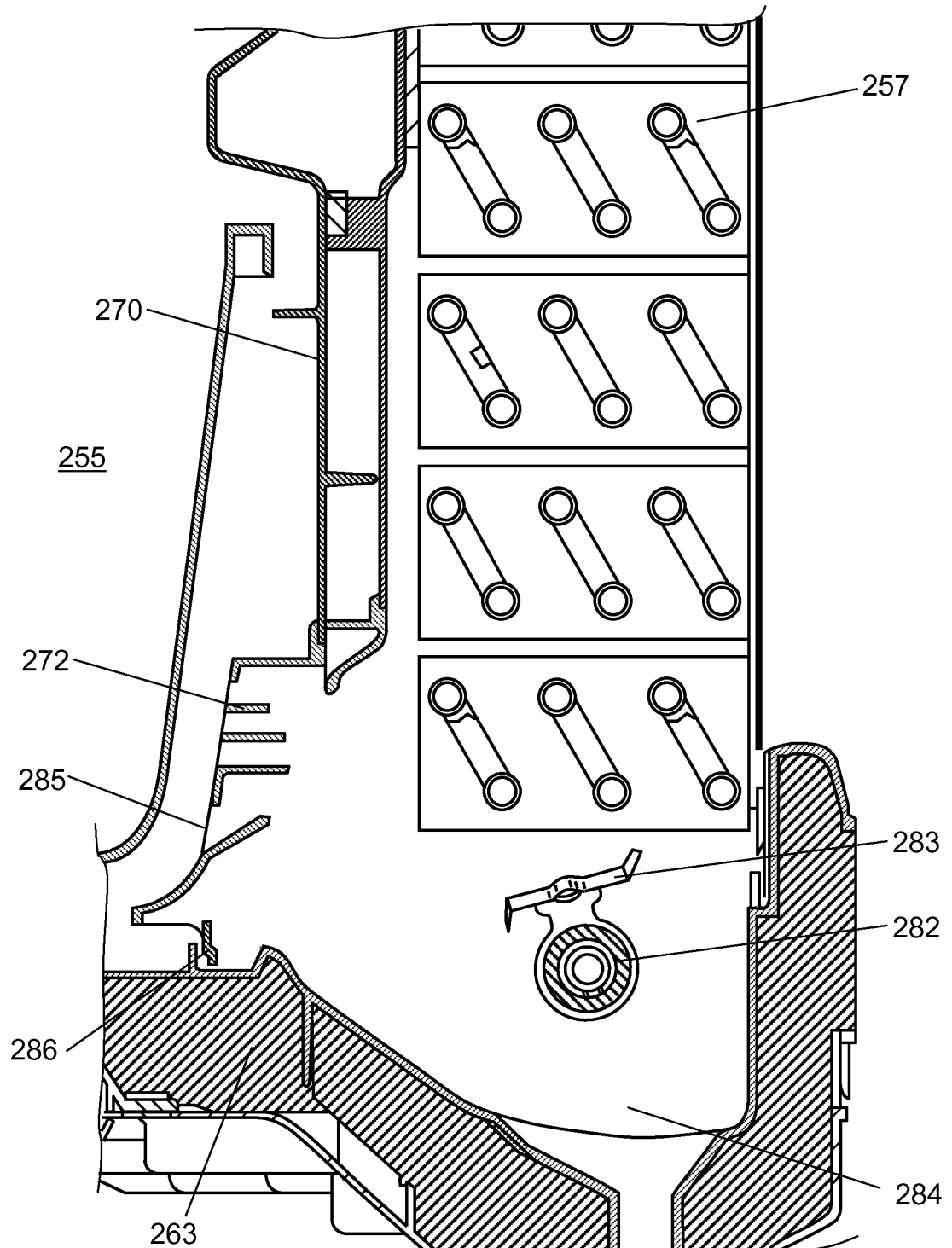


FIG. 9

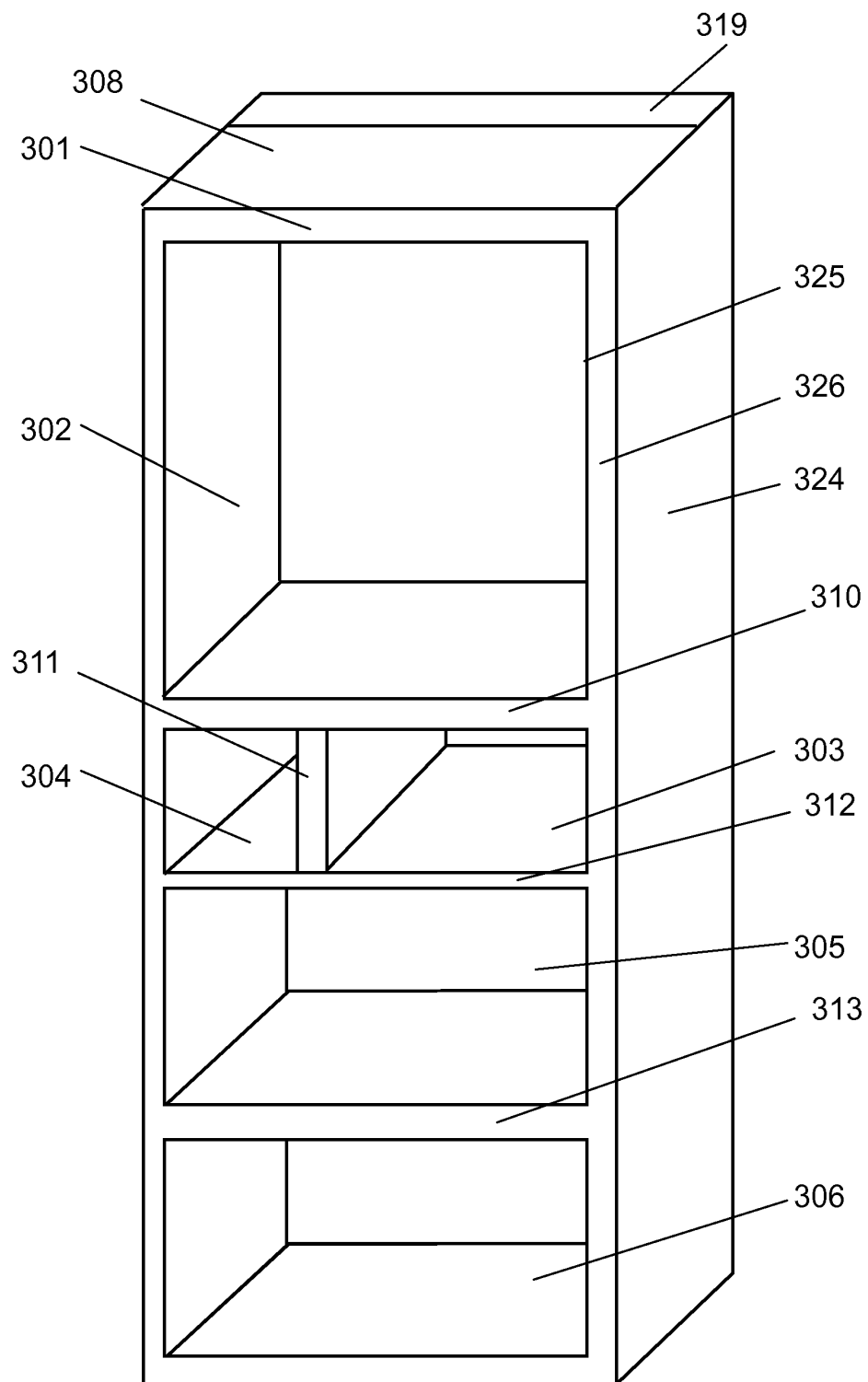


FIG. 10

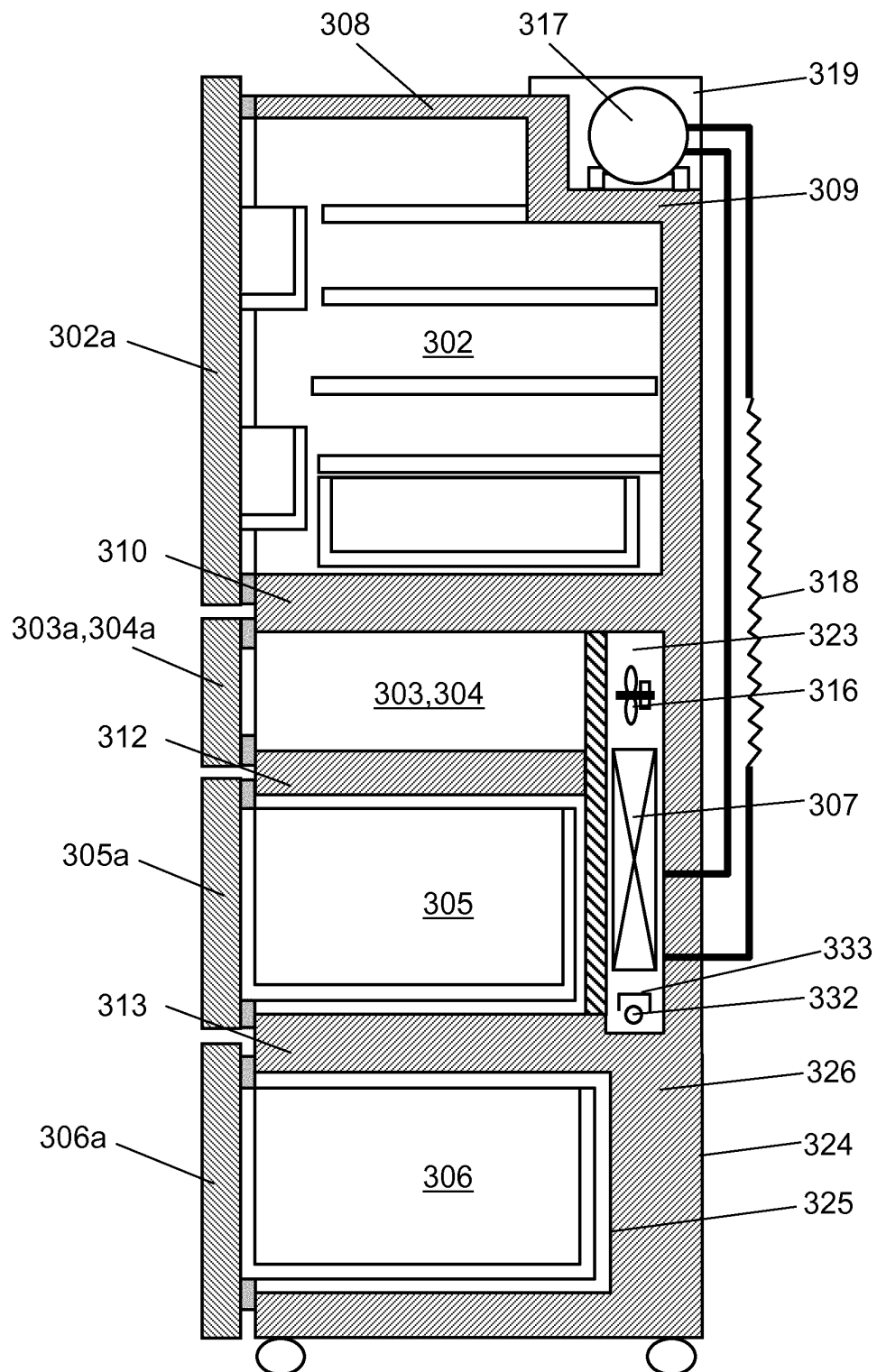


FIG. 11

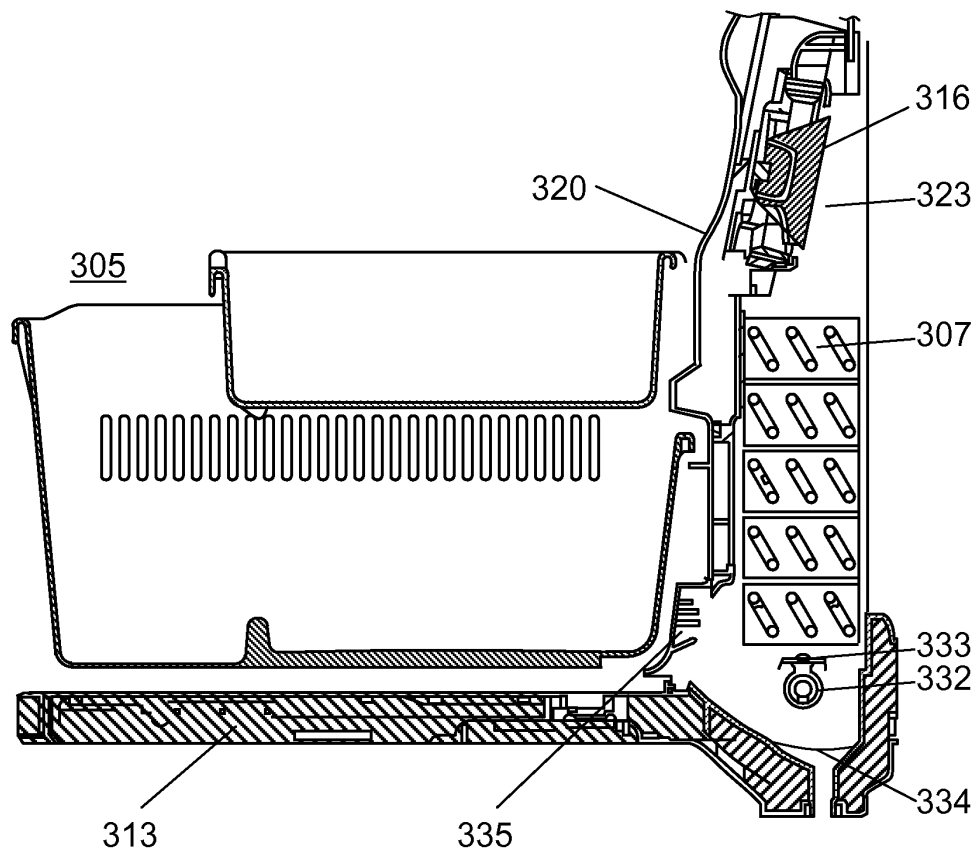


FIG. 12

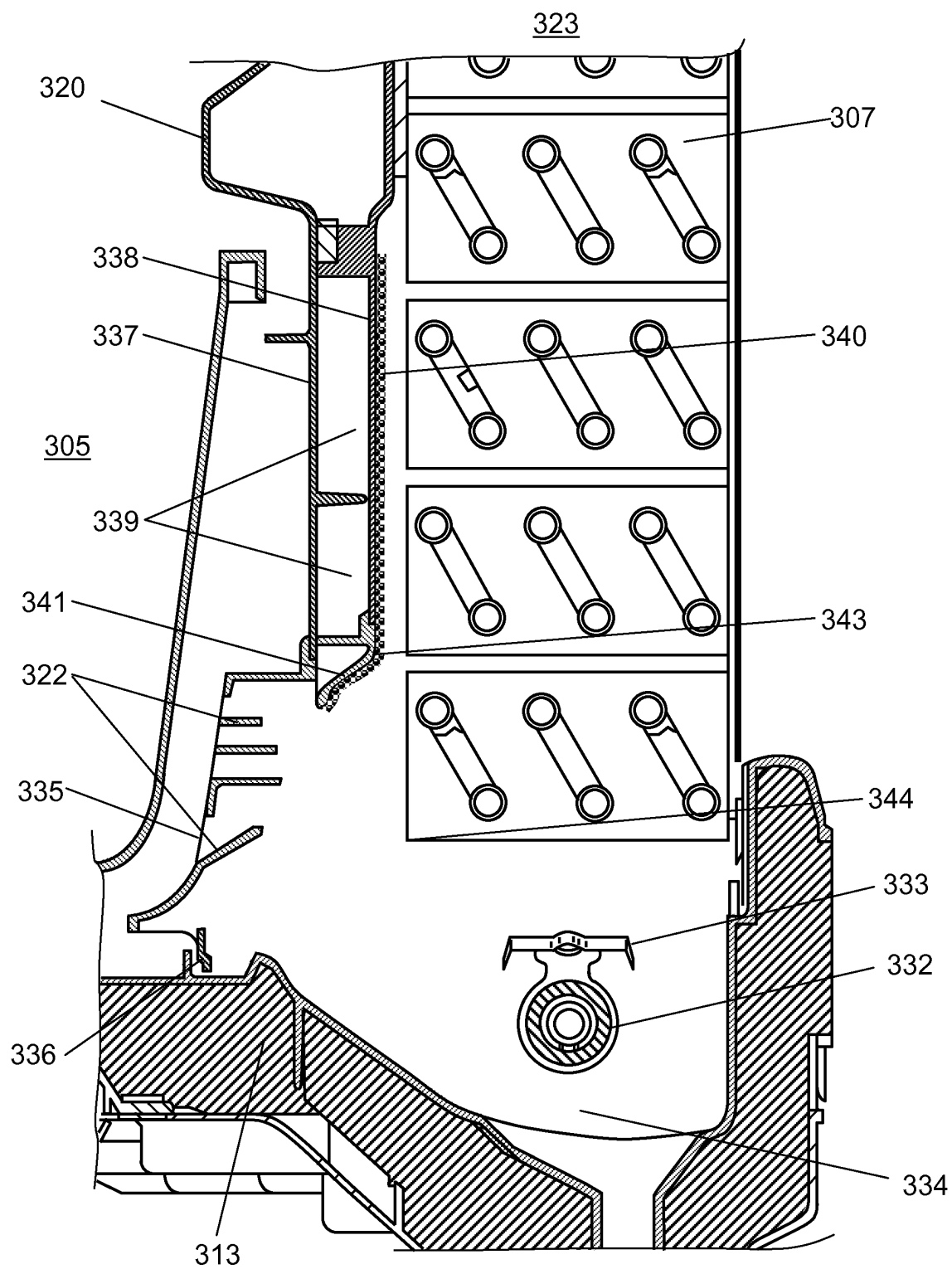


FIG. 13

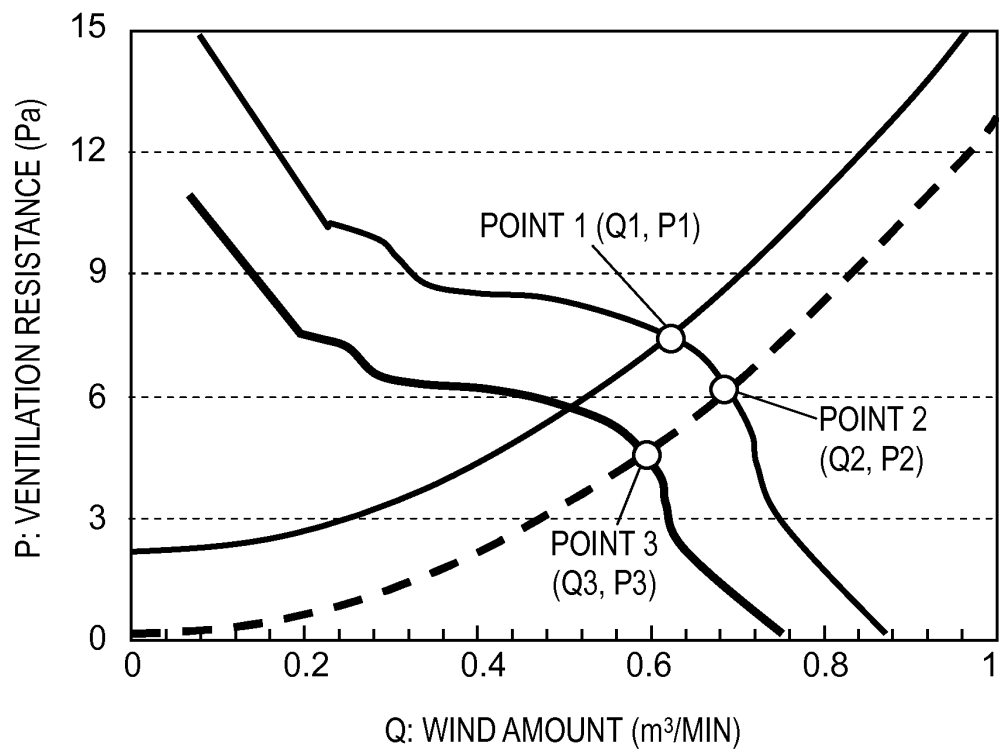


FIG. 14

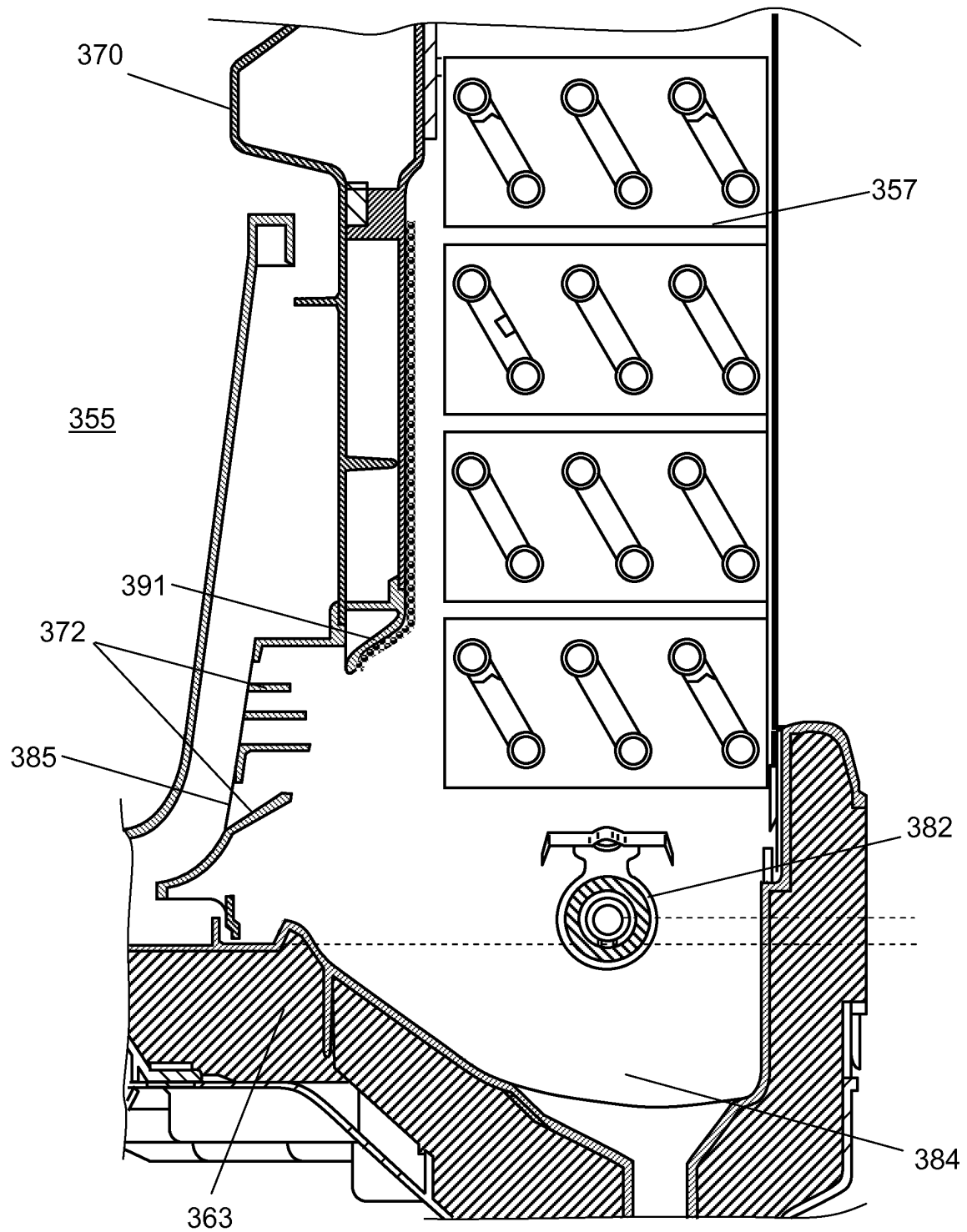


FIG. 15

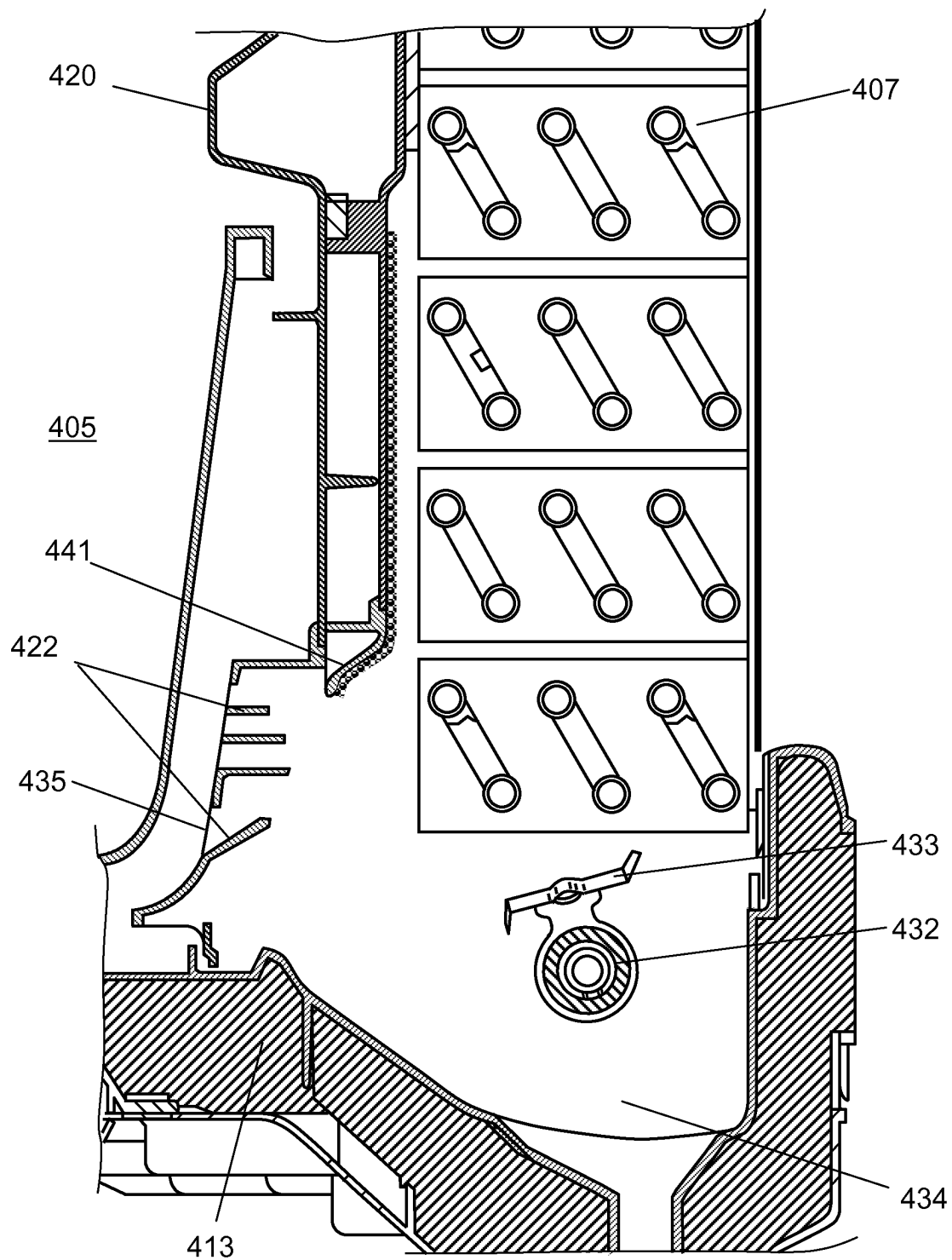


FIG. 16

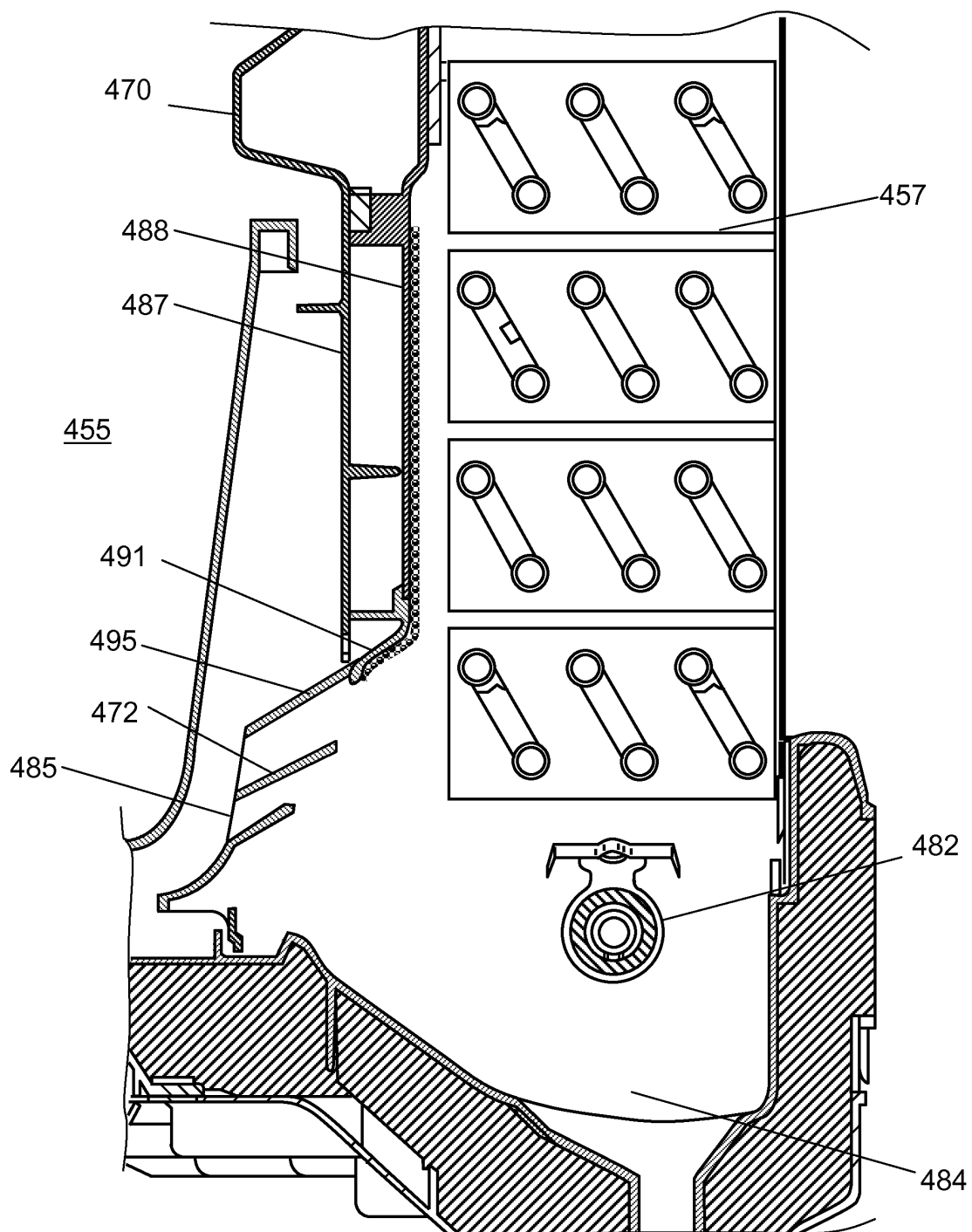


FIG. 17

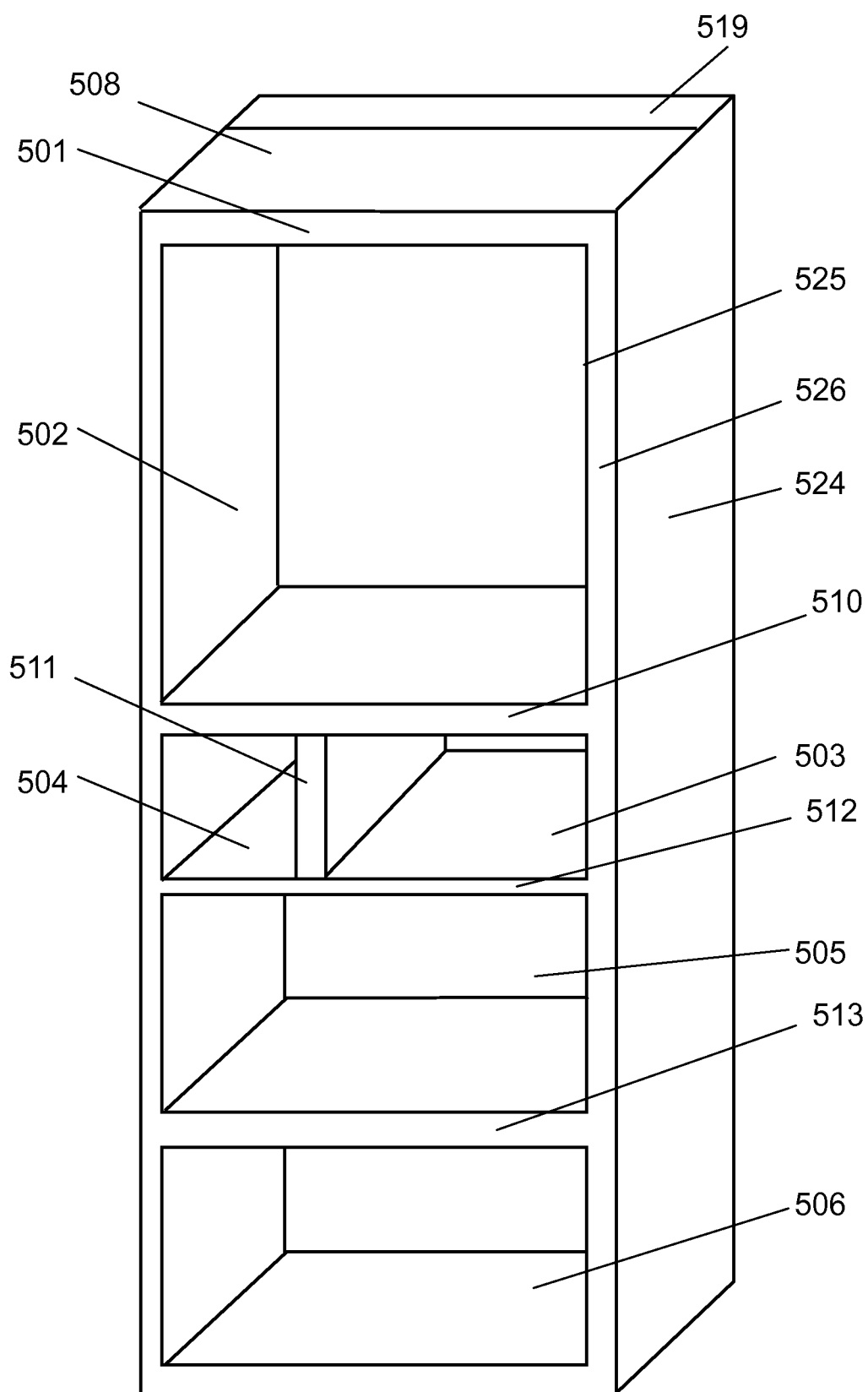


FIG. 18

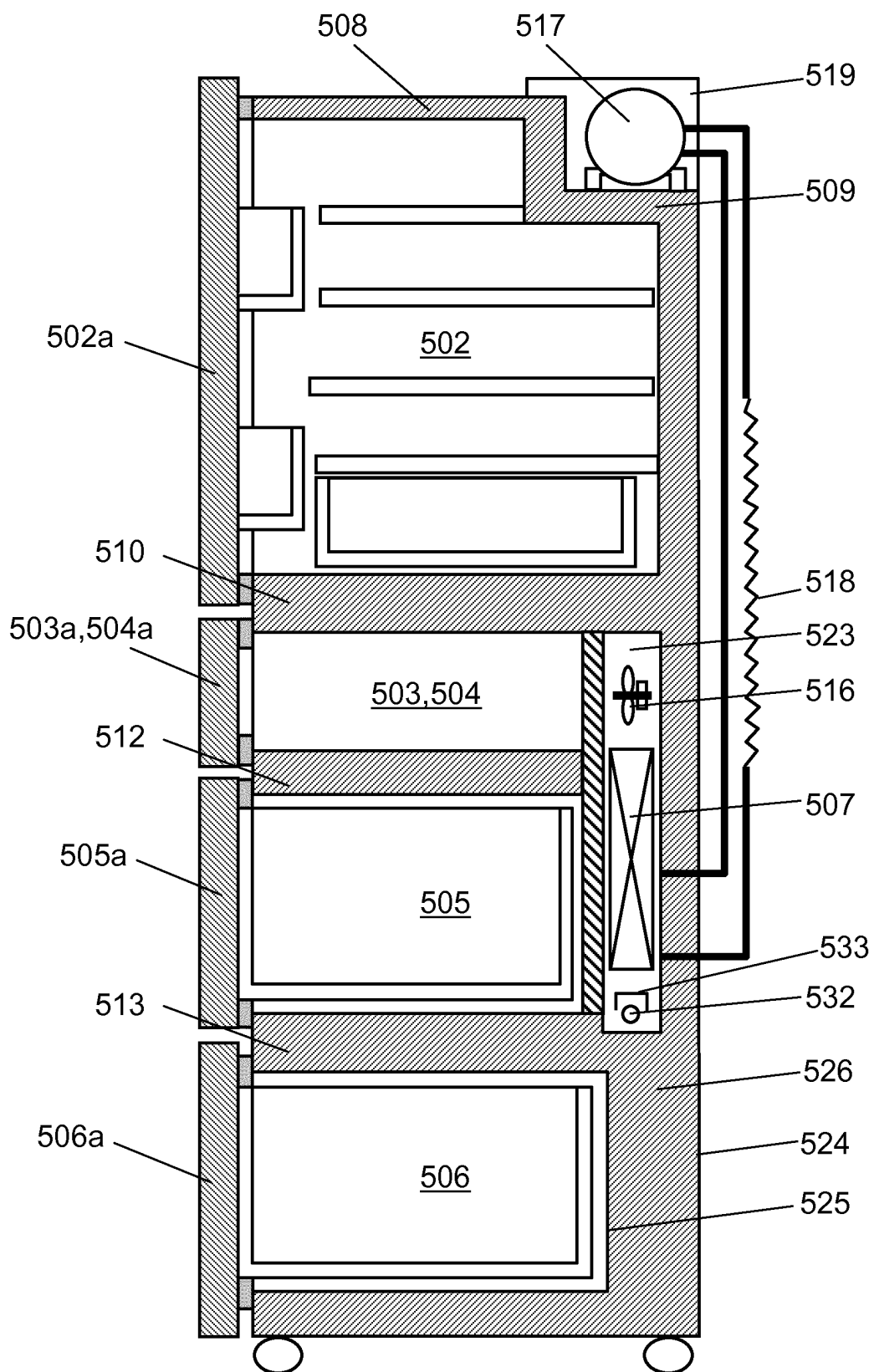


FIG. 19

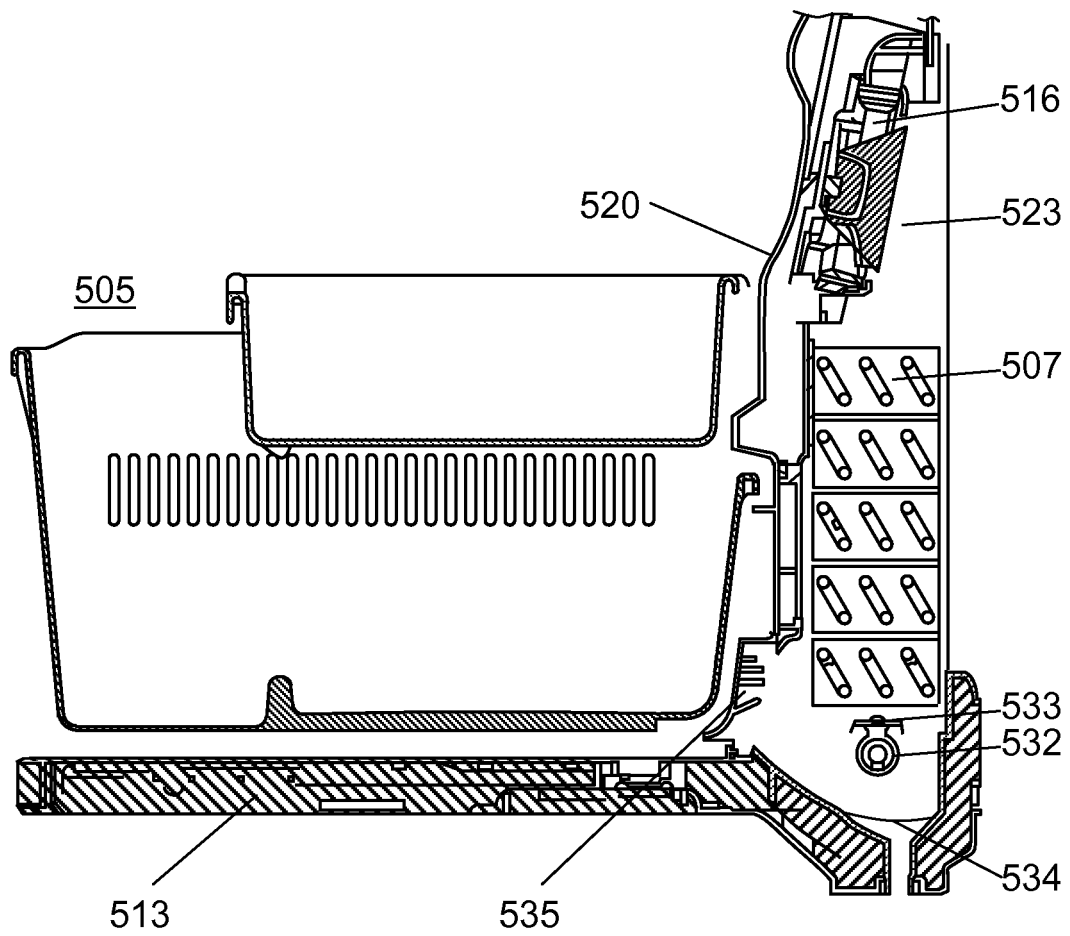


FIG. 20

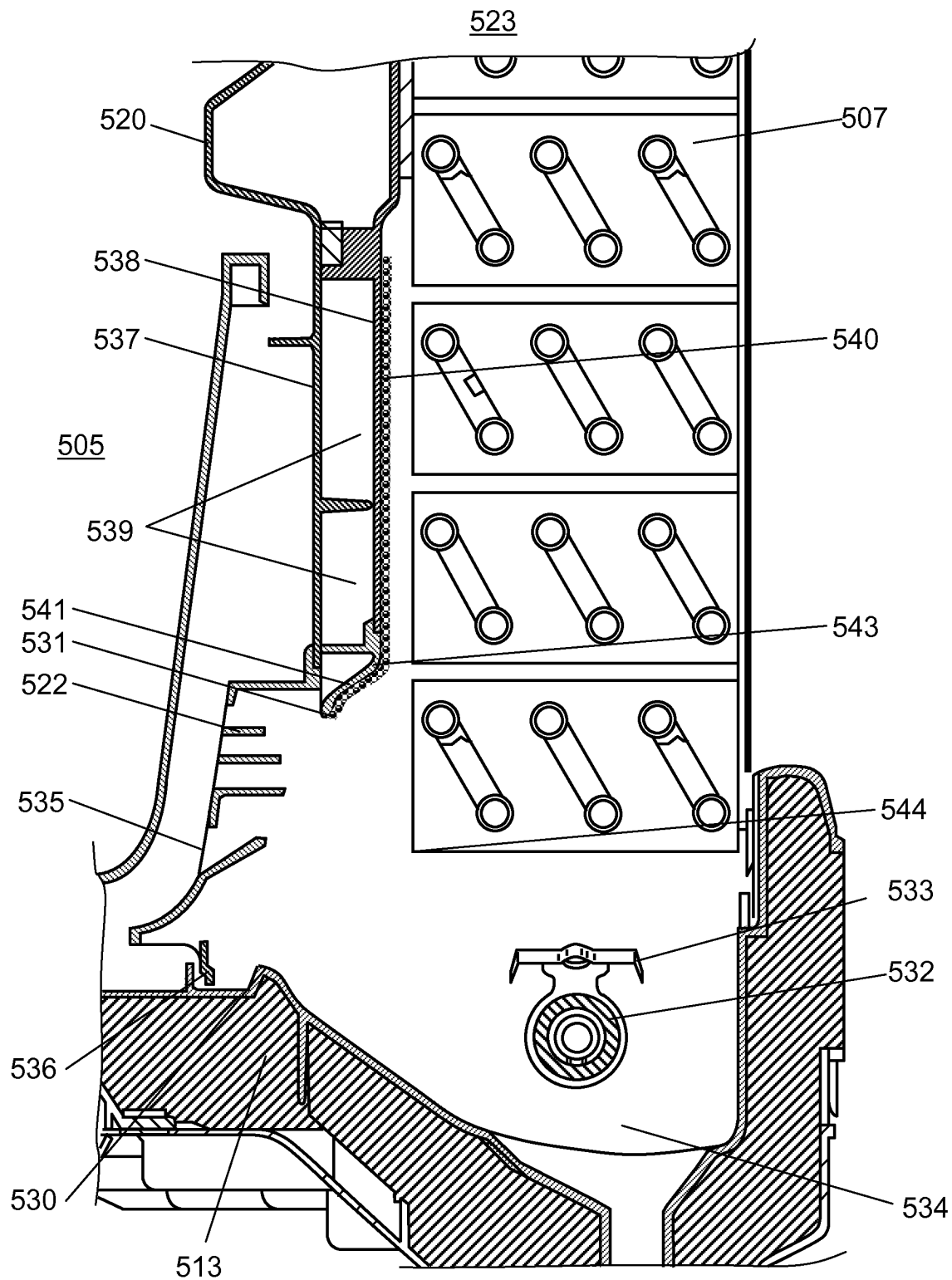


FIG. 21

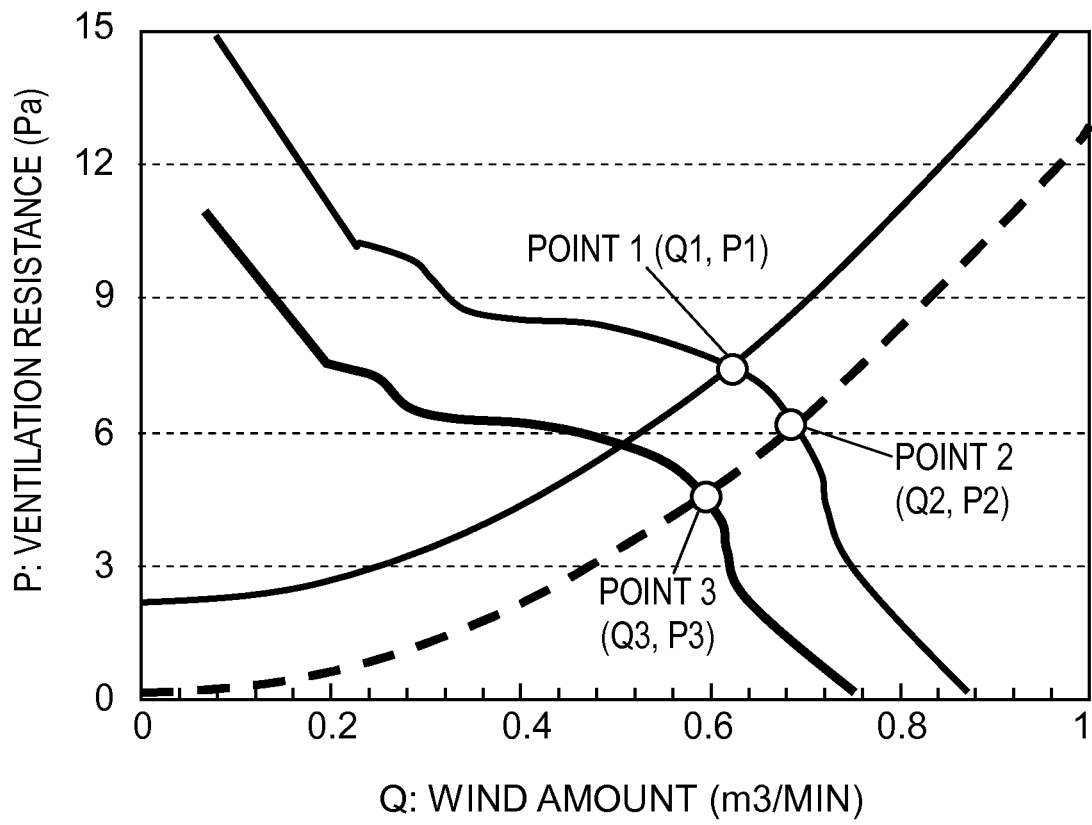


FIG. 22

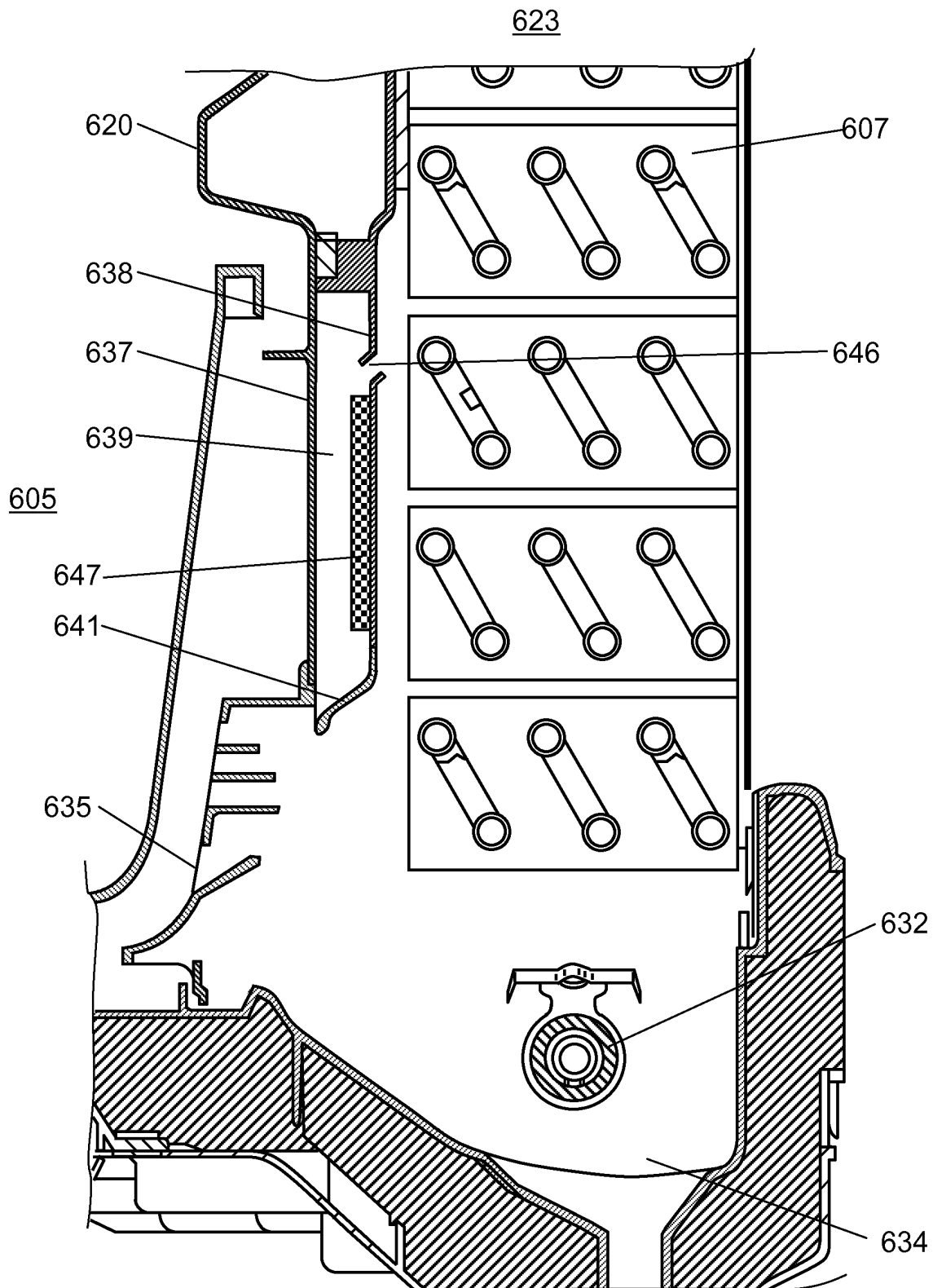


FIG. 23

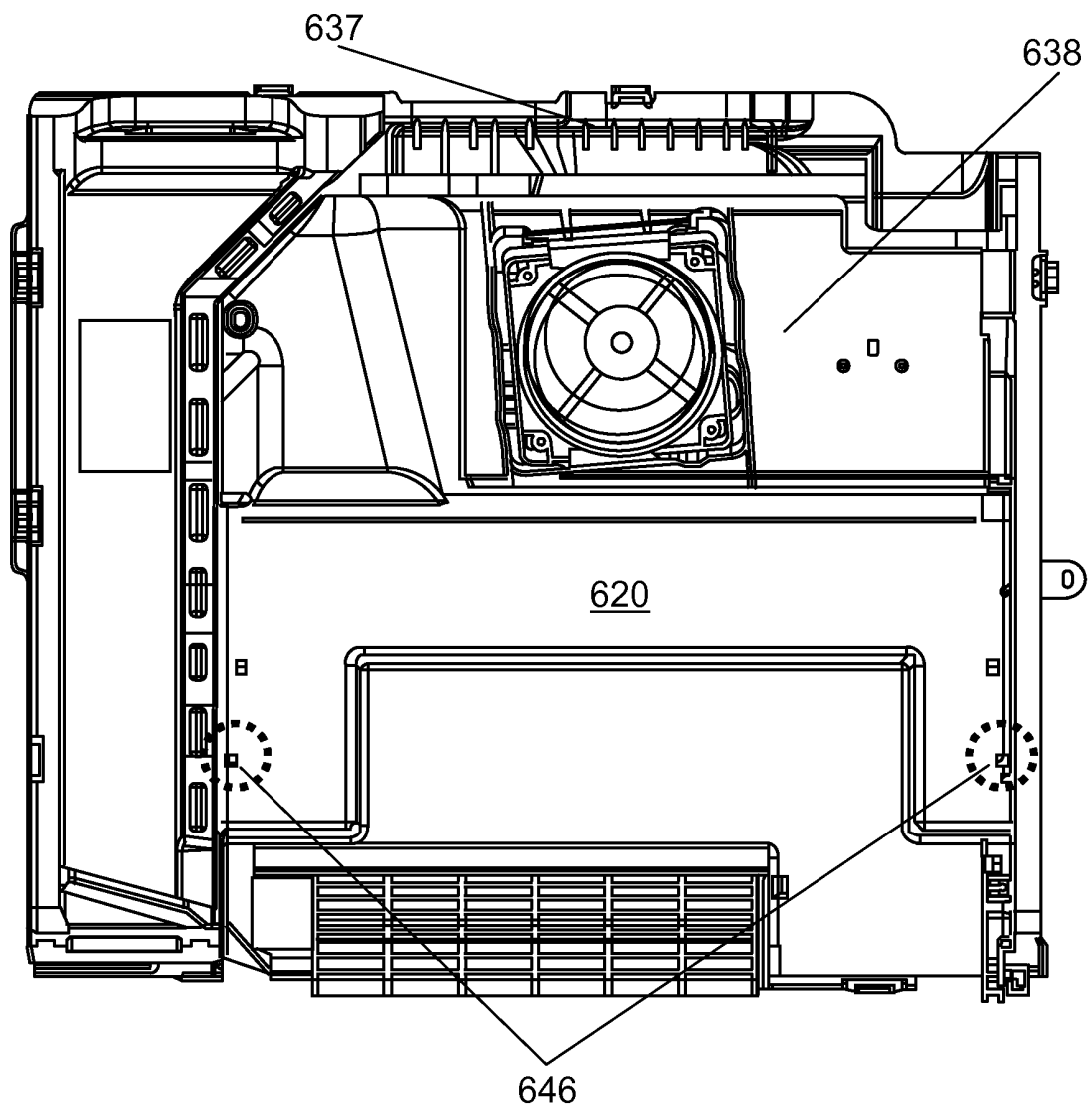


FIG. 24

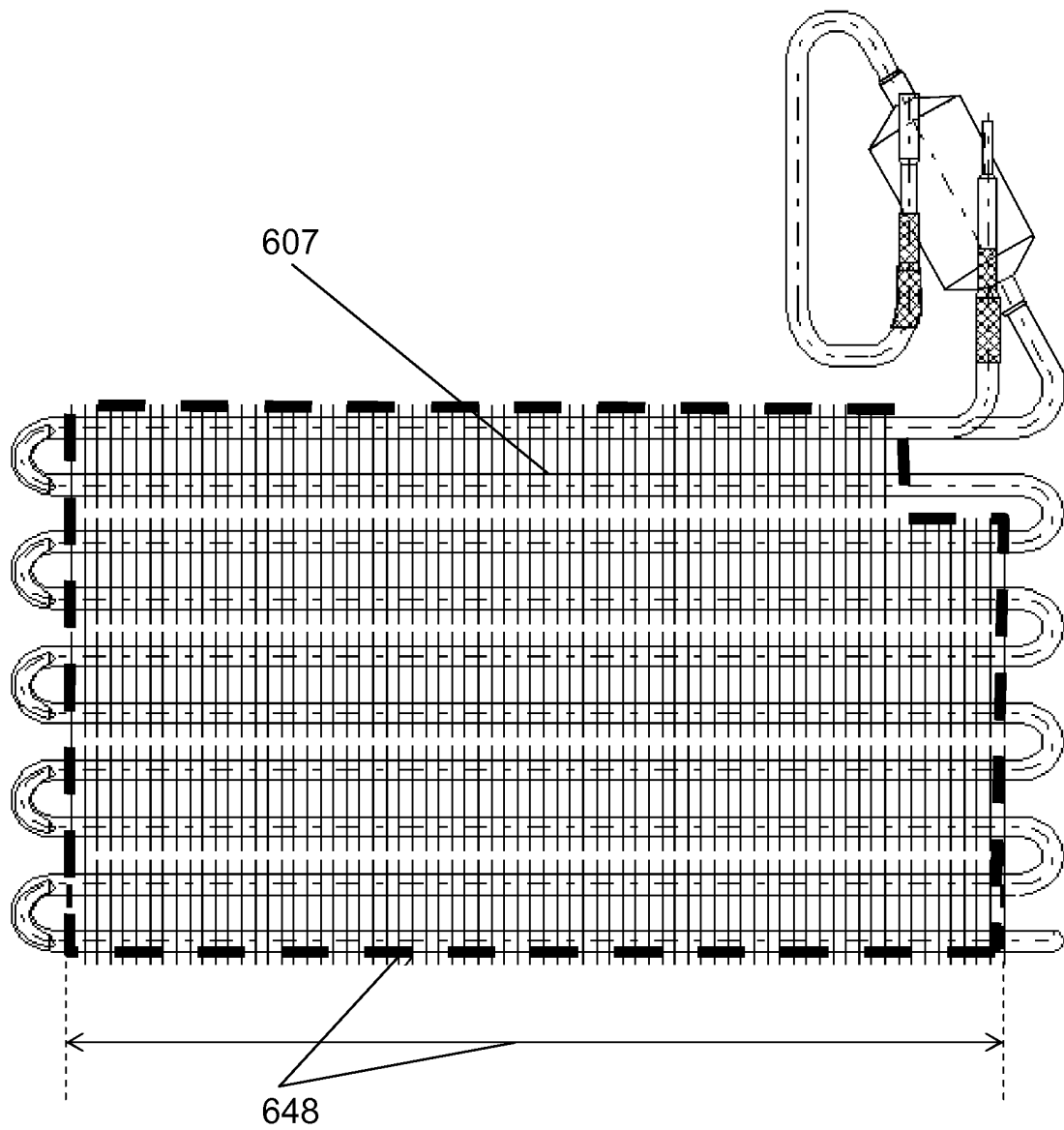


FIG. 25

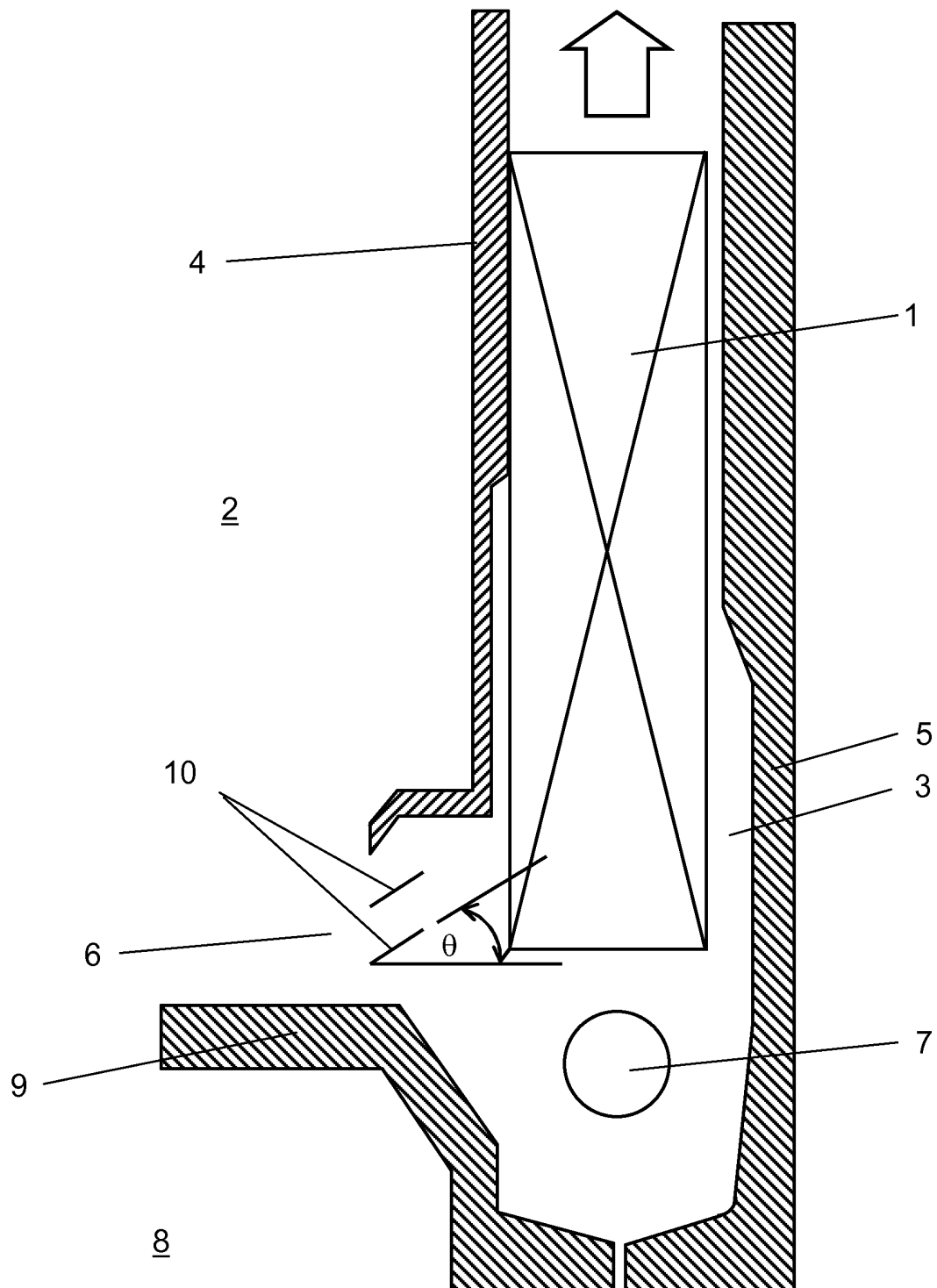


FIG. 26A

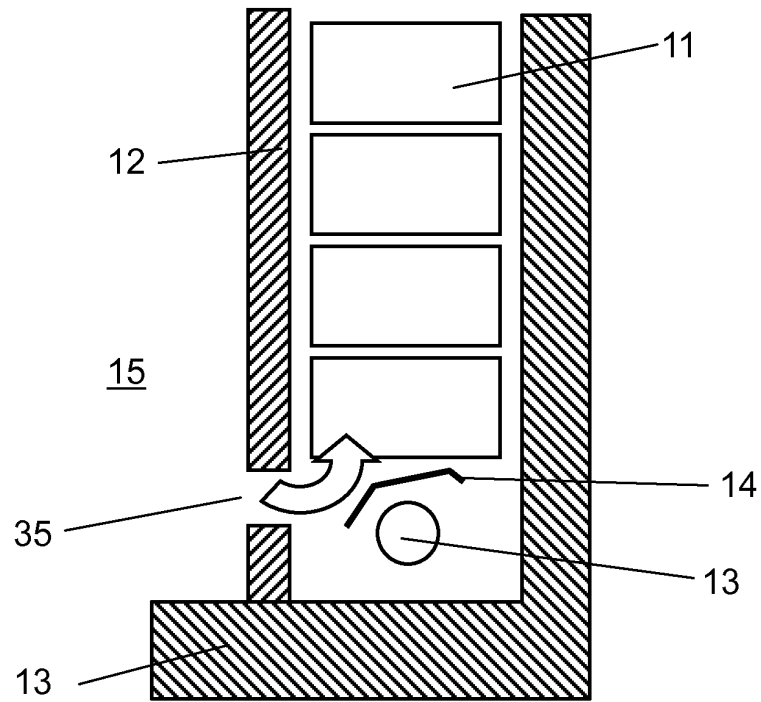


FIG. 26B

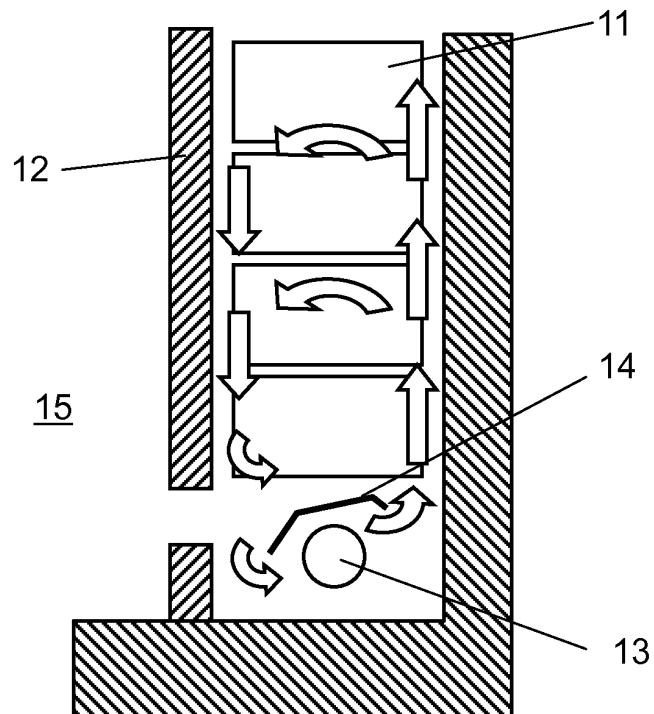


FIG. 27

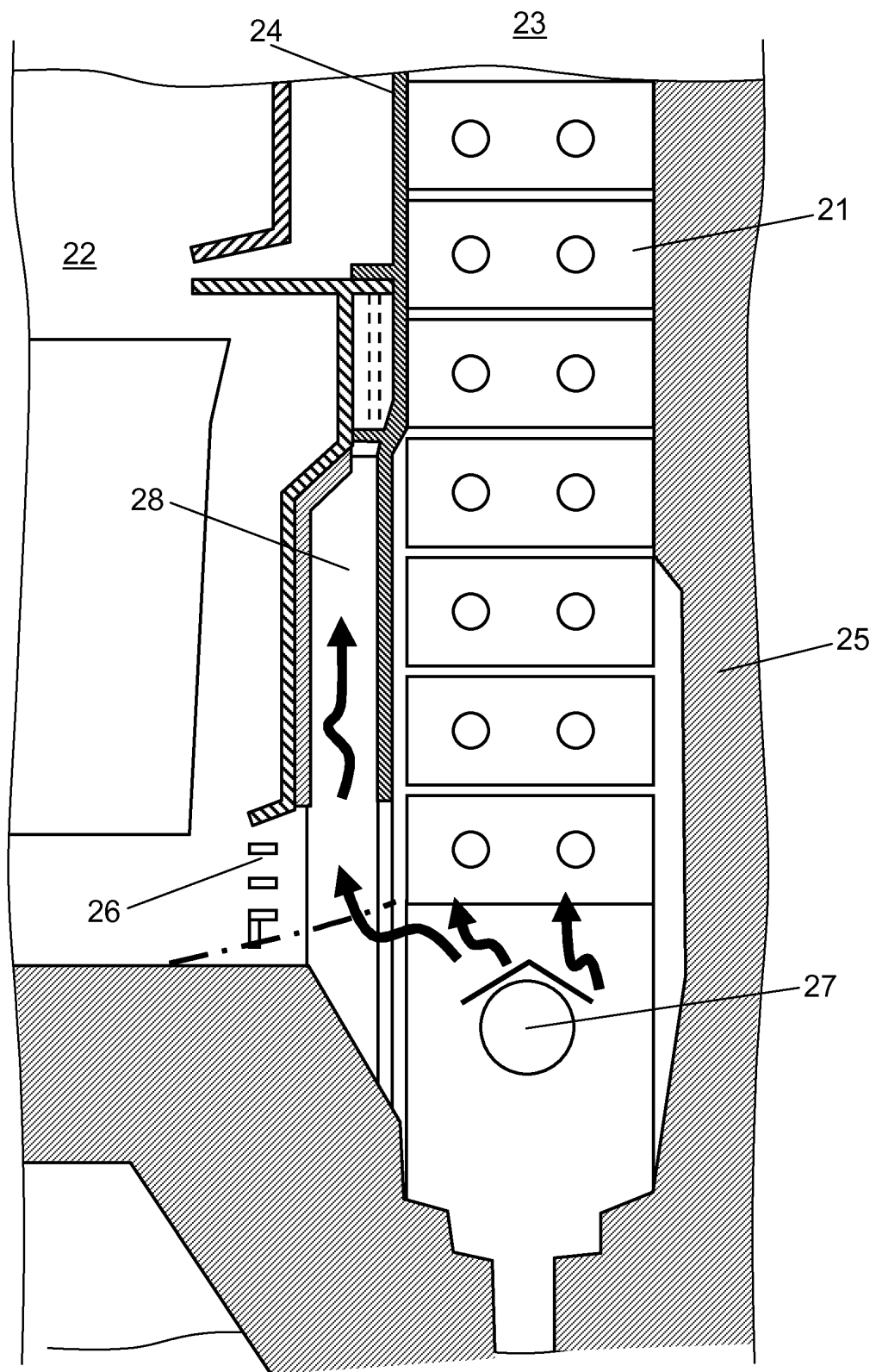
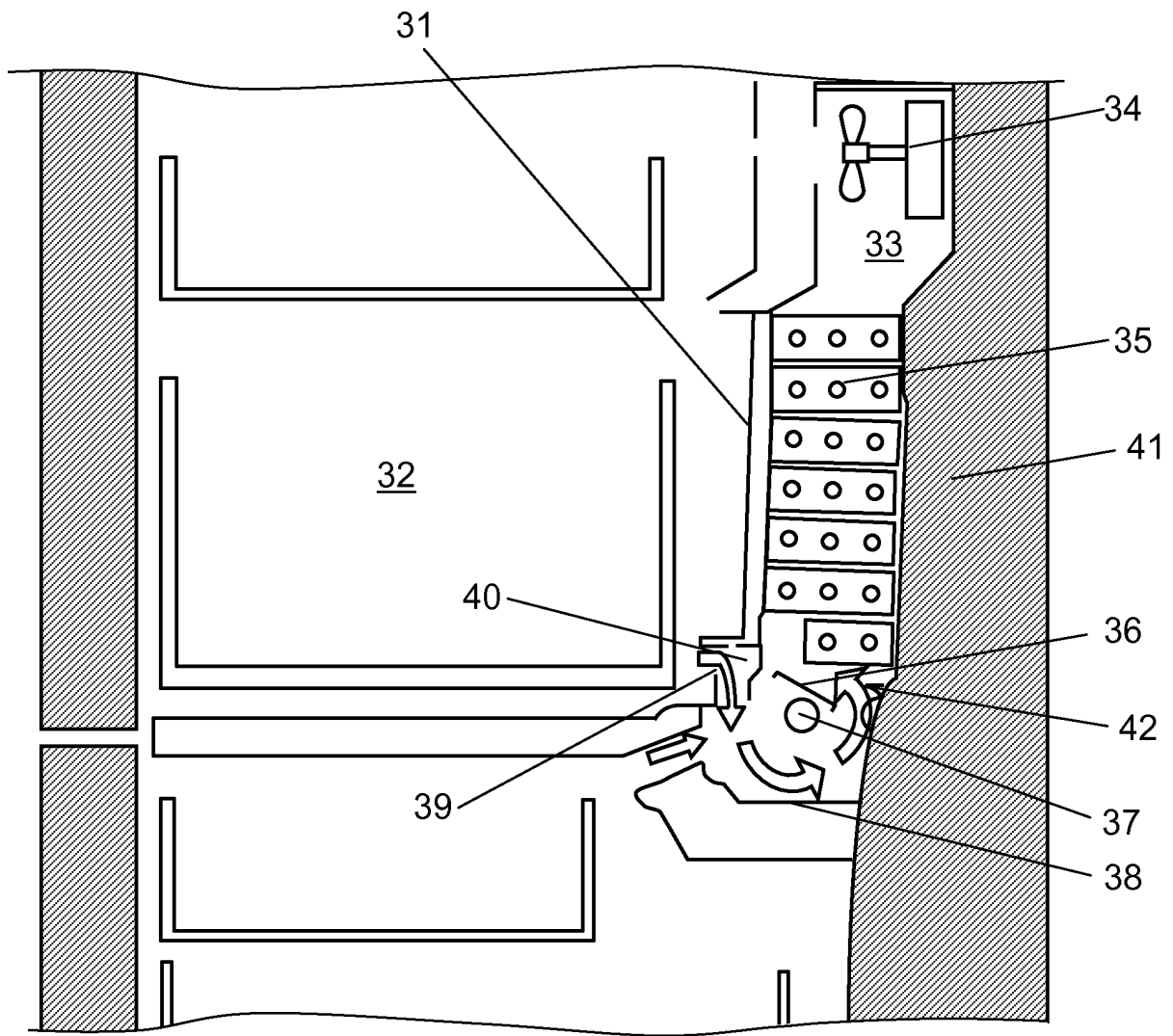


FIG. 28



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/007729

## A. CLASSIFICATION OF SUBJECT MATTER

F25D21/08(2006.01) i, F25D23/00(2006.01) i

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)

F25D21/08, F25D23/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

|                           |           |                            |           |
|---------------------------|-----------|----------------------------|-----------|
| Jitsuyo Shinan Koho       | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2013 |
| Kokai Jitsuyo Shinan Koho | 1971-2013 | Toroku Jitsuyo Shinan Koho | 1994-2013 |

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                         | Relevant to claim No.                |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| Y<br>A    | JP 2004-85070 A (Matsushita Refrigeration Co.),<br>18 March 2004 (18.03.2004),<br>paragraphs [0020] to [0039]; fig. 3, 4<br>(Family: none) | 1-7, 9-11, 19<br>8, 23, 24,<br>26-28 |
| Y<br>A    | JP 2011-127850 A (Sharp Corp.),<br>30 June 2011 (30.06.2011),<br>paragraphs [0033] to [0070]; fig. 4, 7, 8<br>(Family: none)               | 1-7, 9-11<br>8, 23, 24,<br>26-28     |
| Y<br>A    | JP 2007-93108 A (Sanyo Electric Co., Ltd.),<br>12 April 2007 (12.04.2007),<br>paragraphs [0022] to [0042]; fig. 1, 2, 4<br>(Family: none)  | 6, 7, 17, 21<br>8, 23, 24,<br>26-28  |

☒ 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"&amp;" document member of the same patent family

Date of the actual completion of the international search  
07 February, 2013 (07.02.13)Date of mailing of the international search report  
19 February, 2013 (19.02.13)Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/007729

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                   | Relevant to claim No.                                         |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| X         | JP 2010-60188 A (Hitachi Appliances, Inc.),<br>18 March 2010 (18.03.2010),<br>paragraphs [0033] to [0057]; fig. 2, 5, 6<br>(Family: none)                            | 12-16, 18, 20,<br>22, 25<br>17, 19, 21<br>8, 23, 24,<br>26-28 |
| A         | JP 2006-46791 A (Matsushita Electric<br>Industrial Co., Ltd.),<br>16 February 2006 (16.02.2006),<br>paragraphs [0002] to [0005], [0028]; fig. 3, 4<br>(Family: none) | 1-28                                                          |
| A         | JP 2007-71487 A (Hitachi Appliances, Inc.),<br>22 March 2007 (22.03.2007),<br>paragraphs [0029] to [0030]; fig. 1, 3<br>& CN 1928470 A                               | 1-28                                                          |
| A         | JP 2004-190960 A (Toshiba Corp.),<br>08 July 2004 (08.07.2004),<br>fig. 2<br>(Family: none)                                                                          | 1-28                                                          |

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/007729

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:  
See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/007729

Continuation of Box No.III of continuation of first sheet (2)

The technical feature common to the invention of claim 1 and the inventions of claims 12 to 28 is "a refrigerator comprising: a refrigerator body; a freezing compartment in a freezing temperature zone within the refrigerator;

a cooler provided on the rear surface side of the freezing compartment and generating cool air; a defrosting heater provided below the cooler; and a cooler cover for covering the cooler and having a cool air return opening for allowing cool air to return therethrough to the cooler, the cool air having cooled the freezing compartment."

However, the above-said technical feature cannot be considered to be a special technical feature, since the technical feature does not make a contribution over the prior art in the light of the contents disclosed in the document (JP 2004-85070 A (Matsushita Refrigeration Co.), 18 March 2004 (18.03.2004), paragraphs [0020] to [0039]; fig. 3, 4).

In addition, there is no other same or corresponding special technical feature between the invention of claim 1 and the inventions of claims 12-28.

Consequently, the following two inventions (invention groups) are involved in claims.

(Invention 1) the inventions of claims 1-11

(Invention 2) the inventions of claims 12-28

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- JP 2007071487 A [0028]
- JP 2011127850 A [0028]
- JP 2010060188 A [0028]
- JP 2011089718 A [0028]