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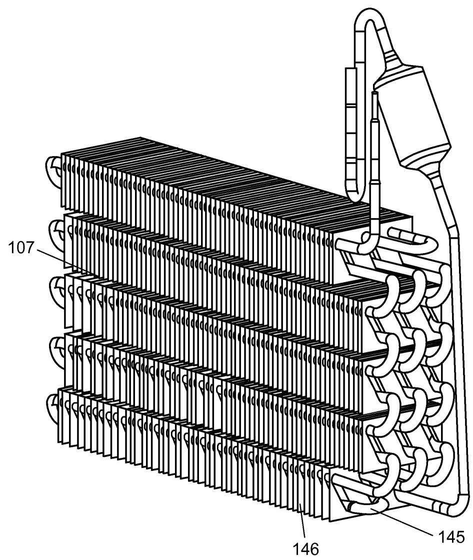
(54) REFRIGERATOR

(57) Provided is a refrigerator including a freezing compartment sectioned by a heat insulating wall, a cold storage compartment disposed above the freezing compartment, and a cooler compartment disposed behind the freezing compartment. The refrigerator further includes a cooling device (107) disposed in the cooler compartment, and including vertically stacked refrigerant pipes (145) equipped with fins (146), and a cold storage compartment return duct that returns cold air returning from the cold storage compartment toward the cooler compartment, the cold storage compartment return duct disposed on a side of the cooling device (107). The lateral length of a lower part of the refrigerant pipes (145) of the cooling device (107) is made shorter than the lateral length of an upper part of the refrigerant pipes (145) so as to improve cooling efficiency by reduction of flow path pressure losses, and to disperse frosting parts of the cooling device (107).

FIG. 6



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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerator which uses cold air generated by a cooling device and circulated by a fan for cooling.

BACKGROUND ART

[0002] For promoting energy saving which is in progress in recent years for refrigerators, it is essential not only to increase cooling efficiency, but also to prevent decrease in cooling efficiency in the actual use of a refrigerator including opening and closing of a door even in a state of frosting on a cooling device, for reduction of power consumption of the refrigerator.

[0003] For the purpose of reducing power consumption of a conventional refrigerator, the following configurations have been proposed as methods for preventing decrease in the cooling efficiency caused by frost adhering to a cooling device. According to an example of the proposed configurations, cold air returning from the inside of a highly humid cold storage compartment to a cooling device reaches the cooling device from below along a guide plate disposed below the cooling device so as to equalize frosting on the cooling device and thereby prevent capability deterioration (for example, see PTL 1). According to another example of the proposed configurations, cold air returning from the inside of a refrigerator flows through the interior of a heat insulating partitioning wall disposed below a cooling device to pass through a distance substantially equivalent to the lateral length of the cooling device from the lower side of the cooling device, and thereby offer an advantage of equalization of frosting on the cooling device (for example, see PTL 2). According to a further example of the proposed configurations, a flow path, a shield, and a guiding member are provided to direct the flow of cold air toward the center of a cooling device as much as possible in returning from the inside of a refrigerator to the cooling device (for example, see PTL 3). This configuration diffuses return cold air for equalization of frosting on the cooling device, and also prevents clogging of the cooling device caused by uneven frosting, so as to avoid decrease in cooling efficiency.

[0004] The foregoing conventional refrigerators are hereinafter described with reference to the drawings.

[0005] FIG. 7 is a perspective view illustrating a configuration of the surroundings of a cooling device of a refrigerator described in PTL 1, particularly illustrating guide plate 28 for cold storage compartment return cold air 27. Cold air generated by cooling device 7 circulates inside the refrigerator, and flows from the inside of the refrigerator into cooling device 7 as return cold air after circulation. Cold storage compartment return cold air 27 from the cold storage compartment enters return duct 29 disposed on the right side as illustrated in FIG. 7. Guide plate 28 positioned between defrosting heater 32 and drain pan 34 extends from an outlet of return duct 29 toward the left side below cooling device 7, forming a duct-shaped space between guide plate 28 and drain pan 34. Openings 28a are further formed in the surface of guide plate 28. Cold storage compartment return cold air 27 is dispersed by openings 28a, and flows toward an area below cooling device 7. Then, cold storage compartment return cold air 27 is mixed with freezing compartment return cold air 30 flowing from a freezing compartment into a space between guide plate 28 and the lower end of cooling device 7, and the mixture of air 27 and 30 is uniformly sucked into a lower portion of cooling device 7.

[0006] As described above, guide plate 28 is formed between defrosting heater 32 and drain pan 34 as an extension of return duct 29. This configuration produces the mixture of cold storage compartment return cold air 27 from the highly humid cold storage compartment and freezing compartment return cold air 30 from the freezing compartment, and thereby equalizes frosting on cooling device 7. Accordingly, this configuration maintains cooling performance for a long period by preventing unevenness of clogging between fins of cooling device 7 caused by frosting, and also shortens defrosting time of defrosting heater 32. As a result, power consumption decreases. Moreover, guide plate 28 is disposed in the up-down direction of cooling device 7. In this case, the inside length of the refrigerator in the depth direction does not become shorter, and advantages such as avoidance of decrease in the inner volume of the refrigerator can be offered.

[0007] FIGS. 8A and 8B are a front cross-sectional view of the surroundings of a cooling device of a refrigerator described in PTL 2, and a side cross-sectional view illustrating flow of cold air during operation of a cold storage compartment, respectively. Cooling device 7 is provided behind a freezing compartment (not shown). A cold storage compartment is provided on the upper side of the freezing compartment, and a vegetable compartment is provided on the lower side of the freezing compartment. Cold air having cooled the cold storage compartment and circulated the inside of the refrigerator is supplied to the vegetable compartment via return duct 29 extending from the cold storage compartment (cold storage compartment-vegetable compartment communication duct). Vegetable compartment return cold air from the vegetable compartment is directed into cooler compartment 23 via vegetable compartment return duct 31 provided within heat insulating partitioning wall 13. According to this configuration, return cold air from the cold storage compartment positioned on the upper side of the freezing compartment is directed to temporarily enter the vegetable compartment without direct flow into the cooler compartment, and subsequently enter cooler compartment 23 as vegetable compartment return cold air. Thereafter, the vegetable compartment return cold air is directed into cooler compartment 23 after passing through a vegetable compartment return delivery port which makes the lateral length of the vegetable compartment return cold air substantially equivalent to the lateral length of cooling device 7.

[0008] This configuration avoids decrease in the effective inner volume inside the refrigerator, and also offers an effect of equalization of frosting on cooling device 7. Accordingly, this configuration produces an advantage of excellent energy saving based on improvement of heat exchange efficiency of cooling device 7.

[0009] FIG. 9 is a cross-sectional configuration view illustrating the interior of a cooler compartment of a refrigerator described in PTL 3.

[0010] Cooling device 7 is disposed behind freezing compartment 14, and a cold storage compartment is disposed above freezing compartment 14. Cold storage compartment return cold air having cooled the cold storage compartment is introduced into cooler compartment 23 via a return duct disposed on the cooling device side. Flow path 47 is provided between a front face of cooling device 7 and cooling device cover 20 which separates freezing compartment 14 from cooler compartment 23, to disperse cold storage compartment return cold air having a high humidity, and thereby equalize frost adhering to cooling device 7.

[0011] This configuration disperses frost adhering to cooling device 7. Accordingly, this configuration reduces decrease in cooling efficiency of cooling device 7 caused by clogging with frosting, and lowers the height of a frost layer adhering to cooling device 7. As a result, the efficiency during defrosting also improves.

[0012] According to the conventional refrigerator described with reference to FIG. 7, an energy saving effect is produced by equalizing the frosting condition of frost adhering to the cooling device and thereby preventing decrease in the cooling efficiency during frosting. However, the addition of guide plate 28 increases the cost and decreases the inside volume. Moreover, guide plate 28 disposed in the vicinity of cooling device 7 has an extremely low temperature, and frost easily remains inside the duct constituted by guide plate 28. Accordingly, there arises a problem that the cooling performance deteriorates due to blocking of the flow path by the remaining frost, in view of the long-term use of the refrigerator for approximately 10 years. In addition, guide plate 28 disposed in the vicinity of a lower surface of defrosting heater 32 is influenced by a temperature effect produced by heat generation from defrosting heater 32 during defrosting. The temperature of the surface of defrosting heater 32 increases to approximately 300°C by the heat generated from defrosting heater 32 during defrosting. As a result, the temperature of the surface of guide plate 28 provided in the vicinity of defrosting heater 32 increases to approximately 100°C or higher. Accordingly, there arises a problem that a component covering the surface, such as aluminum foil or other metal, is needed to avoid thermal deformation. Thus, the material cost or the man-hour cost increases.

[0013] On the other hand, according to the conventional refrigerator described with reference to FIG. 8, return cold air toward cooling device 7 passes through the inside of heat insulating partitioning wall 13 below cooling device 7 before returning to cooling device 7. In this case, cold air flows from the lower side of cooling device 7 with a lateral length substantially equivalent to the lateral length of cooling device 7. This configuration increases the heat exchange efficiency of cooling device 7 to the maximum, thereby achieving excellent energy saving. In addition, this configuration offers an advantage of equalization of frosting on cooling device 7. However, the vegetable compartment is cooled by utilizing such a flow path configuration which uses return cold air having cooled the cold storage compartment. In this case, the vegetable compartment is easily affected by temperature fluctuations of the cold storage compartment. Particularly in the summer season when a door of the cold storage compartment is frequently opened and closed under the environment of a high outside temperature, there arises a problem that the temperature of the vegetable compartment increases to such a level as to deteriorate freshness keeping capability. Moreover, the return flow path toward cooling device 7 is configured to extend inside heat insulating partitioning wall 13. Accordingly, the thickness of heat insulating partitioning wall 13 increases due to the necessity of constituting the flow path, and thus problems such as decrease in the inner volume of the refrigerator and a rise of the component cost occur.

[0014] According to the conventional refrigerator described with reference to FIG. 9, return cold air flowing from the cold storage compartment toward cooling device 7 is introduced through flow path 47 toward the central portion of the cooling device to equalize the frosting condition of frost adhering to cooling device 7 and thereby prevent decrease in the cooling efficiency during frosting. However, this configuration produces more ineffectual spaces such as a flow path, and causes a problem of decrease in the inner volume of the refrigerator. Moreover, there further arises a problem that abnormal noise is generated between cooling device 7 and the shield in contact with cooling device 7, because the shield is made of a material having a different linear expansion coefficient, due to thermal deformation of the shield caused by radiation heat from the defrosting heater during defrosting.

[0015] In consideration of the aforementioned circumstances, there is provided according to the present invention a refrigerator which improves cooling efficiency and defrosting efficiency during frosting based on equalization of frosting so as to achieve high energy saving performance, and also decreases ineffectual spaces while reducing cost and increasing the storage volume.

Citation List

Patent Literature

[0016]

PTL 1: Unexamined Japanese Patent Publication No. H11-183011
PTL 2: Unexamined Japanese Patent Publication No. 2011-38714
PTL 3: Unexamined Japanese Patent Publication No. H7-270028

SUMMARY OF THE INVENTION

[0017] A refrigerator according to the present invention includes: a freezing compartment sectioned by a heat insulating wall; a cold storage compartment disposed above the freezing compartment; a cooler compartment disposed behind the freezing compartment; and a cooling device disposed in the cooler compartment, and including vertically stacked refrigerant pipes equipped with fins. The refrigerator further includes a cooling device cover that covers a front face of the cooling device, and a cold storage compartment return duct disposed on a side of the cooling device as a duct through which cold air from the cold storage compartment returns toward the cooler compartment. The lateral length of a lower part of the refrigerant pipes of the cooling device is shorter than the lateral length of an upper part of the refrigerant pipes.

[0018] According to the refrigerator of the present invention having this configuration, flow path pressure losses decrease by enlargement of a space of a portion to which inside cold air returns. Accordingly, cooling efficiency improves, and simultaneously dispersion of a frosting portion is achievable. This configuration prevents performance deterioration caused by frost, and improves defrosting efficiency based on dispersion of frost, even under high-humidity conditions where frosting easily occurs. Accordingly, the refrigerator provided herein can enhance energy saving, and also can secure a sufficient inner volume.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

FIG. 1 is a perspective view of a refrigerator according to a first exemplary embodiment of the present invention.
FIG. 2 is a vertical cross-sectional view of the refrigerator according to the first exemplary embodiment of the present invention.
FIG. 3 is an enlarged cross-sectional view of the surroundings of a cooling device of the refrigerator according to the first exemplary embodiment of the present invention.
FIG. 4 is a front view of the surroundings of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention.
FIG. 5A is a front view of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention.
FIG. 5B is a side view of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention.
FIG. 6 is a perspective view of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention.
FIG. 7 is a perspective view illustrating a main part of the surroundings of a cooling device of a conventional refrigerator.
FIG. 8A is a front cross-sectional view illustrating the surroundings of a cooling device of a conventional refrigerator.
FIG. 8B is a side cross-sectional view illustrating the surroundings of the cooling device of the conventional refrigerator.
FIG. 9 is a cross-sectional view illustrating the interior of a cooler compartment of the conventional refrigerator.

DESCRIPTION OF EMBODIMENT

[0020] An exemplary embodiment according to the present invention is hereinafter described with reference to the drawings. In this description, configurations identical to or exhibiting no difference from the corresponding conventional configurations are not detailed. It is intended that the present invention should not be limited in any way to the exemplary embodiment described herein.

FIRST EXEMPLARY EMBODIMENT

[0021] A first exemplary embodiment of the present invention is hereinafter described in detail with reference to the drawings.

[0022] FIG. 1 is a perspective view of a refrigerator according to the first exemplary embodiment of the present invention, and FIG. 2 is a vertical cross-sectional view of the refrigerator according to the first exemplary embodiment of the present invention. FIG. 3 is a side cross-sectional view of the surroundings of a cooling device of the refrigerator according to the first exemplary embodiment of the present invention, and FIG. 4 is a front cross-sectional view of the surroundings of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention. FIG. 5A is a front view of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention, and FIG. 5B is a side view of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention. FIG. 6 is a perspective view of the cooling device of the refrigerator according to the first exemplary embodiment of the present invention.

[0023] As illustrated in FIGS. 1 through 6, refrigerator main body 101 is a heat insulating body which includes outer box 124 made of metal (such as iron plate) and opening to the front, inner box 125 made of rigid resin (such as ABS (acrylonitrile butadiene styrene) resin), and rigid urethane foam 126 foamily filling a space between inner box 125 and outer box 124. Cold storage compartment 102 is provided in the upper part of refrigerator body 101. Provided below cold storage compartment 102 are upper freezing compartment 103, and ice-making compartment 104 disposed in parallel with upper freezing compartment 103. Lower freezing compartment 105 is provided between vegetable compartment 106 disposed in the lower part of refrigerator body 101, and upper freezing compartment 103 and ice-making compartment 104 disposed in parallel with each other. Front surfaces of upper freezing compartment 103, ice-making compartment 104, lower freezing compartment 105, and vegetable compartment 106 are openably closed by not-shown drawer type doors 103a, 104a, 105a, and 106a, respectively. A front surface of cold storage compartment 102 is openably closed by double-door 102a.

[0024] The temperature of the inside of cold storage compartment 102 is generally set within a range from 1°C to 5°C with a lower limit of a temperature set immediately above freezing for cold storage. The temperature of the inside of vegetable compartment 106 is often set within a range equivalent to or slightly higher than the range of the inside temperature of cold storage compartment 102, i.e., from 2°C to 7°C. The freshness of leafy vegetables is maintained for a longer period when the temperature of the inside of vegetable compartment 106 is set lower.

[0025] Both the temperature of the inside of upper freezing compartment 103 and the temperature of the inside of lower freezing compartment 105 are generally set within a range from -22°C to -18°C for frozen storage. However, these temperatures are set to lower temperatures in a range from -30°C to -25°C in some cases, for example, for improvement of frozen storage conditions.

[0026] Since the inside temperatures of cold storage compartment 102 and vegetable compartment 106 are set to positive values, each temperature range of cold storage compartment 102 and vegetable compartment 106 is called a cold storage temperature zone. On the other hand, since the inside temperatures of upper freezing compartment 103, lower freezing compartment 105, and ice-making compartment 104 are set to negative values, each temperature range of upper freezing compartment 103, lower freezing compartment 105, and ice-making compartment 104 is called a freezing temperature zone. Upper freezing compartment 103 may be a room whose temperature range is switchable between the cold storage temperature zone and the freezing temperature zone as a switching compartment switchable by a damper mechanism or the like.

[0027] A top surface of refrigerator body 101 is recessed stepwise in the direction toward the rear of the refrigerator, forming machine compartment 119 within the stepwise recess portion. The top surface of refrigerator body 101 is constituted by first top surface 108 and second top surface 109. Machine compartment 119 includes compressor 117, a dryer (not shown) for removing moisture, and a capacitor (not shown). Compressor 117, the dryer, the capacitor, a radiation pipe (not shown) for heat radiation, capillary tube 118, and cooling device 107 are sequentially connected in an annular shape. Refrigerant is sealed into the connection of these components to constitute a freezing cycle. Combustible refrigerant is often used for this refrigerant in view of protection of the environment in recent years. When a three-way valve or a selector valve are provided for the freezer cycle, the machine compartment may further include these function components.

[0028] Cold storage compartment 102 is separated from ice-making compartment 104 and upper freezing compartment 103 by first heat insulating partitioning portion 110. Ice-making compartment 104 is separated from upper freezing compartment 103 by second heat insulating partitioning portion 111. Ice-making compartment 104 and upper freezing compartment 103 are separated from lower freezing compartment 105 by third heat insulating partitioning portion 112.

[0029] Second heat insulating partitioning portion 111 and third heat insulating partitioning portion 112 are components assembled after foaming of refrigerator body 101. Accordingly, foamed polystyrene is generally used as a heat insulating material of these portions 111 and 112. Alternatively, a rigid urethane foam may be used for increasing heat insulation performance and rigidity. In addition, a vacuum heat insulating material having high heat insulation properties may be inserted to further reduce the thickness of the partitioning structure.

[0030] Reduction of the thicknesses of the shapes of second heat insulating partitioning portion 111 and third heat insulating partitioning portion 112 or elimination of these portions 111 and 112 while leaving sufficient moving areas of the door frames can secure a sufficient cooling flow path, and improve the cooling capability. Alternatively, the interiors of second heat insulating partitioning portion 111 and third heat insulating partitioning portion 112 may be cut out to form a flow path. In this case, the cost decreases as a result of material reduction.

[0031] Lower freezing compartment 105 is separated from vegetable compartment 106 by fourth partitioning portion 113.

[0032] A configuration of the surroundings of a cooling device according to this exemplary embodiment is now described.

[0033] Cooler compartment 123 is provided in the rear part of refrigerator body 101. Cooler compartment 123 includes cooling device 107 of a fin and tube type, as a typical example, for generating cold air. Cooling device 107, disposed with the shorter side of cooling device 107 at the top, extends in the up-down direction throughout an area behind lower freezing compartment 105 including the rear regions of second partitioning portion 111 and third partitioning portion 112 corresponding to heat insulating partitioning walls. Cooling device cover 120 for covering cooling device 107 is disposed on the front face of cooler compartment 123. Cooling device cover 120 includes cold air return port 135 through which cold air having cooled lower freezing compartment 105 returns toward cooler compartment 123. Cooling device 107 is made of aluminum or copper.

[0034] Cooling device cover 120 is constituted by front cover 137 on the lower freezing compartment 105 side, and rear cover 138 on the cooling device 107 side. Metal heat transfer promoting member 140 is disposed on the cooling device 107 side of rear cover 138. Heat transfer promoting member 140 according to this exemplary embodiment is made of aluminum foil having a thickness t of 8 μm for heat transfer promotion during defrosting in consideration of cost. The dimension of heat transfer promoting member 140 in the up-down direction corresponds to the dimension from the lower end to the upper end of cooling device 107, and the dimension of heat transfer promoting member 140 in the left-right direction is a relatively large dimension in a range up to a length of approximately 15 mm larger than the length between fins of cooling device 107. Heat transfer promoting member 140 attached to rear cover 138 promotes heat transfer during defrosting to improve the defrosting efficiency and offer defrosting time reduction effect. Aluminum foil may be further disposed on inner box 125 behind cooling device 107 for providing further effect. Moreover, when heat transfer promoting member 140 is formed by an aluminum plate having a larger thickness than the thickness of the aluminum foil, or material having higher heat conductivity (such as copper) than the heat conductivity of aluminum, the heat transfer promotion effect further increases.

[0035] Cold air supply fan 116 is disposed in the vicinity of cooling device 107 (such as in an upper space) for supplying cold air generated by cooling device 107 toward the respective storage compartments of cold storage compartment 102, ice-making compartment 104, upper freezing compartment 103, lower freezing compartment 105, and vegetable compartment 106 by forced convention cooling. Glass-tube heater 132 is disposed below cooling device 107 as a defrosting heater for removing frost adhering to cooling device 107 and cold air supply fan 116 during cooling. Heater cover 133 for covering glass-tube heater 132 is disposed above glass-tube heater 132. Heater cover 133 has a dimension equivalent to or larger than the diameter of the glass-tube, and equivalent to or larger than the lateral length of the glass-tube so as to avoid generation of abnormal noise which is generated when drops of water falling from cooling device 107 during defrosting directly drop on the surface of the high-temperature glass-tube of glass-tube heater 132.

[0036] Drain pan 134 disposed below glass-tube heater 132 is a portion integrally formed with an upper surface of fourth partitioning portion 113 as a freezing compartment lower surface which receives defrosted water falling as melted frost after adhesion to cooling device 107.

[0037] Protrusion 136 is provided on drain pan 134 formed integrally with the upper surface of fourth partitioning portion 113. Protrusion 136 protrudes from the freezing compartment lower surface toward the inside of the refrigerator to catch and fix the lower part of cooling device cover 120. Protrusion 136 is disposed between a lower end of cold air return port 135 and glass-tube heater 132. In this arrangement, red heat into the refrigerator becomes invisible. Moreover, protrusion 136 lies behind the lower end of the cold air return port of cooling device cover 120 as viewed from the inside of the refrigerator, so that the appearance is good and the external appearance is improved.

[0038] In recent years, refrigerant used in a freezing cycle is isobutane as combustible refrigerant having a small global warming potential in view of protection of the global environment. Isobutane as hydrocarbon has a specific gravity approximately twice larger than that of air at the normal temperature and under the atmospheric pressure (2.04 under 300K). Accordingly, the refrigerant filling amount decreases in comparison with the conventional freezing cycle, and cost reduction is achievable. Moreover, in case of leakage of combustible refrigerant, the leakage amount becomes smaller, and safety further increases.

[0039] According to this exemplary embodiment, isobutane is used as the refrigerant, and the maximum temperature of the glass-tube surface as an outer case of glass-tube heater 132 during defrosting is regulated for the purpose of explosion proof. Accordingly, a double-layered glass-tube heater having a double-layered glass-tube is adopted for reducing the temperature of the glass-tube surface of glass-tube heater 132. Alternatively, a component having high radiation capability (such as aluminum fin) may be wound around the glass-tube surface as means for reducing the temperature of the glass-tube surface. In this case, the glass-tube may be constituted by a single-layer pipe for reduction of the external dimensions of glass-tube heater 132.

[0040] A pipe heater in tight contact with cooling device 107 may be used as means for increasing efficiency during defrosting together with glass-tube heater 132. In this case, cooling device 107 is efficiently defrosted by utilizing direct heat transfer from the pipe heater. Simultaneously, frost adhering to drain pan 134 and cold air supply fan 116 around cooling device 107 is melted by glass-tube heater 132. This configuration decreases the defrosting time, thereby enhancing energy saving and reducing an inside temperature rise produced during the defrosting time.

[0041] When glass-tube heater 132 and the pipe heater are combined, capacity reduction of glass-tube heater 132 is achievable by appropriately setting the heater capacities of glass-tube heater 132 and the pipe heater. When the heater capacity decreases, the temperature of the outer case of glass-tube heater 132 during defrosting lowers accordingly. As a result, red heat during defrosting can decrease.

[0042] Cooling of the refrigerator is now described. Cooling starts with actuation of compressor 117 when the inside temperature of lower freezing compartment 105 increases to a start temperature of a freezing compartment sensor (not shown) or higher as a result of entrance of heat from the outside air or opening and closing of the doors. High-temperature and high-pressure refrigerant delivered from compressor 117 is cooled and liquefied particularly within the radiation pipe (not shown) disposed in outer box 124 by heat exchange with the air outside outer box 124 and rigid urethane foam 126 within the refrigerator in the course for finally reaching the dryer (not shown) disposed in machine compartment 119.

[0043] Then, the pressure of the liquefied refrigerant is reduced by capillary tube 118, and the resultant refrigerant is introduced into cooling device 107 for heat exchange with inside cold air around cooling device 107. The cold air after heat exchange is supplied into the refrigerator by cold air supply fan 116 disposed in the vicinity of the cold air to cool the inside of the refrigerator. Thereafter, the refrigerant is heated and gasified, and returns to compressor 117. When the inside of the refrigerator is cooled to such a level that the temperature of the freezing compartment sensor (not shown) becomes a stop temperature or lower, the operation of compressor 117 stops.

[0044] Cold air supply fan 116 may be directly disposed on inner box 125, or may be disposed on second partitioning portion 111 assembled after foaming for manufacturing by component block machining for the purpose of reducing the manufacturing cost. A diffuser (not shown) constituted by front cover 137 is disposed in front of cold air supply fan 116 so that air with a high static pressure from cold air supply fan 116 can be delivered into the refrigerator without losses.

[0045] An action and an operation of the refrigerator thus constructed are hereinafter described.

[0046] A layout of a refrigerator which positions vegetable compartment 106 in the lower part, lower freezing compartment 105 in the middle part, and cold storage compartment 102 in the upper part, similarly to this exemplary embodiment, is often used in view of usability and energy saving. In addition, refrigerators of a type which increases the volume by enlarging the inside case dimensions of lower freezing compartment 105 have been available on the market in view of the inside volume and with the tendency of more frequent use of frozen foods.

[0047] According to an air flow configuration of this type of structure, cold air generated by cooling device 107 is initially supplied by cold air supply fan 116 in the vicinity of the cooling device toward cold storage compartment 102, upper freezing compartment 103, and lower freezing compartment 105. Cold air supplied via cooling device cover 120 circulates in upper freezing compartment 103 and lower freezing compartment 105, and returns through cold air return port 135 formed in the lower part of cooling device cover 120 toward cooler compartment 123. On the other hand, cold air supplied toward cold storage compartment 102 is controlled in accordance with opening and closing of the damper (not shown) so as to equalize the temperature of cold air with the inside temperature. After passing through the damper, the cold air is supplied to cold storage compartment 102, and circulates in cold storage compartment 102. Then, the cold air after circulation flows through cold storage compartment return duct 129 extending through the side of the cooling device, and returns to cooler compartment 123.

[0048] Vegetable compartment 106 receives a part of cold air supplied to cold storage compartment 102. The separated part of cold air flows through a vegetable compartment delivery duct (not shown) extending through the side of cooling device 107, and enters vegetable compartment 106. The cold air circulates in vegetable compartment 106 for cooling, and returns to cooler compartment 123. According to this exemplary embodiment, a part of cold air supplied for cooling cold storage compartment 102 is separated as a part for cooling vegetable compartment 106. However, vegetable compartment 106 may be individually cooled by using an exclusively used damper for vegetable compartment cooling.

[0049] In general, a cooler compartment is disposed behind a freezing compartment, so that a duct is required to return cold air from a cold storage compartment disposed on the upper side toward the cooler compartment. The duct is an ineffectual space, and therefore is generally disposed on the cooler compartment side for preventing decrease in the inner volume. In this case, however, cold storage compartment return cold air 127 having a high humidity enters from the side of cooling device 107, so that equalization of frosting is difficult. Accordingly, a problem of uneven frosting on cooling device 107 is arising.

[0050] Under these circumstances, cooling device 107 according to this exemplary embodiment is of a typical fin and tube type similarly to cooling device 107 generally adopted, as cooling device 107 where refrigerant pipes 145 equipped with fins 146 are vertically stacked. Cooling device 107 includes 30 refrigerant pipes 145 disposed in 10 steps substantially in the up-down direction, and in 3 lines in the front-rear direction. According to this exemplary embodiment, the lateral length of refrigerant pipes 145 of cooling device 107 in the lower part is smaller than the lateral length of refrigerant pipes 145 in the upper part. The lateral length of refrigerant pipes 145 in this context refers to a dimension of refrigerant pipes 145 in the left-right direction as viewed from the front of the refrigerator, i.e., a length of refrigerant pipes 145.

[0051] In general, a large amount of frost adhering to cooling device 107 gathers on a flow inlet through which return cold air enters cooling device 107 from the inside of the refrigerator. Particularly, frost easily adheres to a portion through which cold storage compartment return cold air 127 enters cooling device 107 from cold storage compartment 102 having a high humidity via cold storage compartment return duct 129. According to this exemplary embodiment, since the lateral length of the lower portion of refrigerant pipes 145 is smaller than the lateral length of the upper portion of refrigerant pipes 145, flow path blocking caused by adhesion and growth of frost is prevented. Accordingly, slow cooling caused by flow path blocking resulting from growth of frost does not easily occur even under overload conditions produced by entrance of moisture into the refrigerator at the time of opening and closing of the doors, for example, under high-temperature and high-humidity conditions such as in the summer season, wherefore an advantage of quality improvement of the product is offered.

[0052] Moreover, the lateral length of refrigerant pipes 145 in the inlet portion from cold storage compartment return duct 129 into cooling device 107 is shortened, and thus flow path losses (ventilation resistance) produced by enlargement of the space of the inlet portion decreases. Accordingly, circulation air amount increases by the decrease in ventilation resistance of return cold air, and the heat exchange amount rose at cooling device 107 increases the evaporating temperature. As a result, the operation efficiency of the freezing cycle improves and thus energy saving is achievable. In addition, based on the elimination of refrigerant pipes 145 at the inlet portion of cold storage compartment return cold air 127 into cooling device 107, and increase in the circulation air amount, a wider range of cold storage compartment return cold air 127 can exchange heat with cooling device 107. In general, capability of a cooling device Q is expressed as $Q = K * A * \Delta T$. In this equation, K is a coefficient of overall heat transfer, A is a heat transfer area, and ΔT is a temperature difference between the cooling device and passing air. Accordingly, cold storage compartment return cold air 127 having a relatively large temperature difference from the cooling device in the refrigerator can increase heat exchange efficiency of cooling device 107, thereby enhancing energy saving. In addition, as the heat exchange area enlarges, the dehumidification area, i.e., the area of cooling device 107 for frosting increases. Accordingly, deterioration of the cooling capability during frosting decreases. As a result, the period from the start of operation of the refrigerator to the time requiring defrosting can be prolonged. In this case, both the number of times of input of glass-tube heater 132, and input required for cooling the inside of the refrigerator after increase in the inside temperature as a result of defrosting can decrease, and thus further energy saving is achievable.

[0053] Furthermore, reductions of the number of times of input of glass-tube heater 132 and input time of glass-tube heater 132 during defrosting prevent temperature increase by reduction of non-cooling operation time, and temperature increase caused by heat generation from the glass-tube heater. These situations also have effect on foods stored within the refrigerator. Frozen foods stored in the refrigerator deteriorate by the influence of chilblain and fluctuations of heat caused by temperature increase and heat transfer from the temperature of the glass-tube heater during non-cooling operation of defrosting, and entrance of warm air into the refrigerator during defrosting, for example. According to this exemplary embodiment, however, deterioration of foods is prevented even in the case of long-term storage.

[0054] Moreover, during cooling operation of a refrigerator, frost generated from moisture in the air having entered during opening and closing of doors, moisture adhering to foods put into the refrigerator, and moisture from vegetables stored in vegetable compartment 106, for example, adheres to cooling deice 107 with an elapse of time. When the frost grows, heat exchange efficiency between cooling device 107 and circulating cold air lowers to a level insufficient for cooling the inside of the refrigerator, causing slow cooling or no cooling in the final stage. Accordingly, periodical defrosting of the refrigerator is needed to remove frost adhering to cooling device 107.

[0055] According to the refrigerator in this exemplary embodiment, defrosting is automatically executed in a similar manner after an elapse of a certain period from the start of operation of the refrigerator. During defrosting, operations of compressor 117 and cold air supply fan 116 are stopped, and glass-tube heater 132 corresponding to a defrosting heater is energized. The temperature of cooling device 107 increases in accordance with melting of frost which adheres to refrigerant staying inside cooling device 107 or adheres to cooling device 107 while generally undergoing 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 a higher temperature. A defrosting sensor (not shown) is provided on cooling device 107 to stop energization of glass-tube heater 132 when the temperature of cooling device 107 reaches a predetermined temperature. According to this exemplary embodiment, energization of glass-tube heater 132 is stopped when the defrosting sensor detects 10°C.

[0056] In this step, energization of glass-tube heater 132 makes the temperature of the glass-tube surface high, whereby radiation heat thus produced melts frost adhering to cooling device 107, drain pan 134, and cold air supply fan 116 around cooling device 107 in the surroundings of the cooling device, so as to refresh cooling device 107.

[0057] In the condition of low-temperature outside air such as at an outside temperature of approximately 5°C or lower, the temperature of the defrosting sensor (not shown) does not sufficiently increase during defrosting due to the effect of the outside air even after sufficient removal of frost on cooling device 107, and the defrosting time tends to increase. In this case, control for ending defrosting after an elapse of a certain period or longer may be combined depending on the condition of the sensible heat change from 0°C to a higher temperature. This control prevents temperature increase caused by unnecessary heater input or radiation heat into the refrigerator, and temperature increase caused by cooling stop during defrosting, the temperature increases occurring when the defrosting time becomes longer due to insufficient temperature increase of cooling device 107 under the condition of the low-temperature outside air even after sufficient defrosting.

[0058] Similarly, the cooling capability of cooling device 107 according to this exemplary embodiment gradually lowers by the effect of frost accumulating between respective executions of defrosting. For overcoming this drawback, fins 146 are thinned out in an area above refrigerant pipes 145 having the reduced lateral length and disposed at the inlet portion for cold air entering from cold storage compartment return duct 129 into cooling device 107, i.e., a portion to which frost easily adheres. This configuration not only lowers the ventilation resistance of return cold air to increase the circulation air amount, but also reduces closure of the flow path caused by frost during frosting to prevent performance deterioration during frosting and improve the frosting resistance performance.

[0059] Moreover, thinning of fins 146 in the flow direction of cold air further lowers the ventilation resistance and increases the circulation air amount, and also reduces closure of the flow path caused by frosting and offers an advantage of further preventing performance deterioration during frosting.

[0060] Fins 146 of cooling device 107 according to this exemplary embodiment are separate fins on vertically stacked refrigerant pipes 145. In this case, since the number of fins increases, a step for attaching the fins is needed during the manufacturing step of cooling device 107. For overcoming this problem, fins formed into one piece body in the up-down direction may be adopted. This configuration reduces the number of fins attached to the cooling device, and improves productivity by reduction of man-hour. Accordingly, cost reduction is achievable.

[0061] Refrigerant pipes 145 of cooling device 107 according to this exemplary embodiment are of a type called bear pipes having unprocessed inner sides. Accordingly, grooved pipes may be used, for example, so as to increase heat conductivity inside the pipes. The grooved pipes are pipes in which straight grooves or spiral grooves are formed, for example. When the grooved pipes are used, the performance of the cooling device improves, whereby energy saving is further enhanced.

[0062] According to this exemplary embodiment, refrigerant pipes 145 of cooling device 107 are made of an aluminum material. Refrigerant pipes 145 are often made of aluminum in view of cost reduction demanded as a result of a recent rise of material cost. However, copper may be used as material of refrigerant pipes 145. This alternative configuration improves heat conductivity, thereby increasing heat exchange efficiency between the inside and outside of refrigerant pipes 145. Accordingly, energy saving is further enhanced.

[0063] Cold storage compartment return duct opening upper end 143 is disposed above cooling device lower end 144 of cooling device 107 at an opening of cold storage compartment return duct 129 formed on the side of cooling device 107 for entrance into cooling device 107. This configuration enlarges the opening of cold storage compartment return duct 129, thereby reducing flow path losses at the entrance into cooling device 107. Accordingly, cooling performance mainly for cold storage compartment 102 improves as a result of increase in the circulation air amount, and energy saving is enhanced as a result of increase in the heat exchange efficiency. In addition, positioning of cold storage compartment return duct opening upper end 143 above cooling device lower end 144 allows easy introduction of cold storage compartment return cold air 127 into cooling device 107. Furthermore, a part of the side of cooling device 107 is utilized as a flow path. This configuration reduces ineffectual spaces, and secures a sufficient inside volume.

[0064] Cooling device cover 120 includes freezing compartment cold air return port 135 disposed in the lower part of cooling device cover 120. Since freezing compartment cold air return port upper end 139 is disposed above cooling device lower end 144, return cold air having circulated inside the refrigerator has a large heat exchange area for heat exchange with cooling device 107. Accordingly, the heat exchange amount provided by cooling device 107 increases, whereby the capability of cooling device 107 improves.

[0065] Improvement of the heat exchange amount of cooling device 107 and increase in the circulation air amount can decrease the time for cooling the inside of the refrigerator. In this case, the amount of frosting on the cooling device decreases by reduction of the cooling operation time. Accordingly, the defrosting cycle of the cooling device increases, and both the number of times of input of glass-tube heater 132, and input required for cooling the inside of the refrigerator after temperature increase inside the refrigerator caused by defrosting decrease. As a result, energy saving is further enhanced.

[0066] When the heat exchange area of cooling device 107 increases based on improvement of the flow path, the area of cooling device 107 to which frost adheres enlarges accordingly. In this case, deterioration of the cooling capability during frosting is avoidable. As a result, the period from the start of operation of the refrigerator to the time requiring defrosting can be prolonged. In this case, both the number of times of input of glass-tube heater 132, and input required for cooling the inside of the refrigerator after increase in the inside temperature as a result of defrosting can decrease, and thus further energy saving is achievable.

[0067] Air direction guiding members 122 are provided at cold air return port 135. Air direction guiding members 122 are formed at intervals of 5 mm, aiming at prevention of insertion of fingers, and securing strengths of a metal mold and cooling device cover 120. Air direction guiding members 122 are similarly angled upward from the inside of the refrigerator toward the cooling device.

[0068] The upward inclination of air direction guiding members 122 not only lowers the ventilation resistance of a blow-in flow path for return cold air, but also equalizes flow. Accordingly, the cooling efficiency improves, and energy saving is further enhanced.

[0069] According to this exemplary embodiment, the center of glass-tube heater 132 is disposed above fourth partitioning portion 113 constituting a freezing compartment bottom base surface. This configuration makes the shape of drain pan 134 formed integrally with the freezing compartment bottom base surface substantially horizontal, thereby reducing the ineffectual space occupied by glass-tube heater 132. Accordingly, the inner volume increases. In addition, when the depth of drain pan 134 is small as in this configuration, the metal mold cost required in molding constituent components lowers. Accordingly, cost reduction is achievable.

[0070] According to this exemplary embodiment, fourth partitioning portion 113 constituting the freezing compartment base surface is a separate part. Forming only fourth partitioning portion 113 in a sub step, and inserting and assembling fourth partitioning portion 113 into the inner box in a post process as adopted in this exemplary embodiment is a method capable of achieving sharing of work processes and increasing production efficiency. Rather than adopting this constitution, a configuration which forms fourth partitioning portion 113 from the inner box may be employed. In this case, such a method may be used which extends an ABS sheet corresponding to the material of inner box 125 by a forming machine, and forms an integrally molded component including inner box 125 and the partitioning portion. This method is often used when inner box 125 has a small depth. However, this method is also applicable to production of a refrigerator having a large depth for the purpose of thickness equalization achievable by extension of a sheet. When this method is employed, material cost, job labor, management cost, transportation cost, and others for producing the partitioning portions decrease, wherefore considerable cost reduction is achievable. In addition, production efficiency improves, whereby the overall product cost lowers.

[0071] As described above, a refrigerator according to the present invention includes: a freezing compartment sectioned by a heat insulating wall; a cold storage compartment disposed above the freezing compartment; a cooler compartment disposed behind the freezing compartment; and a cooling device disposed in the cooler compartment, and including vertically stacked refrigerant pipes equipped with fins. The refrigerator further includes a cooling device cover that covers a front face of the cooling device, and a cold storage compartment return duct disposed on a side of the cooling device, and configured to guide cold air from the cold storage compartment to the cooler compartment. The lateral length of a lower part of the refrigerant pipes of the cooling device is shorter than the lateral length of an upper part of the refrigerant pipes.

[0072] According to this configuration, flow path pressure losses (ventilation resistance) decreases by enlargement of a space of an inlet portion through which return cold air enters the cooling device from the inside of the refrigerator. Accordingly, the circulation air amount increases by reduction of the ventilation resistance of the return cold air, and the heat exchange amount rose at cooling device increases the evaporating temperature. As a result, the operation efficiency of the freezing cycle improves and thus energy saving is achievable.

[0073] In addition, increase in the circulation air amount raises the heat exchange amount by the cooling device, thereby reducing the time for cooling the inside of the refrigerator. Accordingly, the amount of frosting on the cooling device decreases in accordance with reduction of the cooling operation time. In this case, the defrosting cycle of the cooling device can be prolonged, and therefore both the number of times of input of the defrosting heater, and input required for cooling the inside of the refrigerator after increase in the inside temperature as a result of defrosting can decrease. Accordingly, further energy saving is achievable.

[0074] In general, a large amount of frost adhering to the cooling device gathers in a flow inlet through which return cold air enters the cooling device from the inside of the refrigerator. According to the present invention, the lateral length of the lower portion of the refrigerant pipes of the cooling device is shortened, and thus closure caused by frost is difficult to occur even under the conditions of the summer seasons where high humidity and frequent opening and closing of doors allow easy adhesion of frost to the refrigerant pipes and the fins. Accordingly, equalization of the frosting portions of the cooling device is achievable through dispersion of the frosting portions.

[0075] According to the present invention, a short-lateral length portion of the refrigerant pipes may correspond to an inlet portion through which cold air from the cold storage compartment return duct enters the cooling device.

[0076] Frosting occurs by initial heat exchange with the refrigerant pipe disposed at the entrance of the inlet portion of the cooling device through which return cold air enters, and by subsequent dehumidification. In this case, frost particularly adheres to the portion through which cold storage compartment return cold air enters from the cold storage compartment having a high humidity through the cold storage compartment return duct. According to the present invention, since the refrigerant pipe is shortened at the position through which cold storage compartment return cold air enters, flow path blocking caused by adhesion and growth of frost is avoidable. Accordingly, slow cooling caused by flow path blocking resulting from growth of frost does not occur even under overload conditions produced by entrance of moisture into the refrigerator at the time of opening and closing of the doors, for example, under high-temperature and high-humidity conditions such as in the summer season.

[0077] In addition, since the refrigerant pipe at the inlet portion from the cold storage compartment return duct into the cooling device is shortened, flow path pressure losses (ventilation resistance) decrease by enlargement of the space of the inlet portion. Accordingly, the circulation air amount increases by the decrease in ventilation resistance of return cold air, and the heat exchange amount raised thereby at the cooling device increases the evaporating temperature. As a result, the operation efficiency of the freezing cycle improves and thus energy saving is achievable.

[0078] In addition, based on the elimination of refrigerant pipes at the inlet portion through which cold storage compartment return cold air enters the cooling device, and increase in the circulation air amount, a wider range of cold storage compartment return cold air can exchange heat with the cooling device. Accordingly, cold storage compartment return cold air having a relatively large temperature difference from the cooling device in the refrigerator can increase heat exchange efficiency of the cooling device, thereby enhancing energy saving. In addition, as the heat exchange area enlarges, the dehumidification area, i.e., the area of the cooling device for frosting increases. Accordingly, deterioration of the cooling capability during frosting decreases. As a result, the period from the start of operation of the refrigerator to the time for requiring defrosting can be prolonged. In this case, both the number of times of input of the defrosting heater, and input required for cooling the inside of the refrigerator after increase in the inside temperature as a result of defrosting can decrease, and thus further energy saving is achievable.

[0079] According to the present invention, the fins of the refrigerant pipes may be thinned out above the short-lateral length portion of the refrigerant pipes.

[0080] The cooling device includes the vertically stacked refrigerant pipes equipped with the fins. In this case, the downstream part of the return cold air does not exchange heat when the flow path is closed by frost on the upstream side. As a result, cooling efficiency losses are produced. According to the present invention, however, the fins are thinned out to increase the circulation air amount by reduction of the ventilation resistance of return cold air, and also to avoid performance deterioration during frosting by reduction of closure of the flow path caused by frost during frosting. Accordingly, frosting resistance performance of the cooling device improves.

[0081] According to the present invention, an upper end of an opening of the cold storage compartment return duct may be disposed above a lower end of the cooling device.

[0082] This configuration enlarges the opening of the cold storage compartment return duct, thereby further reducing flow path losses at the entrance into cooling device. Accordingly, cooling performance mainly for the cold storage compartment improves as a result of increase in the circulation air amount, and energy saving is enhanced as a result of increase in the heat exchange efficiency. In addition, positioning of the upper end of the cold storage compartment return duct opening above the lower end of the cooling device allows easy introduction of cold storage compartment return cold air into the cooling device. Furthermore, a part of the side of the cooling device is utilized as a flow path. Accordingly, this configuration reduces ineffectual spaces, and secures a sufficient inside volume.

[0083] According to the present invention, a freezing compartment cold air return port through which cold air from the freezing compartment returns to the cooler compartment may be provided in a lower part of the cooling device cover, and an upper end of the freezing compartment cold air return port may be disposed above a lower end of the cooling device.

[0084] This configuration enlarges the area of return cold air for heat exchange with the cooling device. In addition, the circulation air amount increases by reduction of the ventilation resistance of return cold air, and the heat exchange amount raised thereby at the cooling device increases the evaporating temperature. As a result, the operation efficiency of the freezing cycle improves and thus energy saving is achievable.

[0085] Moreover, increase in the heat exchange amount by the cooling device and the increase in the circulation air amount can decrease the time for cooling the inside of the refrigerator. In this case, the amount of frosting on the cooling device decreases with reduction of the cooling operation time. Accordingly, the defrosting cycle of the cooling device can be prolonged, and both the number of times of input of the defrosting heater, and input required for cooling the inside of the refrigerator after increase in the inside temperature as a result of defrosting can decrease. As a result, further energy saving is achievable.

[0086] When the heat exchange area of the cooling device enlarges by improvement of the flow path, the frosting area of the cooling device increases. Accordingly, deterioration of the cooling capability during frosting is avoidable. As a result, the period from the start of operation of the refrigerator to the time for requiring defrosting can be prolonged. In this case, both the number of times of input of the defrosting heater, and input required for cooling the inside of the refrigerator after increase in the inside temperature as a result of defrosting can decrease, and thus further energy saving is achievable.

[0087] According to the present invention, the fins of the refrigerant pipes may be thinned out on the left and right sides of the flow direction of cold air from the cold storage compartment return duct toward the cooling device.

[0088] Thinning the fins in the flow direction of cold air can further decrease the ventilation resistance of return cold air and increases the circulation air amount. Moreover, flow path blocking by frost during frosting is reduced particularly for return cold air from the cold storage compartment and the vegetable compartment and thus having a high humidity, and further prevention of performance deterioration during frosting is achievable. Accordingly, the frosting resistance performance further improves. Improvement of the frosting resistance performance requires equalization of frosting on the cooling device. Assuming that the amount of moisture contained in circulating cold air is uniform per unit time, flow path blocking by frosting can be delayed by equalization of frosting on the cooling device. In addition, the thickness of frost becomes substantially uniform, and thus defrosting efficiency for melting frost during defrosting improves. Accordingly, the defrosting time decreases.
[0089] According to the present invention, a defrosting glass-tube heater may be provided below the cooling device, and a center height of the glass-tube heater may be positioned above a base bottom surface of the freezing compartment.
[0090] This configuration makes the shape of a drain pan formed integrally with the base surface of the freezing compartment bottom substantially horizontal, thereby reducing the ineffectual space occupied by the defrosting heater. Accordingly, the inner volume increases. In addition, reduction of the depth of the drain pan decreases the metal mold cost required in molding constituent components.

INDUSTRIAL APPLICABILITY

[0091] Accordingly, a refrigerator according to the present invention is applicable to a household refrigerator aimed at improvement of energy saving and freezing freshness keeping performance, and enlargement of the inside volume.

REFERENCE MARKS IN THE DRAWINGS

[0092]

7	cooling device
13	heat insulating partitioning wall
14	freezing compartment
20	cooling device cover
23	cooler compartment
27, 127	cold storage compartment return cold air
28	guide plate
28a	opening
29	return duct
30	freezing compartment return cold air
31	vegetable compartment return duct
32	defrosting heater
34, 134	drain pan
47	flow path
101	refrigerator body
102	cold storage compartment
102a, 103a, 104a, 105a, 106a	door
103	upper freezing compartment
104	ice-making compartment
105	lower freezing compartment
106	vegetable compartment
107	cooling device
120	cooling device cover
123	cooler compartment
124	outer box
125	inner box
126	rigid urethane foam
129	cold storage compartment return duct
132	glass-tube heater
135	cold air return port
139	freezing compartment cold air return port upper end
143	cold storage compartment return duct opening upper end
144	cooling device lower end

145	refrigerant pipe
146	fin

Claims

1. A refrigerator comprising:

    a freezing compartment sectioned by a heat insulating wall;
    a cold storage compartment disposed above the freezing compartment;
    a cooler compartment disposed behind the freezing compartment;
    a cooling device disposed in the cooler compartment, and including vertically stacked refrigerant pipes equipped with fins;
    a cooling device cover that covers a front face of the cooling device; and
    a cold storage compartment return duct disposed on a side of the cooling device, and configured to guide cold air from the cold storage compartment to the cooler compartment,
    wherein
    a lateral length of the refrigerant pipes at a lower part of the cooling device is shorter than a lateral length of the refrigerant pipes at an upper part.

2. The refrigerator according to claim 1, wherein
the part of the refrigerant pipes having shorter lateral length is disposed in an inlet portion through which the cold air enters the cooling device from the cold storage compartment return duct.

3. The refrigerator according to claim 1 or 2, wherein
the fins are thinned out in the part of the refrigerant pipes having shorter lateral length.

4. The refrigerator according to claim 1 or 2, wherein
an upper end of an opening of the cold storage compartment return duct is disposed above a lower end of the cooling device.

5. The refrigerator according to claim 1 or 2 further comprising
a freezing compartment cold air return port disposed in a lower part of the cooling device cover, and configured to return the cold air from the freezing compartment to the cooler compartment,
wherein an upper end of the freezing compartment cold air return port is disposed above a lower end of the cooling device.

6. The refrigerator according to claim 1 or 2, wherein
the fins of the refrigerant pipes are thinned out on left and right sides of a flow direction of the cold air from the cold storage compartment return duct to the cooling device.

7. The refrigerator according to claim 1 or 2 further comprising a defrosting glass-tube heater provided below the cooling device,
wherein
a center height of the glass-tube heater is positioned above a base bottom surface of the freezing compartment.

FIG. 1

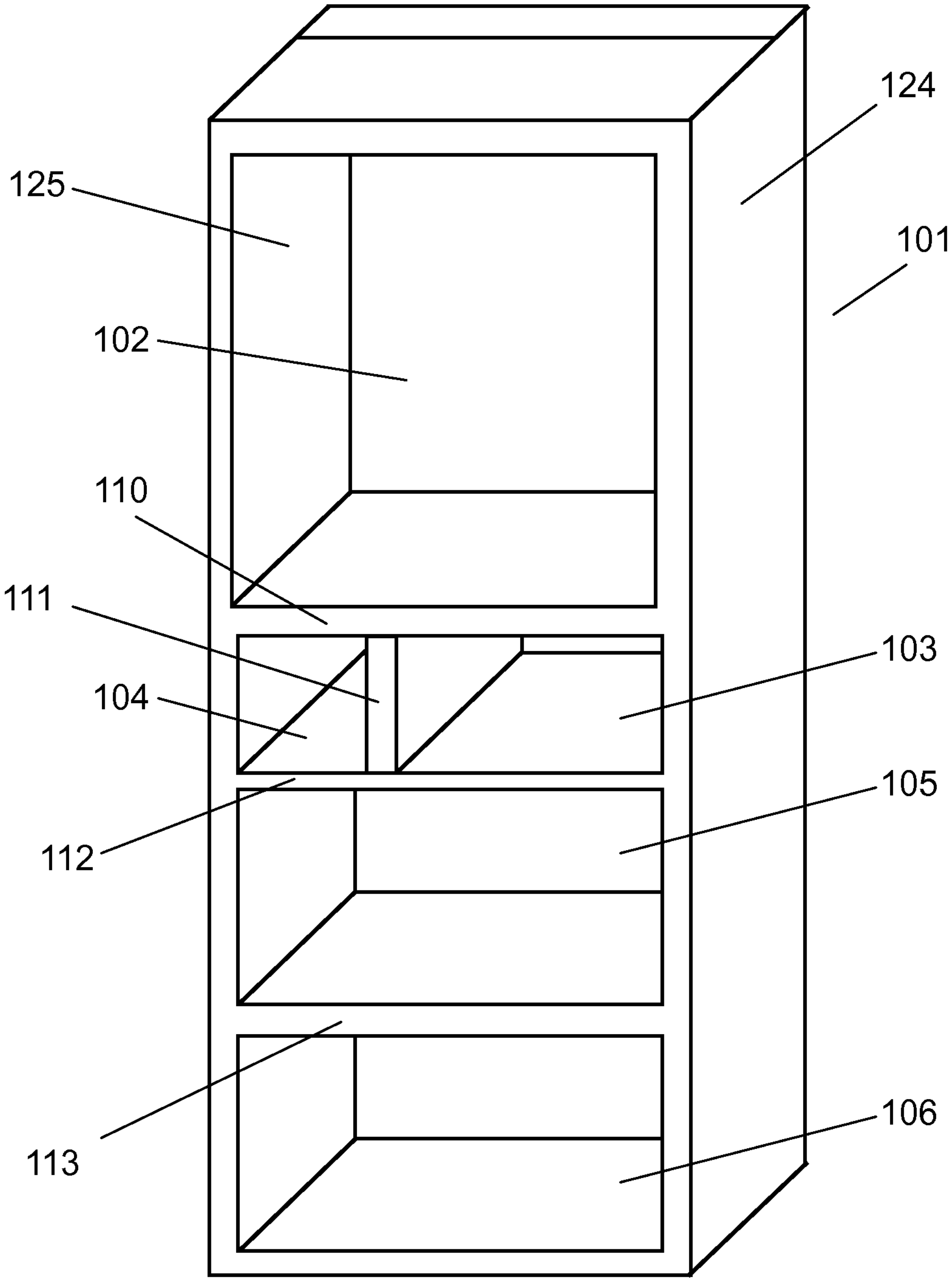

FIG. 2

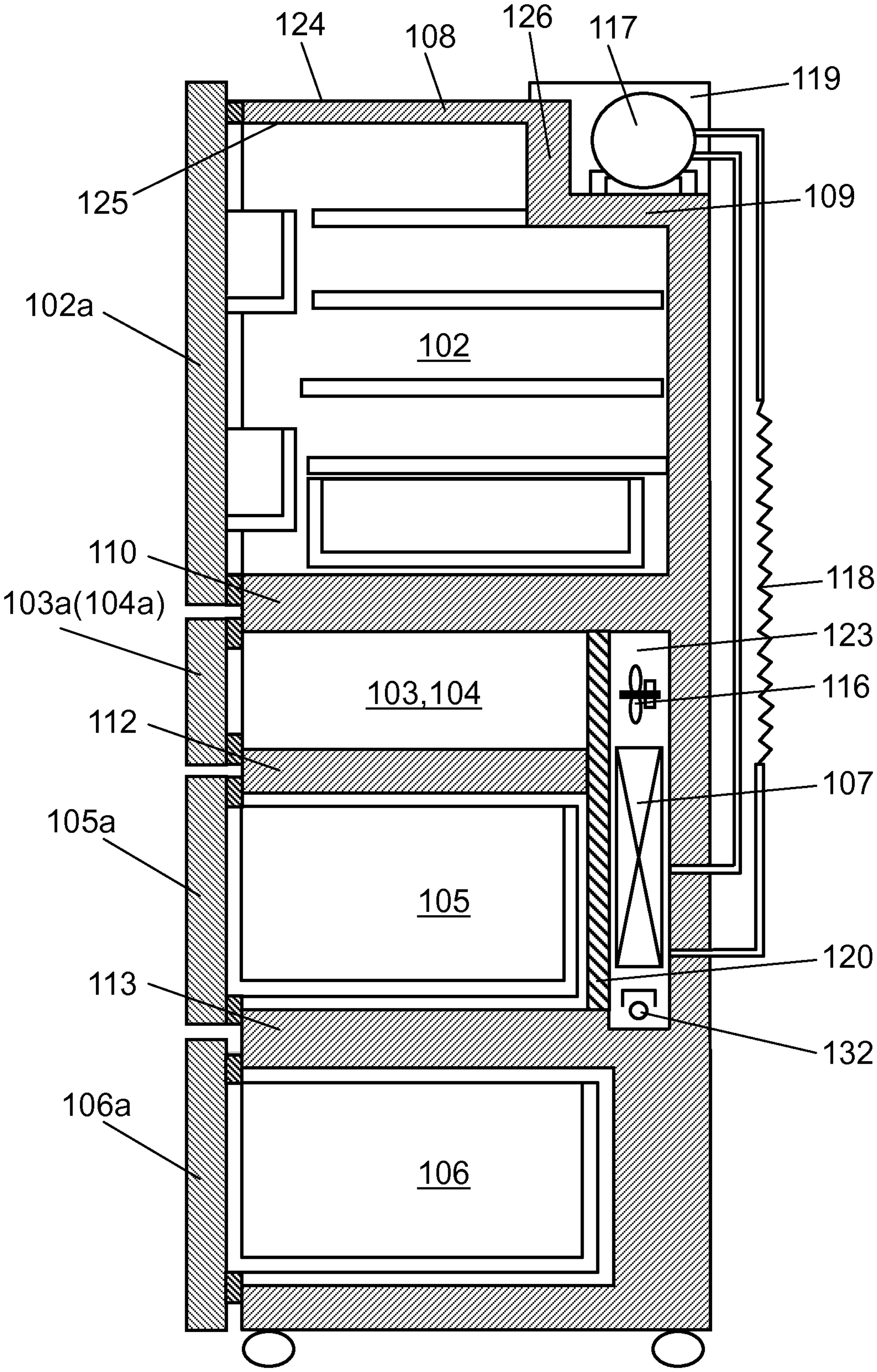
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FIG. 3

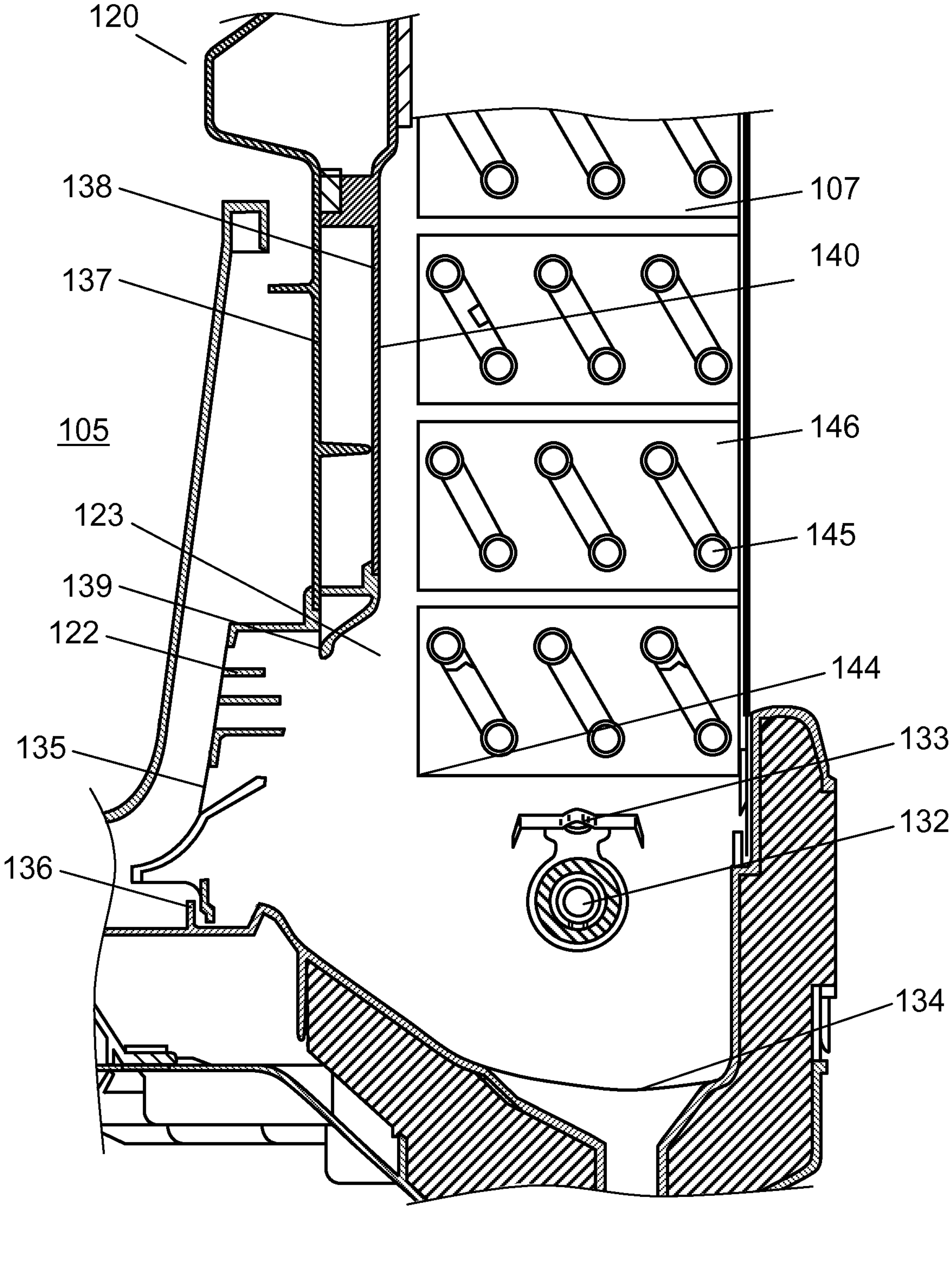
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FIG. 4

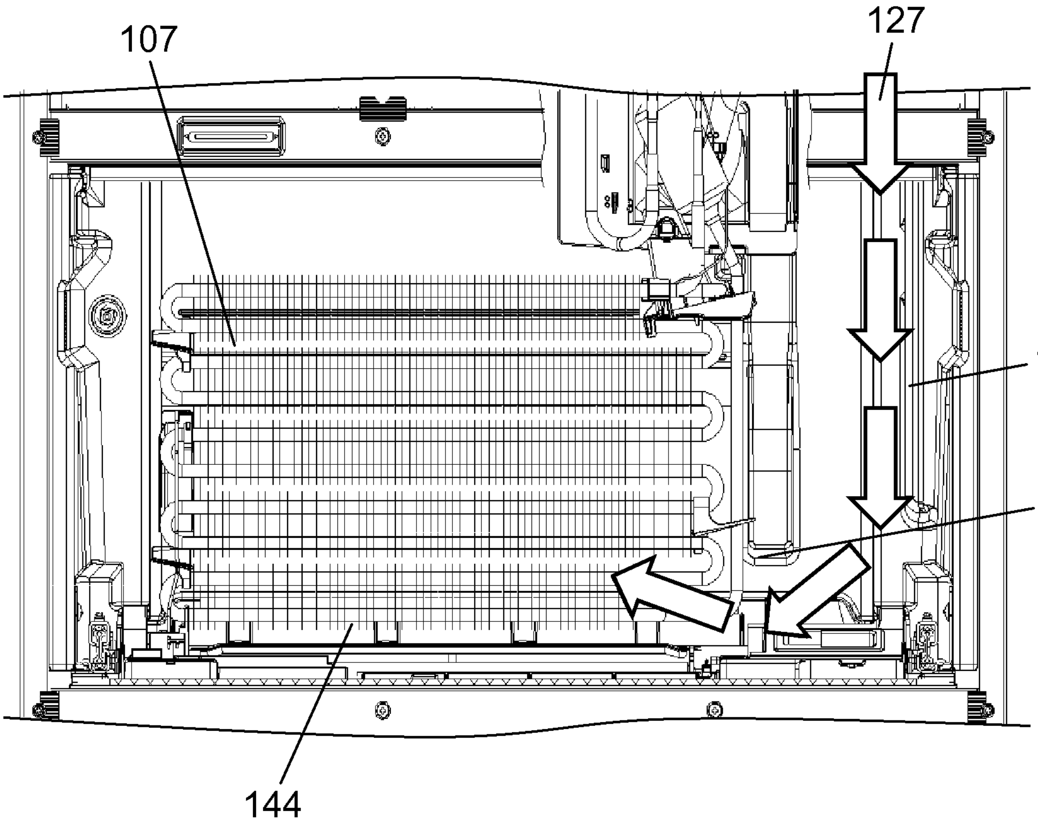


FIG. 5A

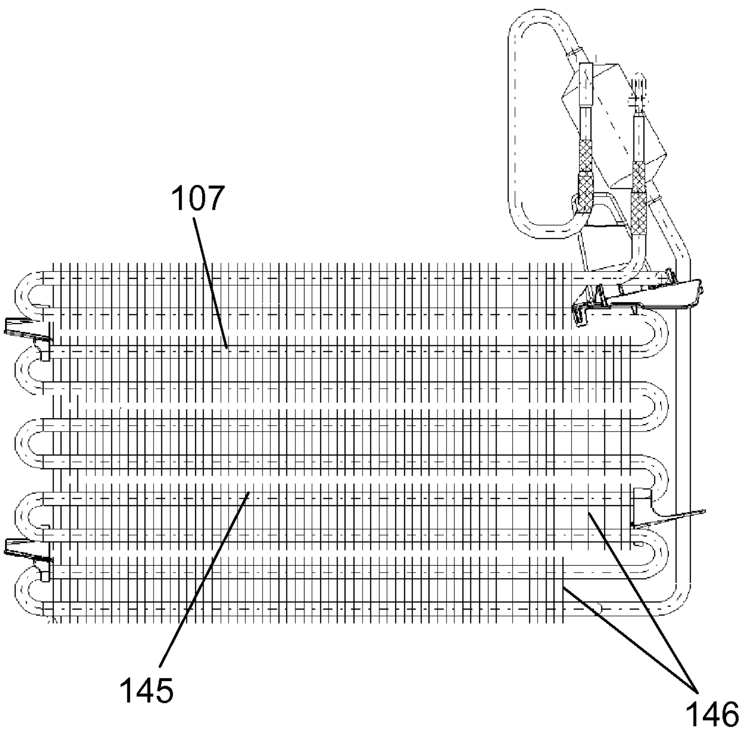


FIG. 5B

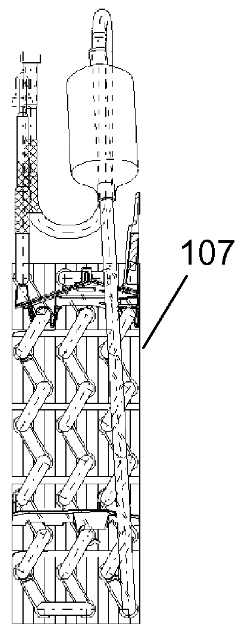


FIG. 6

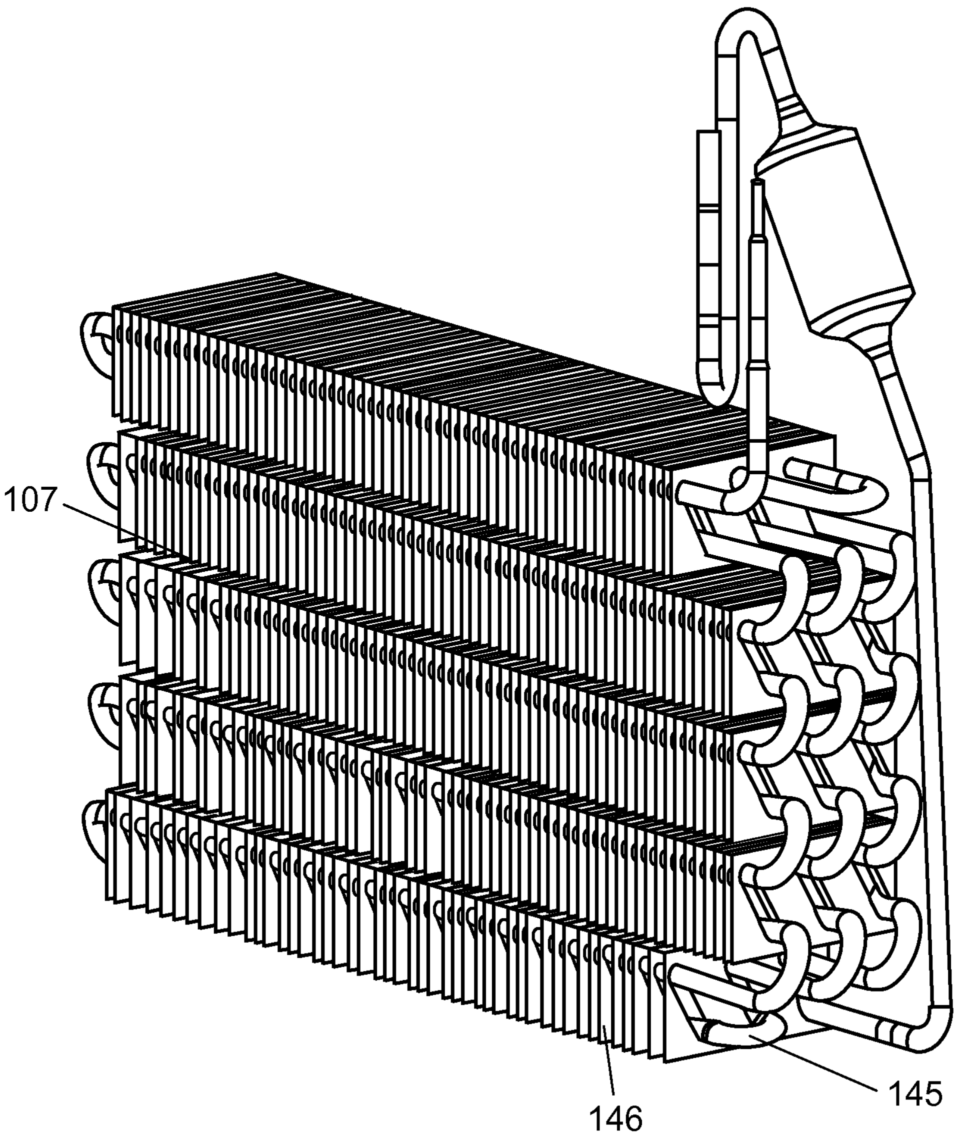


FIG. 7

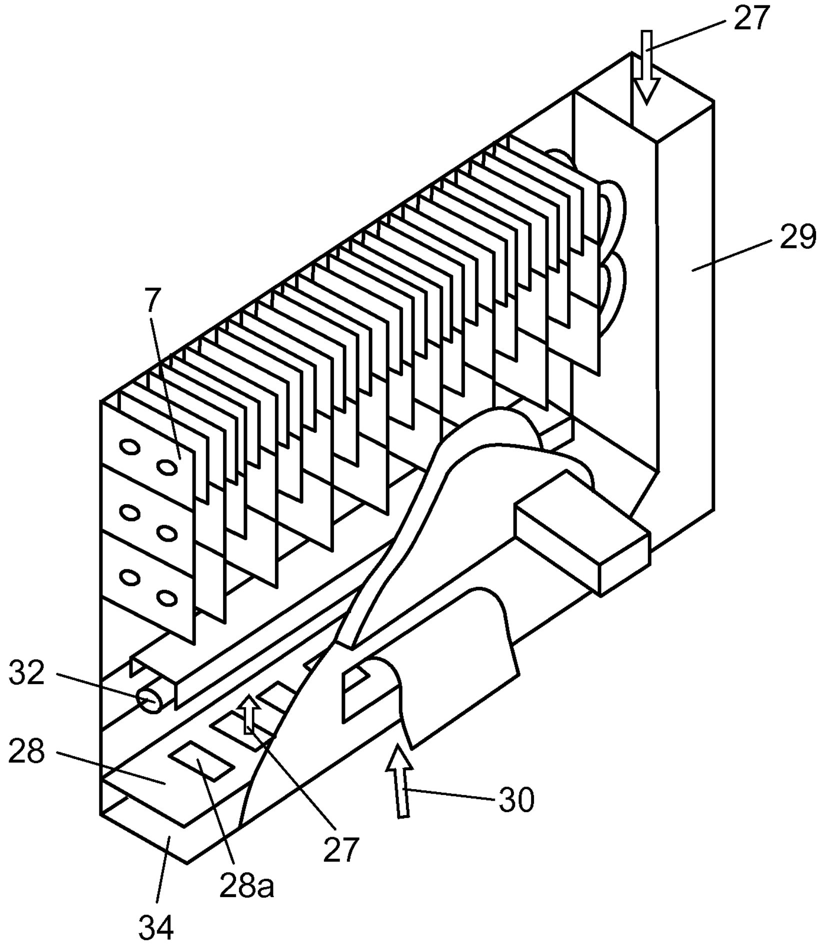


FIG. 8A

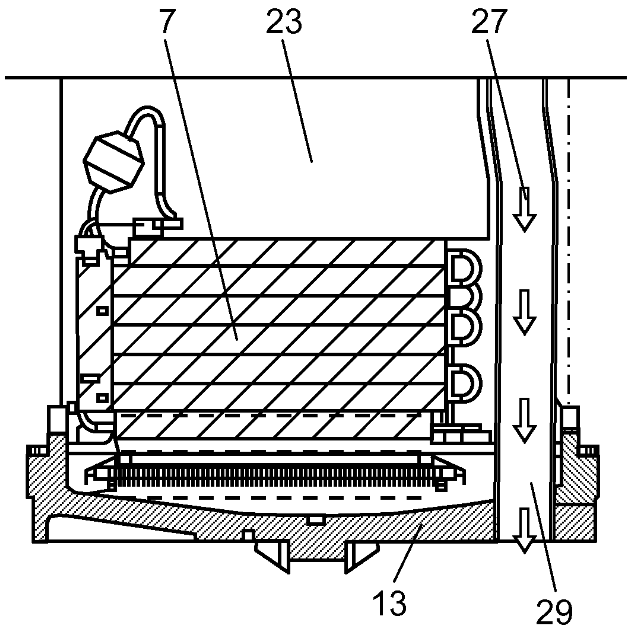


FIG. 8B

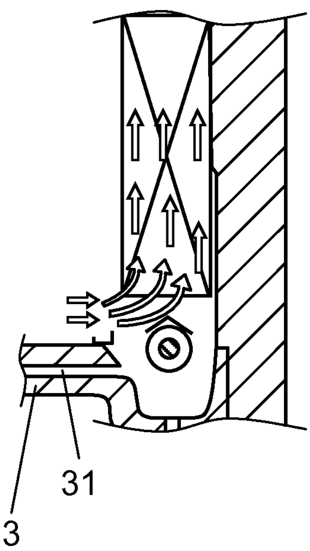
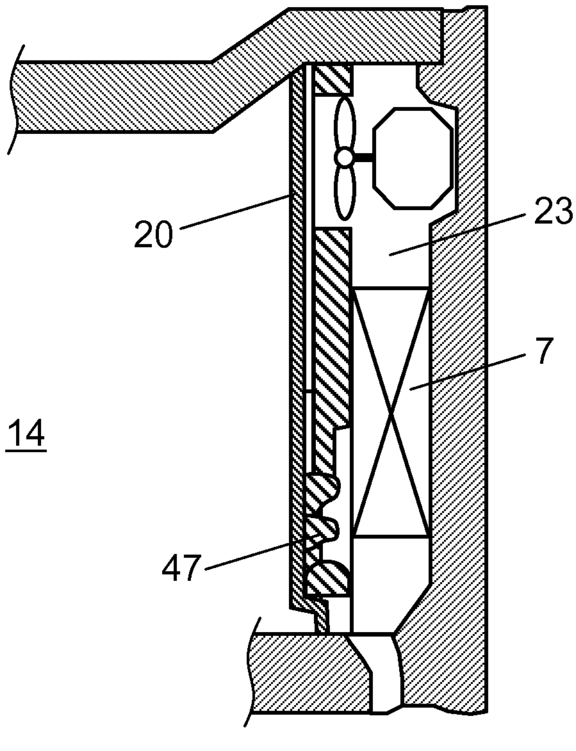


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/005525

A. CLASSIFICATION OF SUBJECT MATTER
F25D21/04(2006.01)i, *F25B39/02*(2006.01)i, *F25D17/08*(2006.01)i, *F25D21/08*(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)
F25D21/04, F25B39/02, F25D17/08, F25D21/08

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	JP 2011-208906 A (Panasonic Corp.), 20 October 2011 (20.10.2011), claims; paragraphs [0042] to [0062]; fig. 1 to 4 (Family: none)	1-7
Y	JP 2012-42192 A (Mitsubishi Electric Corp.), 01 March 2012 (01.03.2012), paragraphs [0012] to [0017]; fig. 1 to 5 (Family: none)	1-7
Y	JP 2000-205737 A (Mitsubishi Electric Corp.), 28 July 2000 (28.07.2000), claims; paragraphs [0007] to [0010], [0019] to [0022]; fig. 1 to 2, 9 to 10 (Family: none)	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 November, 2013 (14.11.13)	26 November, 2013 (26.11.13)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 2011038714 A **[0016]**
- JP H7270028 B **[0016]**