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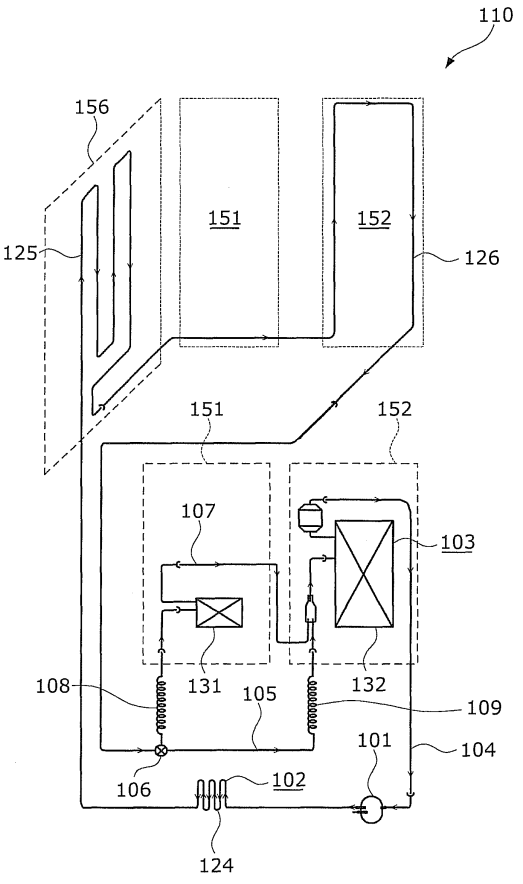
(54) REFRIGERATOR

(57) A refrigerator (100) includes: a vertically-long first body (151) which forms a refrigerator compartment; a vertically-long second body (152) which forms a freezer compartment; an outer case (156) which is made of metal and covers the first body (151) and the second body (152) that are arranged side-by-side; a compressor (101) for compressing a refrigerant; a condenser (102) for dissipating heat of the refrigerant; a first evaporator (131) disposed in a rear part of the first body (151); a second evaporator (132) connected in series with the first evaporator (131) and disposed in a rear part of the second body (152); a bypass pipe (105) which directly connects the condenser (102) and the second evaporator (132); and a switch valve (106) which selects between supplying the refrigerant from the condenser (102) to the first evaporator (131) and supplying the refrigerant from the condenser (102) directly to the second evaporator (132).

FIG. 4



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Description

Technical Field

[0001] The present invention relates to refrigerators and particularly to a cooling cycle unit included in a refrigerator and to a cooling method.

Background Art

[0002] As the capacity of refrigerators has been increasing, the cooling performance of cooling systems has also been improving. On the other hand, to cope with issues such as global warming, refrigerators also need to place consideration on environment and further need to save energy.

[0003] In principal, the improvement of cooling performance and energy saving contradict each other. Thus, achieving energy saving without sacrificing the cooling performance is a task in designing a cooling system.

[0004] For example, Patent Reference 1 describes a cooling system which includes two evaporators which is for a refrigerator compartment and a freezer compartment. The operation of the evaporator for the refrigerator compartment is completely stopped as necessary in an attempt to achieve energy saving while maintaining the cooling performance.

Patent Reference 1: Japanese Unexamined Patent Application Publication No. 2000-88428

Disclosure of Invention

Problems that Invention is to Solve

[0005] However, one of the most popular forms of refrigerators nowadays is a so-called side-by-side type refrigerator that has a refrigerator compartment and a freezer compartment arranged next to each other in a horizontal direction. The refrigerator compartment extends entirely from top to bottom in a vertical direction and, in the same manner as the refrigerator compartment, the freezer compartment extends entirely from top to bottom in a vertical direction.

[0006] In the case of refrigerators having such a form, a refrigerator compartment and a freezer compartment that extend long in a vertical direction tends to cause a temperature difference between an upper side and a lower side of the compartment to be larger. Thus, the problem in the side-by-side type refrigerator is variations in temperature that occurs inside the compartment and such variations need to be suppressed. On the other hand, the side-by-side type refrigerator also needs to save energy placing consideration on the environment.

[0007] In order to address the above-described problems, an object of the present invention is to provide a side-by-side type refrigerator in which temperature distribution inside a compartment is improved while achieving the energy saving.

Means to Solve the Problems

[0008] In order to solve the above problem, a refrigerator according to an aspect of the present invention is a refrigerator which includes a first body which is long in a vertical direction, has an opening in a front face, and forms a refrigerator compartment; a second body which is long in a vertical direction, has an opening in a front face, and forms a freezer compartment; an outer case which is made of metal and covers the first body and the second body that are arranged next to each other in a horizontal direction; and the refrigerator includes: a compressor which compresses a refrigerant; a condenser which is connected in series with the compressor and dissipates heat of the refrigerant; a first evaporator which is connected in series with the condenser and disposed in a rear part of the first body, the first evaporator being an evaporator for evaporating the refrigerant; a second evaporator which is connected in series with the first evaporator and disposed in a rear part of the second body, the second evaporator being an evaporator for evaporating the refrigerant; a pipe which directly connects the condenser and the second evaporator; and a switch valve which selects between supplying the refrigerant from the condenser to the first evaporator and supplying the refrigerant from the condenser directly to the second evaporator.

[0009] With this, it is possible to dispose the evaporator for the refrigerator compartment in a rear part of the refrigerator compartment, and the evaporator for the freezer compartment in a rear part of the freezer compartment. Thus, each of the evaporators can be operated with performance suitable to the corresponding compartment. Therefore, it is possible to cool each of the compartments with the performance that can overcome the variations in temperature in a vertical direction.

[0010] Moreover, even when the evaporator is operated to cool the refrigerator compartment that has a relatively low temperature, it is possible to stop the operation of the evaporator for the refrigerator compartment. This makes it possible to prevent wasteful consumption of energy.

[0011] Furthermore, since the evaporators are disposed in the horizontal direction, the pipe which serves as bypass which extends around the evaporator for the refrigerator compartment is short. Thus, energy loss when the bypass pipe is used is reduced, and it is possible to contribute to energy saving.

[0012] Furthermore, preferably, the condenser includes: a first condenser which provides direct heat exchange with air; and a second condenser which is disposed between the first body and the outer case, the second condenser providing heat exchange with air through the outer case.

[0013] With this, even when dust or the like is attached to the first condenser and the performance as the con-

denser is deteriorated, the second condenser can complement the performance of the first condenser. Therefore, it is possible to maintain the cooling cycle of high energy efficiency for a long period of time. Thus, it is possible to contribute to energy saving.

[0014] Moreover, in the side-by-side type refrigerator, surface area of the outer case of the refrigerator compartment side is especially large. Thus, it is possible to dispose the second condenser over a wide area and dissipates heat over a wide area. Thus, influence of heat from the second condenser to the refrigerator compartment can be reduced as much as possible. Thus, the second condenser can sufficiently complement the performance of the first condenser, and it is possible to maintain the cooling cycle of high efficiency for a long period of time.

[0015] Preferably, the condenser further includes a third condenser disposed at the opening of the second body.

[0016] It is possible to raise the temperature of the rim of the opening of the freezer compartment by heat from the condenser, reduce the temperature difference between the rim of the opening and the outside air, and prevent the generation of dew condensation. With this, the rim of the opening and a door are maintained to be in close contact with each other, preventing leakage of the cool air. Thus, it is possible to contribute to energy saving. Furthermore, a heater or the like do not have to be separately provided, and thus it is possible to achieve energy saving of a refrigerator.

[0017] The refrigerator according to the present invention allows the designing of the cooling cycle suitable to a hydrocarbon refrigerant to be easy, and allows even the hydrocarbon refrigerant to exert performance suitable to the refrigerator compartment and the freezer compartment. Thus, it is possible to easily cope with the environmental issues such as global warming.

[0018] Further, preferably, the refrigerator includes a first circulation device which cools, using the first evaporator, an air introduced from inside of the first body, and introduces the cooled air to the inside of the first body; and a second circulation device which cools, using the second evaporator, an air introduced from inside of the second body, and introduces the cooled air to the inside of the second body.

[0019] With this, even the refrigerator compartment or the freezer compartment that are long in a vertical direction can be evenly cooled with the flow of the air. Furthermore, air is separately cooled with the evaporator suitable to the refrigerator compartment and the evaporator suitable to the freezer compartment. This makes it possible to avoid excessive cooling of the air. Thus, it is possible to improve the energy efficiency and contribute to energy saving.

[0020] Further, preferably, the refrigerator includes the second circulation device which cools, using the second evaporator, an air introduced from inside of the second body, and introduces the cooled air to the inside of the second body; and a cooling plate which is provided such that a front face of the cooling plate faces an inside of the first body and a back face of the cooling plate is in contact with the first evaporator.

[0021] With this, the refrigerator compartment that has a little variation in temperature in a vertical direction is cooled directly. This allows elimination of a blower for transporting, to the refrigerator compartment, the air cooled by the evaporator. Therefore, it is possible to reduce the amount of energy consumption and contribute to energy saving.

[0022] Furthermore, compared to an indirect cooling method, evaporator or the like can be thinner, allowing an increase in the capacity of the refrigerator compartment.

Effects of the Invention

[0023] According to the present invention, it becomes possible to provide a refrigerator which is capable of contributing to energy saving while maintaining and improving the performance as a refrigerator.

Brief Description of Drawings

[0024]

FIG. 1 is a perspective view showing an external appearance of a refrigerator.

FIG. 2 is a perspective view showing an external appearance of the refrigerator with a first door and a second door open.

FIG. 3 is a perspective view showing an external appearance of the refrigerator with the first door and the second door omitted.

FIG. 4 schematically shows a cooling cycle unit.

FIG. 5 is a perspective view schematically showing components of the cooling cycle unit when mounted in the refrigerator.

FIG. 6 is a schematic cross-sectional view illustrating a refrigerator which employs an indirect cooling method.

FIG. 7 is a perspective view showing a blower unit.

FIG. 8 is an exploded perspective view showing the blower unit.

FIG. 9 schematically shows an other cooling cycle unit that is provided to a refrigerator.

FIG. 10 is a schematic cross-sectional view illustrating a refrigerator which employs a direct cooling method.

FIG. 11 is a perspective view showing a cooling plate viewed from behind.

FIG. 12 schematically shows an other cooling cycle unit that is provided to a refrigerator.

Numerical References

[0025]

100 Refrigerator
101 Compressor
102 Condenser
103 Evaporator
104 Refrigerant-return pipe
105 Bypass pipe
106 Switch valve
107 Connecting pipe
108 First thin pipe
109 Second thin pipe
110 Cooling cycle unit
111 First door
112 Third door
113 Through hole
121 Second door
122 Fourth door
123 Opening
124 First condenser
125 Second condenser
126 Third condenser
131 First evaporator
132 Second evaporator
142 Housing
144 Blower
146 Duct
148 Air inlet
150 Main body
151 First body
152 Second body
153 Partition
154 Suction opening
156 Outer case
157 Inner case
158 Inner-back panel
159 Cooling plate
161 First circulation device
162 Second circulation device
163 Shelves
164 Drawer compartment

Best Mode for Carrying Out the Invention

[0026] Next, embodiments of a refrigerator according to the present invention are described with reference to the drawings.

(Embodiment 1)

[0027] FIG. 1 is a perspective view showing an external appearance of a refrigerator.

[0028] A refrigerator 100 is a device for chilling or freezing and preserving a storage item placed inside, and includes a main body 150, a first door 111, a second door 121, a third door 112, a through hole 113, and a fourth door 122. The refrigerator 100 is a rectangular box-shaped body whose height is largest of height, width, and depth.

[0029] The first door 111 is a door which covers the opening on the right when facing the main body 150, with flexibility in opening and closing. In this embodiment, the first door 111 is attached to the main body 150 using a hinge (not shown) so as to turn back and forth centering on a vertical axis that extends in an anterior portion of the right-side wall of the main body 150. In addition, the first door 111 is in the form of a rectangle which is long in the vertical direction, and disposed so as to extend from top to bottom of the refrigerator 100, with the above axis extending along the right-edge rim of the first door 111.

[0030] The second door 121 is a door which covers the opening on the left when facing the main body 150, with flexibility in opening and closing. In this embodiment, the second door 121 is attached to the main body 150 using a hinge (not shown) so as to turn back and forth centering on a vertical axis that extends in an anterior portion of the left-side wall of the main body 150. In addition, the second door 121 is in the form of a rectangle which is long in the vertical direction, and disposed so as to extend from top to bottom of the refrigerator 100, with the above axis extending along the left-edge rim of the second door 121.

[0031] The through hole 113 is a hole penetrating through the first door 111 in the thickness direction. The through hole 113 is a hole through which a storage item stored behind the first door 111 is taken out or through which a storage item is put for storage behind the first door 111, without opening the first door 111.

[0032] The third door 112 is a door which covers the through hole 113 with flexibility in opening and closing. In this embodiment, the third door 112 is attached to the first door 111 using a hinge (not shown) so as to turn back and forth centering on a horizontal axis that extends at the lower end of the through hole 113. In addition, the first door 112 is square in shape as viewed from the front (round-cornered), with the above axis extending along the lower-end rim of the third door 112.

[0033] The fourth door 122 is a door that opens and closes at an opening 123 where ice or the like supplied from inside of the refrigerator 100 is received.

[0034] FIG. 2 is a perspective view showing an external appearance of the refrigerator with the first door and the second door open.

[0035] FIG. 3 is a perspective view showing an external appearance of the refrigerator with the first door and the second door omitted. FIG. 2 shows also a storage item A stored in the refrigerator 100.

[0036] As shown in these figures, the refrigerator 100 includes a first body 151, a second body 152, and an outer case 156.

[0037] The first body 151 is a vertically-long heat-insulating body having an opening in the front face and defining a refrigerator compartment. In this embodiment, the first body 151 is disposed on the right in the refrigerator 100 so as to extend entirely from top to bottom of the refrigerator 100. The refrigerator compartment is a compartment having a temperature inside maintained in

the temperature range of no lower than 0 degree C, and especially in the case of preserving vegetables and the like under moist conditions, this compartment is partitioned by providing a drawer case therein so as to provide a sub-compartment in which such vegetables stored therein are not directly exposed to the cool air circulating inside the refrigerator compartment.

[0038] The second body 152 is a vertically-long heat-insulating body having an opening in the front face and defining a freezer compartment. In this embodiment, the second body 152 is disposed on the left in the refrigerator 100 so as to extend entirely from top to bottom of the refrigerator 100. The freezer compartment is a compartment having a lower temperature maintained at around minus 18 degrees C, and storing a storage item such as a frozen food.

[0039] The outer case 156 is a metal plate covering the first body 151 and the second body 152 which are arranged next to each other in the horizontal direction.

[0040] The main body 150 in this embodiment is manufactured as follows. That is, each of the refrigerator compartment and the freezer compartment separated by a partition 153 is manufactured, independently by an inner case 157, with resin in solid casting. Outside the inner case 157, the outer case is disposed so as to cover the inner case 157 with a predetermined gap between the outer case and the inner case 157. Inside the partition 153, there is also a gap which is communicated with the gap located between the outer case 156 and the inner case 157. Into the gap located between the outer case 156 and the inner case 157 and into the gap of the partition 153, rigid urethane foams or the like are injected and foamed to serve as a heat insulating material, for example. Thus, the main body 150 is manufactured.

[0041] Consequently, in this embodiment, the wall between the first body 151 and the second body 152 is inseparable, which means that the first body 151 and the second body 152 share the partition 153 as a wall part.

[0042] Next, the cooling cycle unit provided to the refrigerator 100 is described.

[0043] FIG. 4 schematically shows a cooling cycle unit.

[0044] FIG. 5 is a perspective view schematically showing components of the cooling cycle unit when mounted in the refrigerator.

[0045] The cooling cycle unit 110 functions to forcibly transfer heat from one space to another by dissipating heat using a condenser 102 and absorbing heat using an evaporator 103, and the evaporator 103 is disposed at such a position as to cool the inside of the refrigerator 100 while the condenser 102 is disposed in a mechanical compartment outside the refrigerator 100 so that the inside of the refrigerator 100 can be cooled. As shown in these figures, the cooling cycle unit which the refrigerator 100 employs is a device including the compressor 101, the condenser 102, and the evaporator 103, and implements a cooling cycle by connecting these devices annularly with a refrigerant-return pipe 104 that is a path of a refrigerant, and circulating the refrigerant. In this embodiment, the refrigerator 100 further includes a bypass pipe 105, which serves as a pipe, and a switch valve 106.

[0046] The compressor 101 and the condenser 102 are disposed in the mechanical compartment. The mechanical compartment and the evaporator 103 which is disposed inside of the refrigerator are disposed in lower and upper parts partitioned by a heat insulating material. With a drain pipe which introduces water resulting from defrosting of the evaporator 103 into the mechanical compartment, the inside of the refrigerator and the mechanical compartment are structurally connected.

[0047] The compressor 101 is a device which compresses a gaseous refrigerant flowing in the refrigerant-return pipe 104 and thereby increases the pressure of the refrigerant.

[0048] The condenser 102 is a device which dissipates heat of the gaseous refrigerant at an increased pressure into the atmosphere to cool the refrigerant and thereby converts the refrigerant into a liquid refrigerant at a high pressure. In this embodiment, the condenser 102 includes the first condenser 124, a second condenser 125, and a third condenser 126.

[0049] The first condenser 124 is a main condenser which provides direct heat exchange with the air, and is disposed, in a state of exposure to the air, in the lower and rear part of the refrigerator 100. In this embodiment, the main condenser is in the form of spiral fin coil obtained by spirally winding, onto a pipe, a thin heat dissipation fin made of a high thermally conductive material such as aluminum, and is formed by folding the pipe plural times in a meandering state.

[0050] The second condenser 125 is an auxiliary condenser which is disposed in a meandering state between the outer side wall of the first body 151 and the outer case 156 so as to be in close contact with the rear surface of the outer case 156, and provides heat exchange with the air via the metallic outer case 156. Since there is a heat insulating material between the second condenser 125 and the inside of the first body 151, the heat from the second condenser 125 is less likely to influence the inside of the first body 151. Furthermore, since the inside of the first body 151 is the refrigerator compartment having a relatively high temperature, the heat gradient between the second condenser 125 and the inside of the first body 151 is low, with the result that the heat is less likely to be transferred therebetween.

[0051] The third condenser 126 is an auxiliary condenser which is disposed along the rim of the opening of the second body 152, and functions not only to cool the refrigerant by dissipating the heat, but also to increase a temperature of the rim of the opening of the second body 152 to prevent dew condensation.

[0052] With the above structure of the condenser 102, even in the case where the performance of the first condenser 124 exposed to the atmosphere has been degraded due to dust accumulation or the like, the second condenser 125 complements the performance of the condenser 102, which makes it possible to maintain the per-

formance of the cooling cycle unit 110 for a long period of time without the need for maintenance to ensure the performance.

[0053] In addition, since the dew condensation at the opening of the freezer compartment can be prevented, a decrease in the sealing level of the second door 121 due to frost formation can be prevented, which makes it possible to improve or maintain the energy efficiency of the refrigerator 100.

[0054] The evaporator 103 is a device which evaporates the refrigerant inside to absorb the heat of the surrounding air or the like. In this embodiment, the evaporator 103 includes a first evaporator 131 and a second evaporator 132 which are connected in series with each other with a connecting pipe 107. The connecting pipe 107 penetrates the back of the first body 151 and the back of the second body 152, passing through the heat insulating material, so that the evaporators are connected to the both ends of the connecting pipe 107.

[0055] The first evaporator 131 is an evaporator which is connected in series with the third condenser 126 and disposed in a rear part of the first body 151, and plays a role in cooling the inside of the first body 151. It is to be noted that, in a refrigerator of the side-by-side type in which the height of the refrigerator compartment is the same as the height of the freezer compartment, the second evaporator 132 is disposed in the height direction inside the freezer compartment in order to evenly cool the freezer compartment down to around minus 18 degrees C while the first evaporator 131 that cools the refrigerator compartment down to a temperature around 0 to 6 degrees C which is relatively high as compared to the temperature of the freezer compartment is disposed at not so high a level in the height direction inside the refrigerator compartment as the second evaporator 132, and in order to secure a large depth-wise capacity of the refrigerator compartment, the first evaporator 131 is designed to be smaller in size than the second evaporator 132.

[0056] The second evaporator 132 is an evaporator which is connected in series with the first evaporator 131 and disposed in a rear part of the second body 152, and plays a role in cooling the inside of the second body 152. The second evaporator 132 is used to cool the freezer compartment, and therefore is larger in size than the first evaporator 131.

[0057] In this embodiment, evaporators employ a fin-and-tube type heat exchanger, to which the present invention is not limited, and a given heat exchanger is applicable such as a heat exchanger employing a corrugated fin and a flat tube.

[0058] Each of the first evaporator 131 and the second evaporator 132 has a pipe folded plural times in a meandering state, and is configured so that an inlet and an outlet for the flowing refrigerant are located in an upper part of the evaporator.

[0059] As above, the first evaporator 131 for cooling the first body 151 (the refrigerator compartment) and the second evaporator 132 for cooling the second body 152 (the freezer compartment) are provided as separate devices, allowing for cooling suitable to respective set temperature ranges.

[0060] Particularly, in the case where a vertically long freezer compartment such as in this embodiment is provided, there is a need to provide an evaporator having sufficient cooling performance in order to reduce the temperature difference in the vertical direction of the freezer compartment. However, when such an evaporator is located in a rear part of the refrigerator compartment, the refrigerator compartment may be excessively cooled, and it is therefore necessary to provide sufficient heat insulation between the refrigerator compartment and the evaporator. In this case, the heat insulating material will cause a reduction in the capacity of the refrigerator compartment. In view of this, as in the present invention, the first evaporator 131 suitable to cool the refrigerator compartment is provided in the rear part of the first body 151 (the refrigerator compartment) while the second evaporator 132 suitable to evenly cool the freezer compartment is provided in the rear part of the second body 152 (the freezer compartment), with the result that the capacity of the refrigerator compartment can increase.

[0061] Furthermore, when a refrigerator compartment, which includes shelves 163 disposed in an upper part, and drawer compartments 164, which is located below the shelves 163, are vertically arranged inside the first body 151 (refrigerator compartment), and at least one of the drawer compartments is a variable-temperature compartment that allows temperature adjustment in a range around 0 to 6 degrees C, it is possible to secure a large effective unobstructed capacity in the drawer compartment by disposing the first evaporator 131 behind the variable-temperature compartment. This is because, in this way, a path for discharging cool air from the first evaporator 131 to the variable-temperature compartment can be short, and thus depth-wise space can be secured in the first body 151. Furthermore, cooling loss in the cool air path can be reduced and thus cooling efficiency in the variable-temperature compartment can be increased.

[0062] The switch valve 106 is a three-way valve which selects between supplying the refrigerant from the third condenser 126 to the first evaporator 131 and supplying the refrigerant from the third condenser 126 directly to the second evaporator 132, and is disposed in the same space as the compressor 101 and the condenser 102.

[0063] To the switch valve 106 on the downstream side thereof, a first thin pipe 108 connected to the first evaporator 131 and a second thin pipe 109 connected to the second evaporator 132 are switchably connected.

[0064] The bypass pipe 105 is a pipe which is connected between the switch valve 106 and the second thin pipe 109 and directly connects the third condenser 126 and the second evaporator 132 via the switch valve 106. Here, directly connecting means not introducing the refrigerant into the second evaporator 132 via the first evaporator 131 but introducing the refrigerant from the switch

valve 106 directly into the second evaporator 132 by bypassing the first evaporator 131.

[0065] While the bypass pipe 105 is provided between the switch valve 106 and the second thin pipe 109 to connect the pipes, it may be possible that the second thin pipe 109 is connected directly to the switch valve 106.

[0066] The refrigerant for use in the cooling cycle unit 110 of the refrigerator 100 is not particularly limited, but a hydrocarbon refrigerant can be used, for example.

[0067] The hydrocarbon refrigerant includes propane and isobutane, for example. These are preferable because of their very small impacts on global warming as compared to hydrochlorofluorocarbon and hydrofluorocarbon.

[0068] As above, the first evaporator 131 that cools the refrigerator compartment is connected, on the downstream side thereof, in series with the second evaporator 132 that cools the freezer compartment, and furthermore, the cooling cycle is constructed which allows the refrigerant to flow only to the second evaporator 132 on the downstream side by changing the flow path of the refrigerant using the switch valve 106, with the result that, when the refrigerator compartment and the freezer compartment are not cooled to their set temperatures, the cooling cycle can be controlled by switching the switch valve 106 so as to allow the refrigerant to flow to both of the evaporators, and when the temperature of the refrigerator compartment reaches the set temperature, then the cooling cycle can be controlled by switching the switch valve 106 so as to allow the refrigerant to flow not to the first evaporator 131 that cools the refrigerator compartment but only to the second evaporator 132 that cools the freezer compartment only.

[0069] Subsequently, when the temperature of the freezer compartment reaches the set temperature, then the compressor 101 stops operation. This makes it possible to select the introduction of the refrigerant into the first evaporator 131 while maintaining the introduction of the refrigerant into the second evaporator 132. By so doing, even when the second evaporator 132 operates continuously for long hours in order not to cause variations in temperature of the vertically-long second body 152 (the freezer compartment), the first evaporator 131 can be controlled in a manner suitable to the first body 151 (the refrigerator compartment).

[0070] Furthermore, since the first evaporator 131 and the second evaporator 132 can be arranged in the horizontal direction, the connecting pipe 107 that connects the first evaporator 131 and the second evaporator 132 can be shorter, with the result that, when the switch valve 106 allows the refrigerant to be introduced into both the first evaporator 131 and the second evaporator 132, the cooling loss in the connecting pipe 107 can be reduced, allowing an increase in the cooling efficiency of the second evaporator 132, and the amount of flammable refrigerant can be reduced, allowing for improvement in the resistance to explosion.

[0071] Furthermore, as the first evaporator 131 is disposed below the refrigerator compartment, the distance between the first evaporator 131 and the mechanical compartment in which the compressor is disposed is shorter, with the result that, even in the case where the flammable refrigerant leaks from around the first evaporator 131, the flammable refrigerant, which has a higher specific gravity than air, will descend and stay in a low level and moreover be able to be easily introduced into the mechanical compartment in which the compressor 101 is disposed, through a drain pipe for draining water resulting from defrosting of the first evaporator 131, and then be released from the mechanical compartment to outside the refrigerator, so that an increase in concentration of the flammable refrigerant inside the refrigerator due to stagnation of the leaked flammable refrigerant can be suppressed, which allows for improvement in the resistance to explosion.

[0072] Also in the case where the flammable refrigerant leaks from the second evaporator 132, the leaked refrigerant can be drained to the inside of the mechanical compartment through the drain pipe in the same manner as above, so that stagnation of the leaked refrigerant inside the refrigerator can be prevented, which allows for improvement in the resistance to explosion.

[0073] As described above, the first evaporator 131 and the second evaporator 132 are disposed below the refrigerator compartment and the freezer compartment, respectively, so that the heights of both the lower ends of the evaporator 103 become approximately the same, which enhances the draining property from inside to outside the refrigerator through the mechanical compartment, but the position of the first evaporator 131 that is shorter in height than the second evaporator 132 may be moved up so that the heights of both the upper ends of the evaporator 103 become approximately the same.

[0074] This allows the connecting pipe 107 that connects the refrigerant outlet of the first evaporator 131 and the refrigerant inlet of the second evaporator 132 to extend almost horizontally between the first evaporator 131 and the second evaporator 132, with the result that the length of the connecting pipe 107 can be shortest, and when the switch valve 106 allows the refrigerant to flow to both the first evaporator 131 and the second evaporator 132, the cooling loss in the connecting pipe 107 can be reduced further, and the amount of flammable refrigerant can also be reduced further.

[0075] By employing the refrigerator 100 with the above structure, it is possible to increase the whole energy efficiency and thereby contribute to energy saving.

[0076] FIG. 6 is a schematic cross-sectional view illustrating a refrigerator which employs an indirect cooling method.

[0077] As shown in this figure, the refrigerator 100 which employs the indirect cooling method for the second body 152 (freezer compartment) includes a second circulation device 162. The second circulation device 162 includes a blower 144, a duct 146, an air inlet 148, and a suction opening 154. The second circulation device

162 is provided in a rear part of inside of the second body 152 and cools, using the second evaporator 132, an air introduced from inside of the second body 152, and introduces the cooled air to the inside of the second body 152. Furthermore, the second circulation device 162 is disposed such that the air cooled by the second evaporator 132 does not directly cool the inside of the second body 152, that is, a front part of the inside of the second body 152 is thermally insulated from the duct 146 and the second evaporator 132 by the heat insulating material provided in a back of an inner-back panel 158.

[0078] FIG. 7 is a perspective view showing a blower unit.

[0079] FIG. 8 is an exploded perspective view showing the blower unit.

[0080] As shown in these figures, the blower 144 is a device which can generate a flow of air, and an axial fan is employed in this embodiment. Furthermore, the blower 144 is attached, in a tilted posture, to an upper part of a housing 142 in which the second evaporator 132 is housed. The blower 144 and the housing 142 form the blower unit, and can be easily arranged within the duct 146 as the blower unit.

[0081] The duct 146 is a path which guides air with a predetermined path and formed by a tube-like member made of heat insulating material.

[0082] The air inlet 148 and the suction opening 154 are openings provided in the inner-back panel 158 and communicate with the duct 146. The cooled air flowing in the duct 146 is discharged to inside of the second body 152 through the air inlets 148 that are provided at predetermined locations, and the air inside the second body 152 is sucked into the duct 146 through the suction opening 154 .

[0083] As above, when the second circulation device 162 is provided in a rear part of the second body 152 to cool an inside of the second body 152 by the indirect cooling method, flow of air is forcibly generated inside the second body 152. This enables to reduce variations in temperature of the air inside the second body 152. This is especially effective for the vertically-long second body 152 of which inside temperature is relatively low.

[0084] Furthermore, the second evaporator 132 and an air immediately after being cooled by the second evaporator 132 are less likely to cause the temperature of the inner-back panel 158 to drop. Thus, dew condensation on the front face of the inner-back panel 158 can be prevented as much as possible.

[0085] Furthermore, a temperature gradient between the air cooled by the first evaporator 131 and the temperature inside of the first body 151, and a temperature gradient between the air cooled by the second evaporator 132 and the temperature inside of the second body 152 are relatively gentle. Thus, it is possible to reduce a thickness of heat insulating material that is provided (i) between the first evaporator 131 and inside of the first body 151, and (ii) between the second evaporator 132 and inside of the second body 152, respectively. This contributes to the increase of capacity of the refrigerator 100.

[0086] It is to be noted that, in this embodiment, a first circulation device 161 is provided in a rear part of the first body 151. The structure and a functional advantage of the first circulation device 161 are similar to the second circulation device 162 which employs the indirect cooling method. Thus, the detailed description of the first circulation device 161 is omitted.

[0087] Following describes an other embodiment of a refrigerator according to the present invention with reference to the drawings.

(Embodiment 2)

[0088] FIG. 9 schematically shows an other cooling cycle unit that is provided to a refrigerator.

[0089] A cooling cycle unit 110 according to this embodiment includes a first evaporator 131 and a second evaporator 132 that are connected in parallel with a condenser 102. More specifically, a refrigerant discharged from the compressor 101 flows to a first condenser 124, which is a main condenser, where the refrigerant is condensed. Then, the refrigerant flows to a second condenser 125, which is an auxiliary condenser, where the refrigerant is further condensed. Further, the refrigerant flows to a third condenser 126, which is an auxiliary condenser, and, through heat dissipation effect, prevents a dew condensation at an opening of a freezer compartment where temperature is largely different from the outside air temperature. Then, the first evaporator 131 and the second evaporator 132 are connected in parallel via a switch valve 106.

[0090] Furthermore, a first thin pipe 108 as a decompressor is connected between the switch valve 106 and the first evaporator 131. A second thin pipe 109 as a decompressor is connected between the switch valve 106 and the second evaporator 132. Then, passing through outlet pipes of the first evaporator 131 and the second evaporator 132, refrigerants merge at a refrigerant-return pipe 104, go through the compressor 101, and circulate.

[0091] Using the switch valve 106, it is possible to switch between introducing the refrigerant into the first evaporator 131 only and into the second evaporator 132 only.

[0092] With the switch valve 106, refrigerant flow paths are switched according to a load condition of the refrigerator compartment and the freezer compartment, and there is no case that the refrigerant flows to both the first evaporator 131 and the second evaporator 132 simultaneously. Instead, the refrigerant is always circulated only in one of the evaporators. Thus, it is possible to reduce the amount of the refrigerant.

[0093] Therefore, even when a flammable refrigerant is used, as compared to Embodiment 1, the amount of refrigerant can be smaller and a structure for explosion-proof can be simpler. Furthermore, with the smaller amount of refrigerant, load to the compressor 101 can

also be reduced thus it is possible to enhance energy saving.

[0094] Others are the same as the cooling cycle unit 110 in Embodiment 1. Thus, the description thereof is omitted.

[0095] FIG. 10 is a schematic cross-sectional view illustrating a refrigerator which employs a direct cooling method.

[0096] In this embodiment, the refrigerator 100 employs the indirect cooling method for the second body 152 (freezer compartment), and employs the direct cooling method for the first body 151 (refrigerator compartment). Note that the indirect cooling method is similar to Embodiment 1, and thus the description thereof is omitted.

[0097] As shown in the figure, the refrigerator 100 which employs the direct cooling method has a cooling plate 159 provided in a rear part of inside of the first body 151. The cooling plate 159 is provided such that a front face of the cooling plate faces the inside of the first body 151 and a back face of the cooling plate is in contact with the first evaporator 131.

[0098] FIG. 11 is a perspective view showing a cooling plate viewed from behind.

[0099] As shown in the figure, to the cooling plate 159, the tube-like first evaporator 131 is provided in a meandering state. The cooling plate 159 and the first evaporator 131 are in contact with each other so that the first evaporator 131 can provide heat exchange through the cooling plate 159.

[0100] As above, when the first evaporator 131 and the second evaporator 132 are connected in parallel and the operating status is selectable to allow only one of the evaporators to operate, it is possible to absorb heat with the refrigerant evaporated only by the second evaporator 132. Thus, it is possible to enhance the cooling performance of the second evaporator 132. Therefore, even for the inside of the second body that is long in a vertical direction, sufficient cooling performance can be ensured. Thus, it is possible to overcome the variations in temperature or the like in the vertical direction of the second body 152.

[0101] Furthermore, when the direct cooling method is employed to cool the inside of the first body 151, the air flow path required in the indirect cooling method can be eliminated, and devices or the like that are disposed in a rear part of inside of the first body 151 can be thinner. Thus, it is possible to secure a large storage space inside the first body 151.

[0102] Following describes an other embodiment of a refrigerator according to the present invention with reference to the drawings.

(Embodiment 3)

[0103] FIG. 12 schematically shows an other cooling cycle unit that is provided to a refrigerator.

[0104] In this embodiment, a refrigerator 100 includes two cooling cycle units 110. One of the cooling cycle units 110 includes a compressor 101, a condenser 102 (a second condenser 125, a third condenser 126), and a first evaporator 131. The other of the cooling cycle units 110 includes a compressor 101, a condenser 102 (a first condenser 124), and a second evaporator 132. To put it differently, the refrigerator 100 includes two compressors and can independently supply, to the first evaporator 131 and the second evaporator 132 respectively, the compressed refrigerants.

[0105] Others are the same as the cooling cycle unit 110 in Embodiment 1. Thus, the description thereof is omitted.

[0106] As above, when the refrigerator includes the compressors 101 each of which can be independently operated for the corresponding evaporators 103, it is possible to operate the cooling cycle unit 110 under an optimal condition for a plurality of bodies (such as the first body 151 and the second body 152). In particular, when different cooling methods are employed, such as the case where the direct cooling method is employed for the first body 151 and the indirect cooling method is employed for the second body 152, it is possible to operate the cooling cycle units 110 under an optimal condition with respect to the cooling system by operating the each cooling cycle unit 110 independently. Furthermore, a design flexibility of the cooling cycle unit 110 itself is increased, allowing the cooling cycle unit 110 having high energy efficiency to be designed. In other words, it is possible to contribute to energy saving.

[0107] As described above, the second condenser 125 and the third condenser 126 are connected to the cooling cycle unit which includes the first evaporator 131. However, when considering a design for an appropriate cooling cycle with respect to setting temperatures of the refrigerator compartment and the freezer compartment, it is possible to improve the cooling efficiency by connecting the second condenser 125 and the third condenser 126 to the cooling cycle unit which includes the second evaporator 132 that cools the freezer compartment having a lower temperature than the refrigerator compartment.

[0108] Alternatively, since the cooling cycle unit 110 is independently provided for the refrigerator compartment and the freezer compartment, when the second condenser 125 is connected to the cooling cycle unit which includes the first evaporator 131 that cools the refrigerator compartment, and the third condenser 126 is connected to the cooling cycle unit which includes the second evaporator 132 that cools the freezer compartment, it is possible to reduce the length of the pipe and a material cost and improve workability in assembling. This is because piping, which is for the refrigerator compartment and the freezer compartment that are arranged in the right and the left, can be arranged in the right and the left without causing an intersection of the pipes.

[0109] Note that the above Embodiments 1 to 3 have described (i) the cooling cycle unit 110 which includes

the first evaporator 131, the second evaporator 132, the first condenser 124, the second condenser 125, the third condenser 126, the indirect cooling method, the direct cooling method, and the bypass pipe 105, (ii) the cooling cycle unit 110 which can selectively operate the first evaporator 131 and the second evaporator 132, (iii) the cooling cycle unit 110 which includes the compressors 101, and (iv) a refrigerant or the like in a predetermined combination. However, the present invention is not limited to combinations described in the above embodiments, but the combination may be selected arbitrarily.

Industrial Applicability

[0110] The present invention is applicable to refrigerators for home and professional uses, and, in particular to refrigerators having a refrigerator compartment and a freezer compartment arranged next to each other in the horizontal direction.

Claims

1. A refrigerator including: a first body which is long in a vertical direction, has an opening in a front face, and forms a refrigerator compartment; a second body which is long in a vertical direction, has an opening in a front face, and forms a freezer compartment; an outer case which is made of metal and covers said first body and said second body that are arranged next to each other in a horizontal direction, said refrigerator comprising:

a compressor which compresses a refrigerant;
a condenser which is connected in series with said compressor and dissipates heat of the refrigerant;
a first evaporator which is connected in series with said condenser and disposed in a rear part of said first body, said first evaporator being an evaporator for evaporating the refrigerant;
a second evaporator which is connected in series with said first evaporator and disposed in a rear part of said second body, said second evaporator being an evaporator for evaporating the refrigerant;
a pipe which directly connects said condenser and said second evaporator; and
a switch valve which selects between supplying the refrigerant from said condenser to said first evaporator and supplying the refrigerant from said condenser directly to said second evaporator.

2. The refrigerator according to Claim 1, wherein said condenser includes:

a first condenser which provides direct heat exchange with air; and
a second condenser which is disposed between said first body and said outer case, said second condenser providing heat exchange with air through said outer case.

3. The refrigerator according to Claim 2, wherein said second condenser is disposed in a meandering state on a side of said first body.

4. The refrigerator according to Claim 2, wherein said condenser further includes a third condenser disposed at the opening of said second body.

5. The refrigerator according to Claim 1, wherein the refrigerant is a hydrocarbon refrigerant.

6. The refrigerator according to Claim 1, further comprising:

a first circulation device which cools, using said first evaporator, an air introduced from inside of said first body, and introduces the cooled air to the inside of said first body; and
a second circulation device which cools, using said second evaporator, an air introduced from inside of said second body, and introduces the cooled air to the inside of said second body.

7. The refrigerator according to Claim 1, further comprising:

a second circulation device which cools, using said second evaporator, an air introduced from inside of said second body, and introduces the cooled air to the inside of said second body; and
a cooling plate which is provided such that a front face of said cooling plate faces an inside of said first body and a back face of said cooling plate is in contact with said first evaporator.

FIG. 1

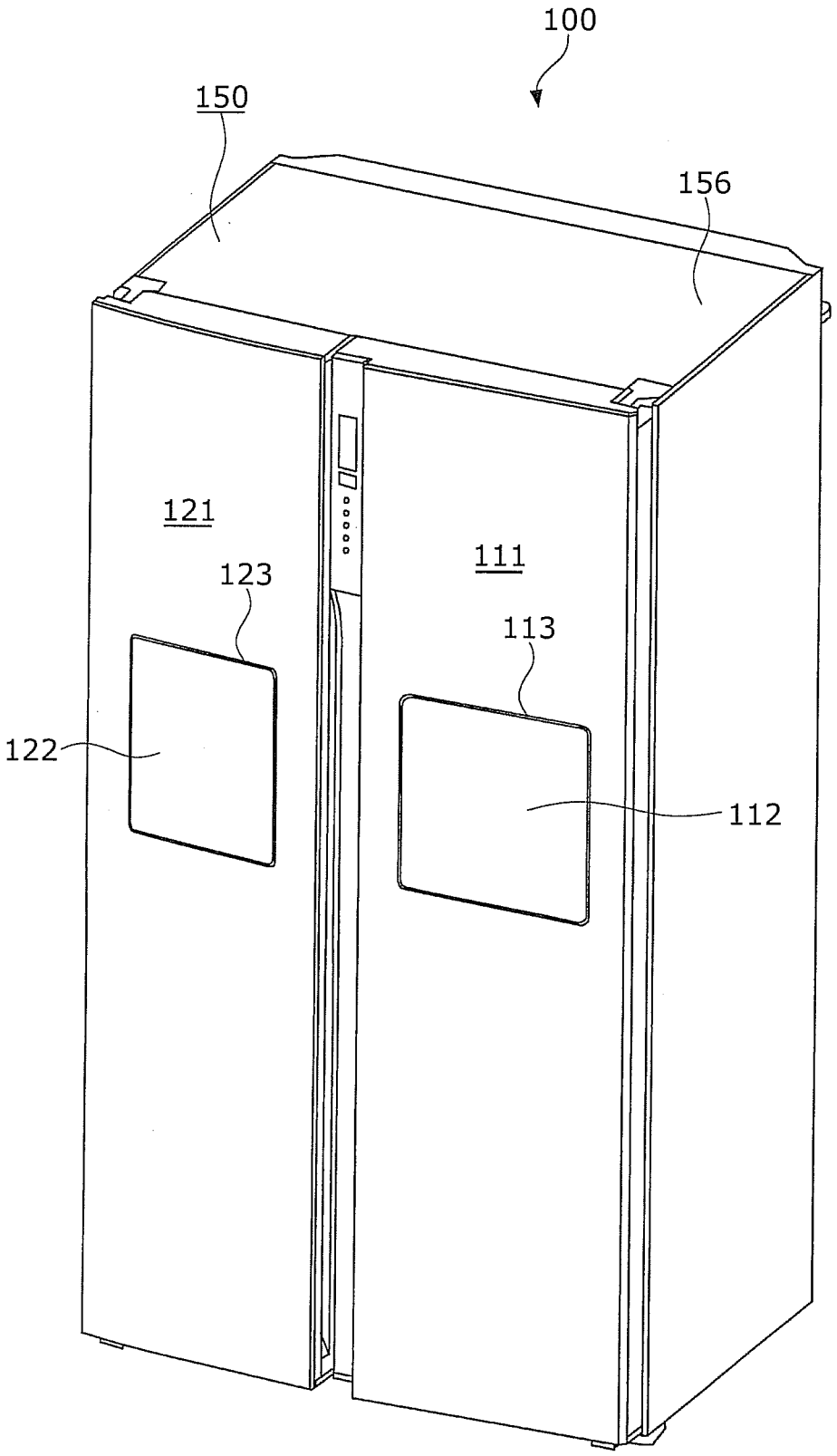

FIG. 2

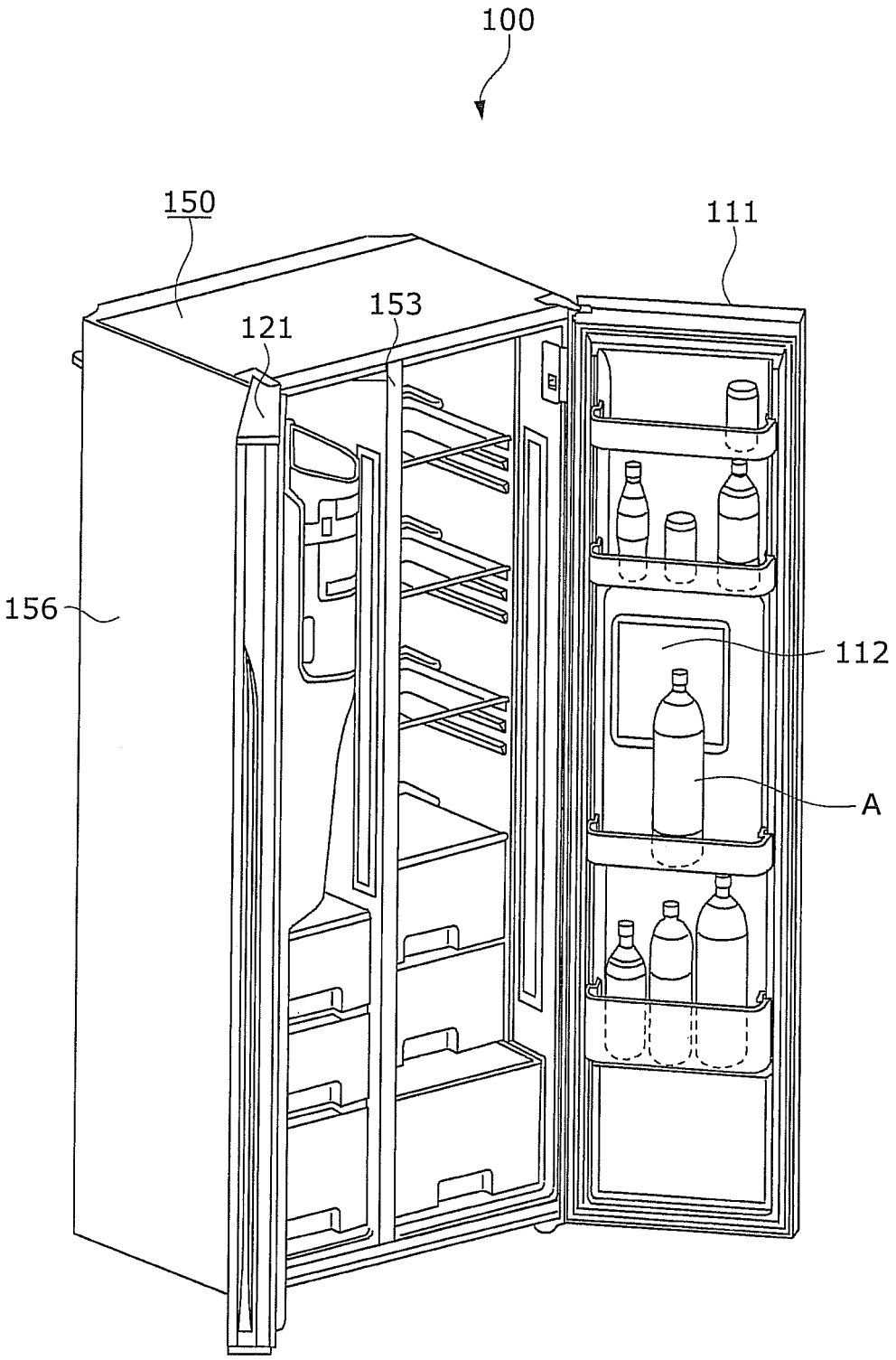

FIG. 3

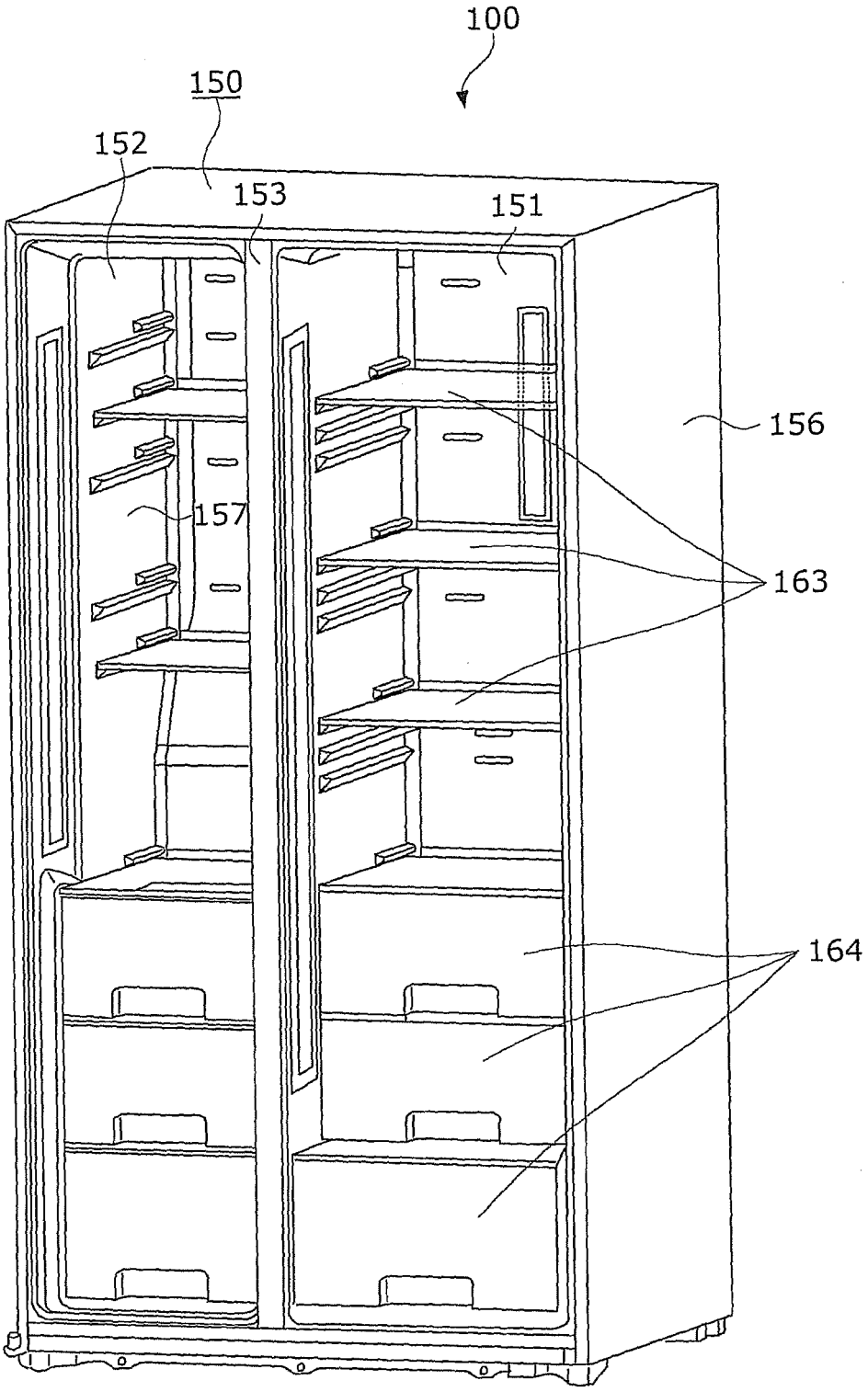

FIG. 4

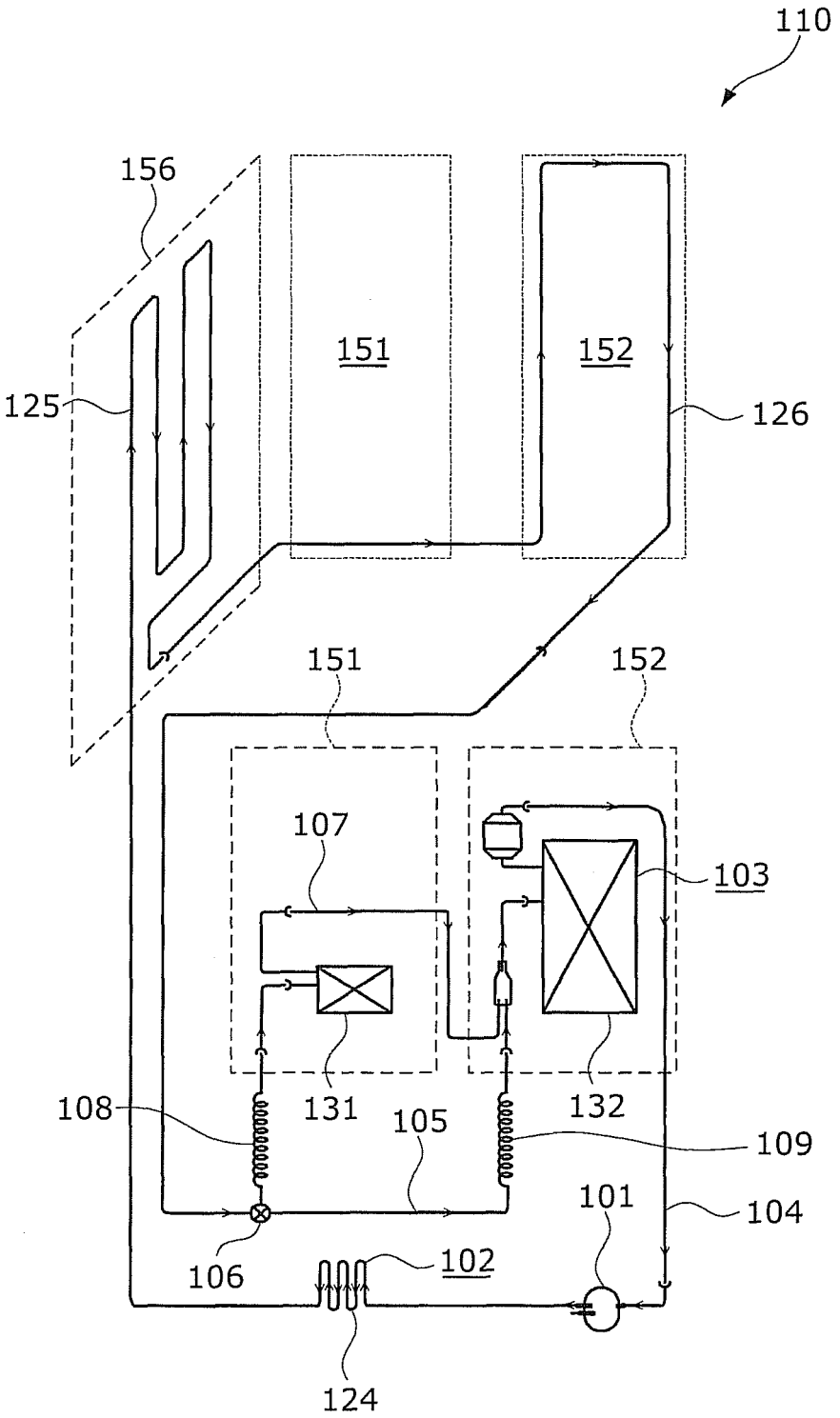
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FIG. 5

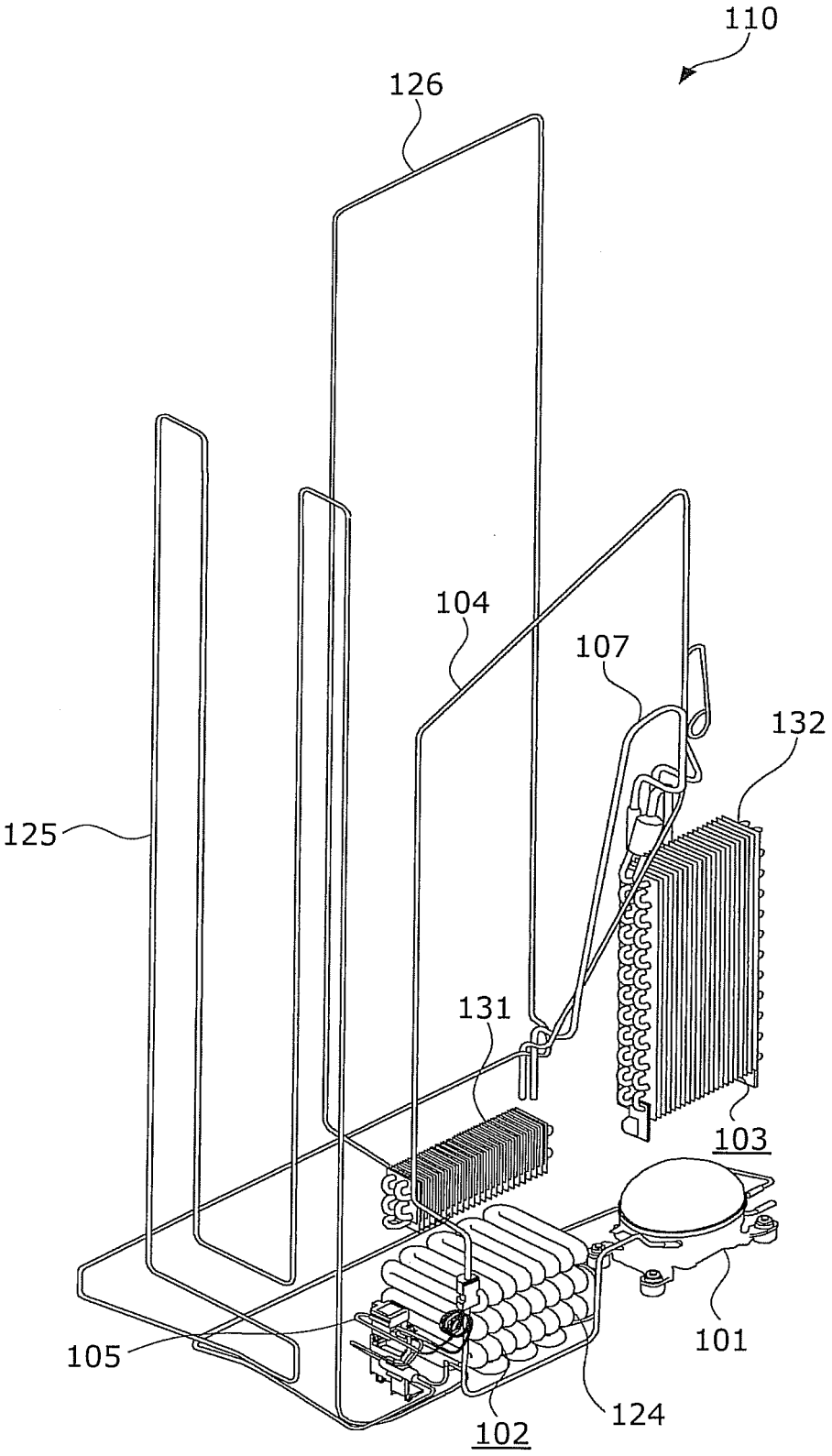

FIG. 6

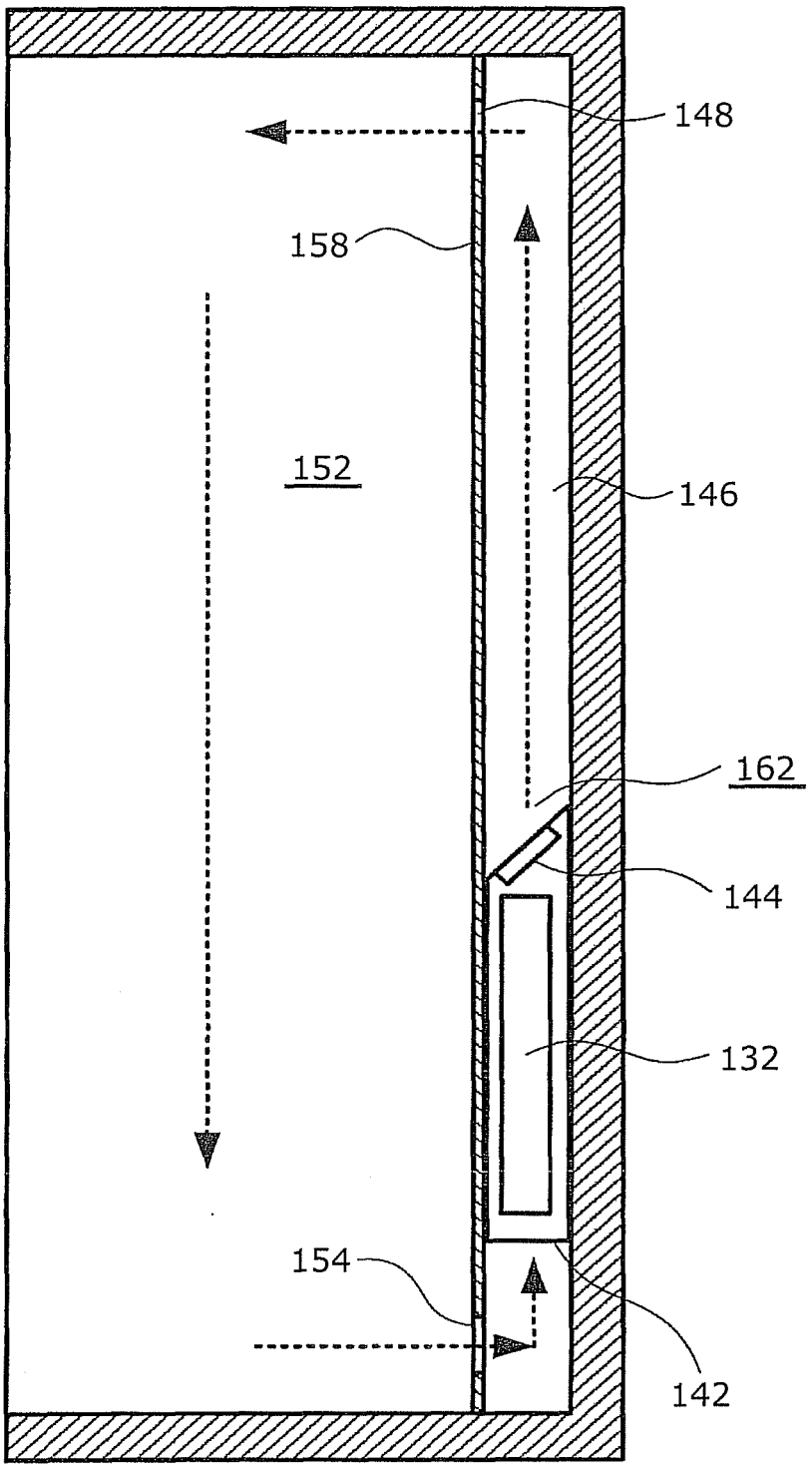

FIG. 7

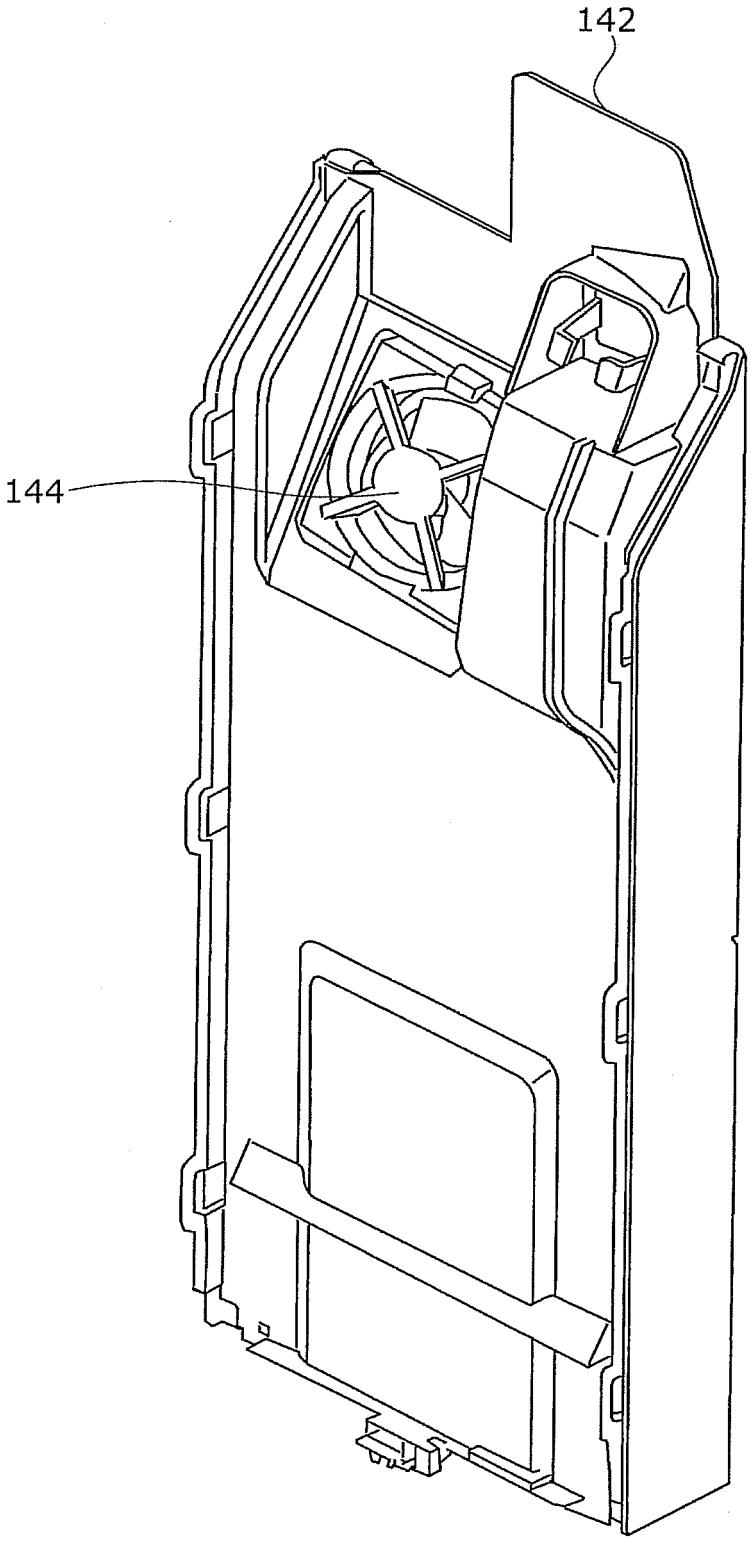

FIG. 8

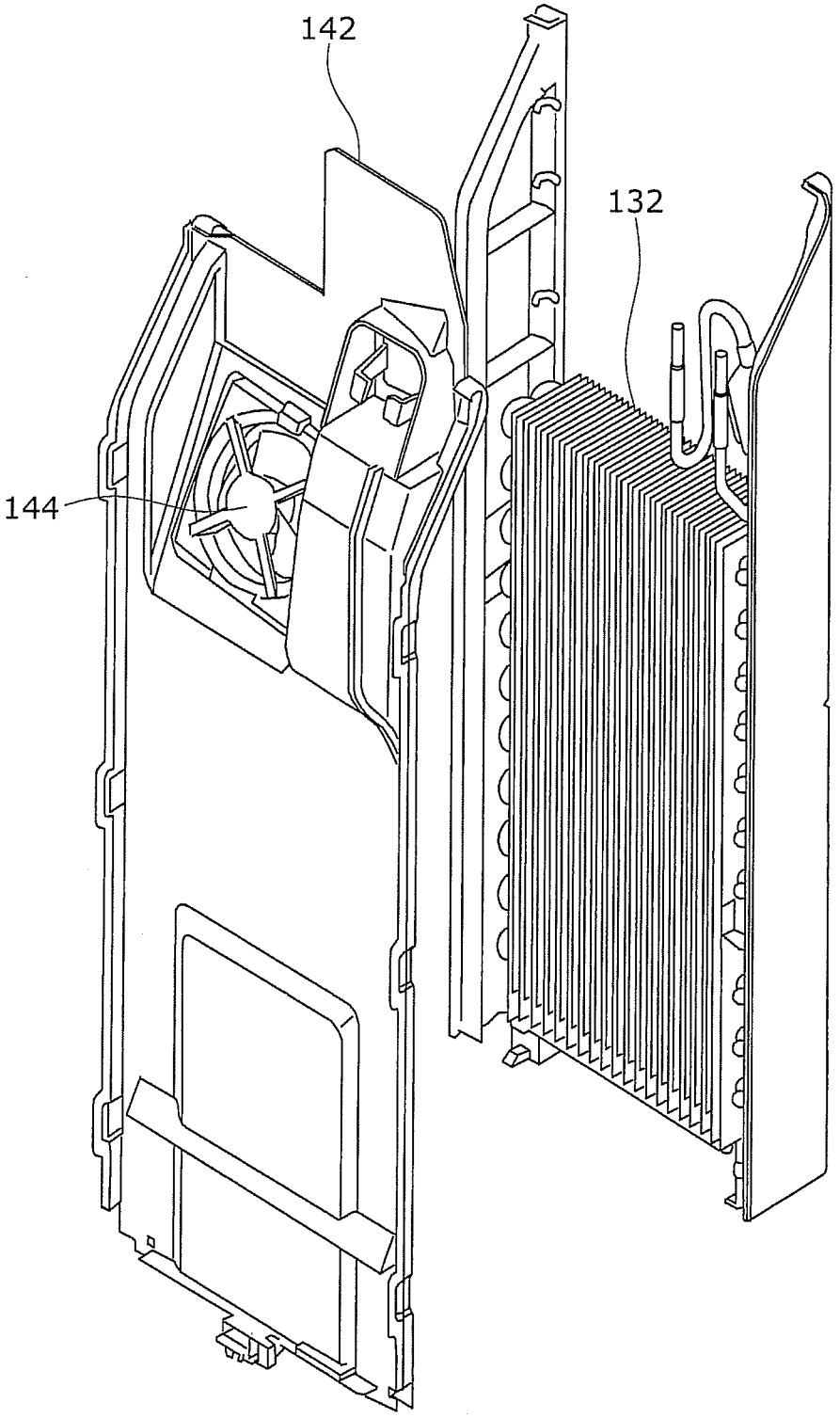

FIG. 9

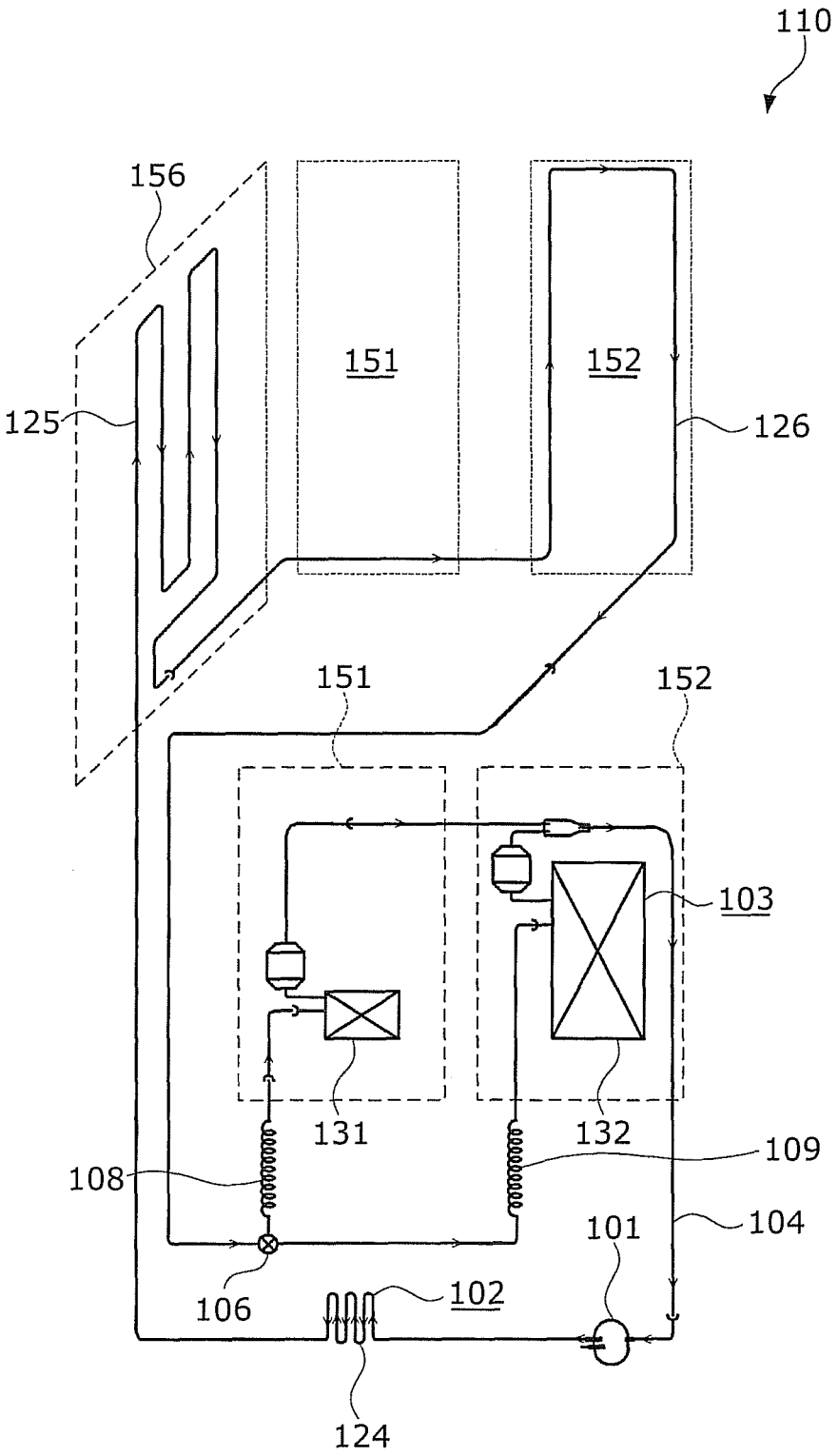
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FIG. 10

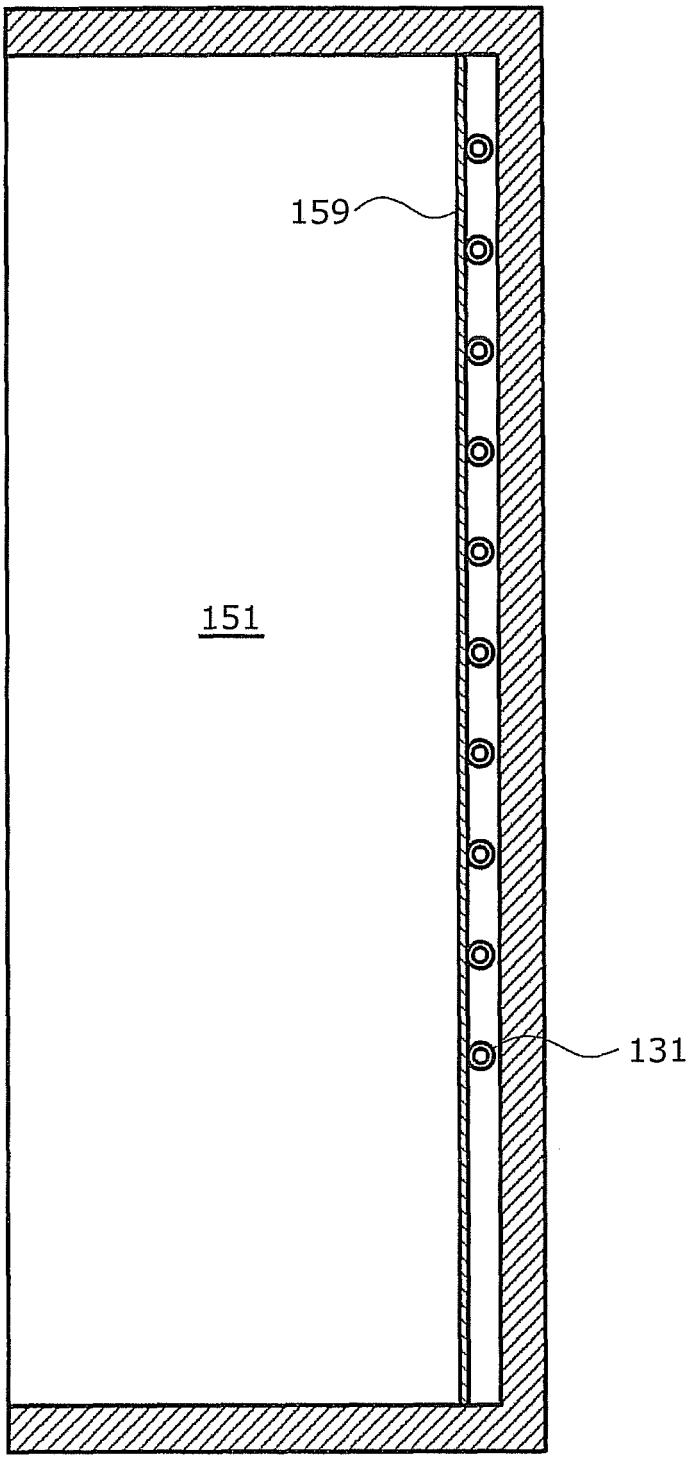


FIG. 11

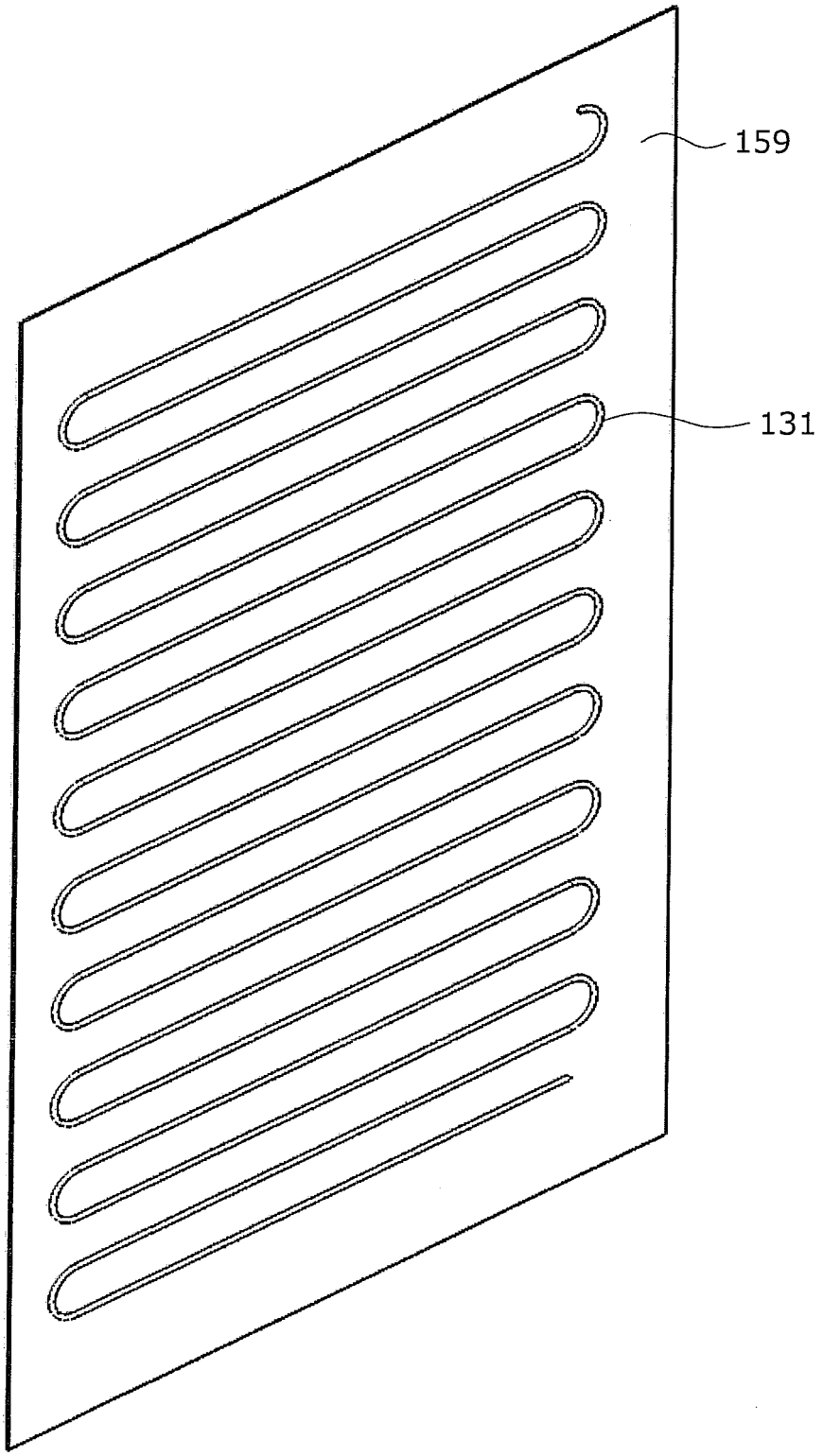
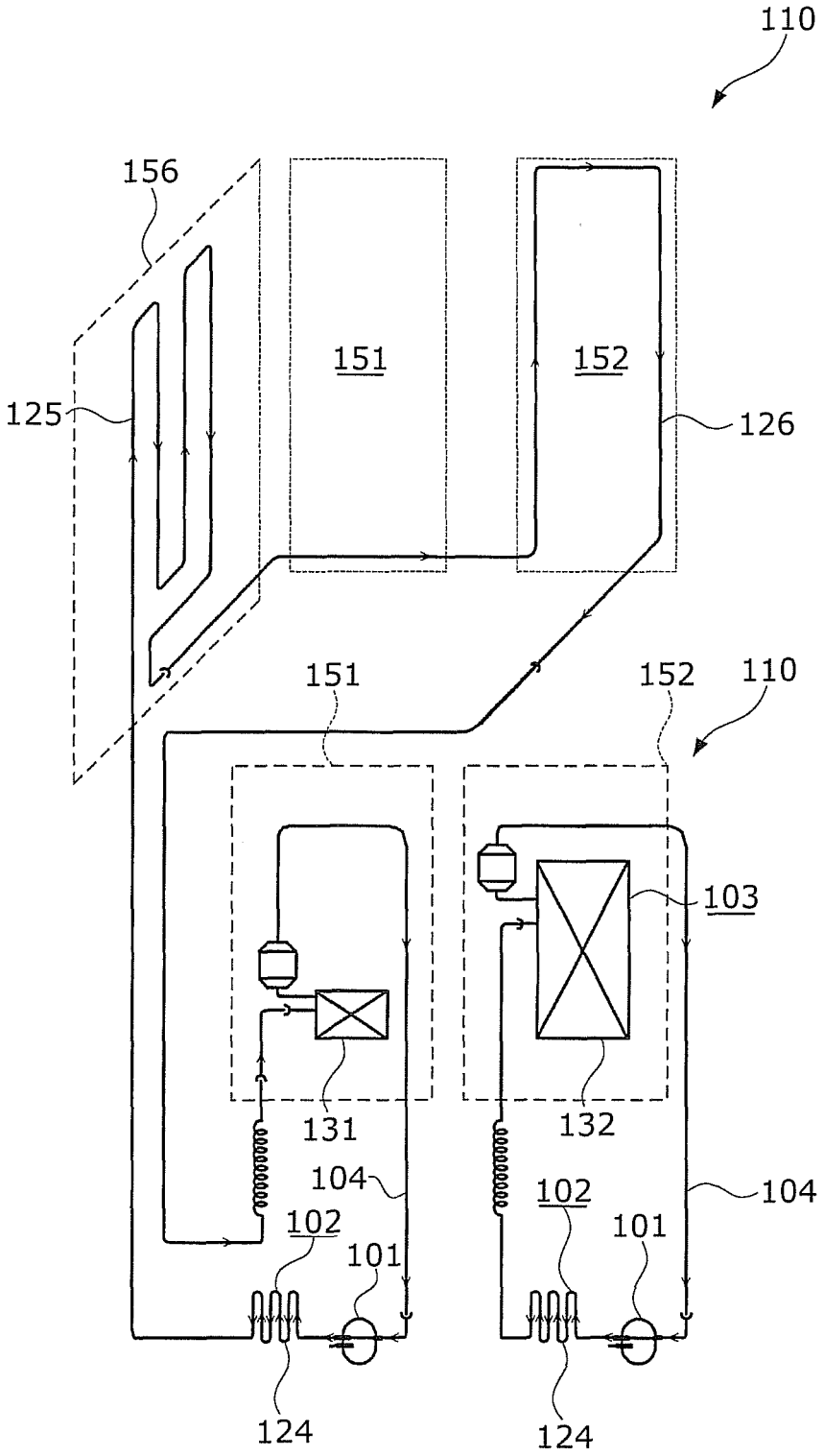


FIG. 12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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/001041

A. CLASSIFICATION OF SUBJECT MATTER
F25D11/02(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)
F25D11/02

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 1996-2009
Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

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	US 4416119 A (WHIRLPOOL CO.), 22 November, 1983 (22.11.83), Column 3, lines 28 to 64; Figs. 1, 2 (Family: none)	1-7
Y	JP 2006-234219 A (Matsushita Electric Industrial Co., Ltd.), 07 September, 2006 (07.09.06), Par. Nos. [0001], [0007], [0024]; Figs. 1 to 3 (Family: none)	1-7
Y	JP 08-166184 A (Sharp Corp.), 25 June, 1996 (25.06.96), Par. Nos. [0014] to [0018]; Fig. 1 (Family: none)	2-4

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April, 2009 (13.04.09)	28 April, 2009 (28.04.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/001041

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-331187 A (Toshiba Corp.), 02 December, 2005 (02.12.05), Par. Nos. [0001] to [0002]; Fig. 2 (Family: none)	5

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000088428 A **[0004]**