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(54) **REFRIGERATOR AND WORKING METHOD THEREOF**

(57) A refrigerator and a operating method thereof. Warm air is prevented from flowing into a storage chamber during defrosting or when cooling starts, heat transfer from a cooling chamber to the storage chamber is prevented, and the temperature rise in the storage chamber is constrained to a low level. A separator (40) is used to divide a part of an air supply passage (16), to form a space portion (14) in communication with a cooling chamber (13) through an air supply opening portion (13a). A first opening portion (19) freely opened and closed is disposed in a separating area between the space portion (14) and the divided air supply passage (16), and a second opening portion (20) freely opened and closed is disposed in a separating area between the space portion (14) and an air return passage (29) or the cooling chamber (13). In this manner, heat transfer from the cooling chamber (13) to storage chambers (4) to (6) can be decreased. In addition, by setting the first opening portion (19) in a closed state and setting the second opening portion (20) in an open state, a condenser (32) performs cooling and an air blower (30) supplies air. In this manner, the space portion (14) used as an air circulation path makes air in the space portion (14) and the cooling chamber (13) circulate and cooled, so as to adjust the temperature thereof.

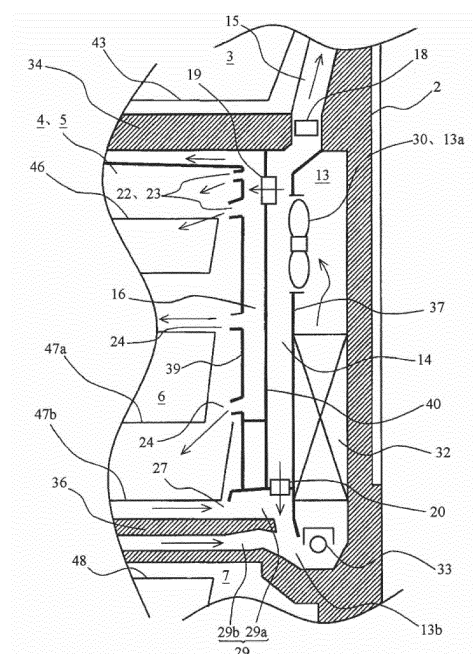


FIG. 4

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a refrigerator that cools and preserves food and the like inside a storage compartment, and more particularly to a refrigerator that can reduce temperature rise inside a storage compartment to be small during defrosting or when cooling starts.

BACKGROUND OF THE INVENTION

[0002] Such a refrigerator has the following problems: During defrosting on a condenser in which a defrosting heater is used as a heat source, warm air around the condenser flows into a storage compartment, resulting in a temperature rise inside the storage compartment. Therefore, as a method for preventing warm air in defrosting from entering a storage compartment, in a known method, a shielding plate is disposed in a cooling air passage and the shielding plate is closed during defrosting, and in another known method, an air gate is disposed for a fan and the air gate is closed (for example known from Japanese Patent Application Publication No. 2009-250476 (pp. 5, FIG. 4 and FIG. 5)).

[0003] FIG. 9(A) shows a structure of an air passage of a refrigerator 100 disclosed in JP 2009-250476. In the refrigerator 100 in the related art, air inlets 105, 106, 107, and 108 are provided in cool-air supply air passages 101, 102, 103, and 104 for conveying air cooled by a condenser to a storage compartment, respectively. In addition, air discharges 113, 114, and 115 are provided in cool-air return air passages 109, 110, and 111 for air to return from the storage compartment to the portion of the condenser, respectively. In addition, an air discharge 116 is provided in a cool-air return air passage (not shown) of a freezer compartment 112. Moreover, during defrosting, all or a part of the air inlets 105 to 108 and the air discharges 113 to 116 are closed.

[0004] FIG. 9(B) shows the surrounding of a fan 117 of the refrigerator 100. In the refrigerator 100, an air gate 118 is disposed in the fan 117, and the air gate 118 is closed during defrosting to prevent warm air from flowing into the cool-air supply air passages 101 to 104.

[0005] In addition, as another example in the related art, it is known that after defrosting ends, an air supply device is delayed to start work after a condenser starts cooling (for example known from Japanese Patent Application Publication No. 2002-195729 (p. 4)).

[0006] As disclosed in JP 2002-195729, after defrosting ends, only a compressor is enabled to work in a state of keeping a fan stopped to lower the temperature of the condenser, so as to cool warm air that fills a cooling compartment, and after delay of a period of time from when the compressor works, the fan is enabled to rotate to convey cool air. In this way, a temperature rise in a freezer compartment caused by the defrosting is reduced.

[0007] However, as shown in FIG. 9, the refrigerator having an air gate or a regulating plate in the related art has the following problems: during defrosting, warm air for defrosting can be prevented from flowing into a storage compartment; however, after defrosting ends and cooling starts, the temperature inside the storage compartment rises. That is, in the refrigerator in the related art, when defrosting ends and cooling starts, air that becomes warm from defrosting inside the cooling compartment or the air passage flows into the storage compartment, and the temperature inside the storage compartment rises.

[0008] In addition, after defrosting ends, a condenser starts cooling in a state in which an air supply device stops working. In a method of cooling air inside the cooling compartment, the temperature rise inside the storage compartment after the cooling starts may be restricted to a minimum; however, the effect is still insufficient. That is, in a state of stopping the air supply device, the condenser is enabled to cool air around and below the condenser; however, because thermal conduction from the condenser to air takes place in natural convection, it is difficult to cool air that accumulates above the condenser or inside the air passage. Therefore, when cooling starts, warm air above the cooling compartment or inside the air passage flows inside the storage compartment.

[0009] In addition, the method of performing cooling by using the condenser and stopping the work of the air supply device further has the following problem: on an air side, thermal conduction takes place in a condition of natural convection; therefore, the thermal conduction has low efficiency and cooling time (pre-cooling time) till air supply starts becomes longer. Therefore, in this period of time, cooling cannot be performed inside the storage compartment, and heat intrusion from outside or heat transfer from the side of the condenser results in a temperature rise inside the storage compartment.

[0010] When the temperature rise inside such a storage compartment causes a large temperature change inside the storage compartment, especially, in the freezer compartment, when a temperature difference is generated between frozen food and the storage compartment, water sublimation occurs because of a vapor pressure difference and results in a problem of drying of food (so-called freezer burn). In addition, when a large temperature change inside the storage compartment causes the food to thaw and to freeze again, ice crystals inside the food become larger, causing damages to cells of food (so-called dryness).

SUMMARY OF THE INVENTION

[0011] The present invention is accomplished in view of the foregoing problems, and the objective is to provide a refrigerator, which can prevent warm air from flowing into a storage compartment during defrosting or when cooling starts, and prevent heat transfer from a cooling compartment to the storage compartment, thereby re-

stricting a temperature rise inside the storage compartment to a minimum.

[0012] The present invention provides a refrigerator, having: a storage compartment; a supply air passage, used for enabling air to flow to the storage compartment; a return air passage, used for enabling the air from the storage compartment to flow through; a cooling compartment, having an air supply opening portion used for enabling the air to flow out from the supply air passage and a return air opening portion used for enabling the air from the return air passage to flow in; a condenser, disposed inside the cooling compartment, and used for cooling the air that flows in from the return air opening portion; and an air supply device, disposed on the air supply opening portion, where, in the refrigerator, the exterior of the cooling compartment is provided with: a separator, at least dividing a part of the supply air passage to form a space portion, the space portion being connected to the cooling compartment through the air supply opening portion; a freely controllable first opening portion, disposed in a separating region between the space portion and the divided supply air passage; and a freely controllable second opening portion, disposed in a separating region between the space portion and the return air passage or between the space portion and the cooling compartment.

[0013] In the refrigerator according to the present invention, the separator is used to divide the part of the supply air passage, and the space portion is formed outside, that is, in front of the cooling compartment, so as to reduce heat transfer from the cooling compartment to the storage compartment. That is, the space portion and the divided supply air passage are arranged between the freezer compartment and the storage compartment; therefore, compared with a case in which only a separating wall is used to separate the cooling compartment and the storage compartment, heat resistance between the cooling compartment and the storage compartment can be increased. The result is that, for example, during defrosting and the like, the temperature rise inside the storage compartment can be restricted to be minimum in a case in which the temperature of the cooling compartment is high.

[0014] In addition, in the refrigerator according to the present invention, because the freely controllable first opening portion is provided in the separating region between the space portion and the divided supply air passage, the first opening portion can be closed to prevent warm air inside the cooling compartment from flowing into the storage compartment. The result is that the temperature rise inside the storage compartment caused when warm air flows in can be prevented.

[0015] In addition, in the refrigerator of the present invention, because the freely controllable second opening portion is provided in the separating region between the space portion and the return air passage or between the space portion and the cooling compartment, in a case in which the temperature of the air in the space portion or cooling compartment is high, the air is enabled to return

to the cooling compartment without flowing into the storage compartment. That is, the first opening portion is set to a closed state, the second opening portion is set to an open state, and the air supply device is enabled to work, so that air that flows out from the air supply opening portion of the cooling compartment flows through the space portion and returns to the cooling compartment through the second opening portion.

[0016] Moreover, as discussed above, in a state of using the space portion as an air path to enable air circulation in the cooling compartment, the condenser performs cooling; in this way, air in the space portion and the cooling compartment can be effectively cooled. The result is that, the temperature of the air in the space portion and the cooling compartment can be adjusted without causing the temperature rise inside the storage compartment.

[0017] Moreover, subsequently, the first opening portion is set to an open state, and the second opening portion is set to a closed state; as discussed above, the air that is cooled and adjusted to a preset temperature can be provided to the storage compartment. The result is that a temperature change inside the storage compartment can be restricted to a minimum.

[0018] In addition, the divider related in the present invention is arranged to divide a freezer supply air passage and the space portion. Therefore, for the freezer compartment that has a very low refrigeration temperature and is very susceptible to heat from the cooling compartment, the temperature change in the freezer compartment can be restricted to a minimum, and the freezer supply air passage is used for enabling cool air to flow to the freezer compartment.

[0019] In addition, in the refrigerator of the present invention, an air passage control device is provided in a refrigerator supply air passage used for enabling cool air to flow to a refrigerator compartment; therefore, the air passage control device can be set to a closed state to prevent warm air from flowing into the refrigerator compartment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 shows a refrigerator according to one embodiment of the present invention.

FIG. 2 is a side sectional view of a general structure of the refrigerator according to one embodiment of the present invention.

FIG. 3 shows a cooling air passage of the refrigerator according to one embodiment of the present invention.

FIG. 4 is a side sectional view of the structure of a periphery of a cooling compartment of the refrigerator according to one embodiment of the present invention.

FIG. 5 is a side sectional view showing a variation

of the refrigerator according to one embodiment of the present invention, where (A) is a side sectional view of a periphery of a first opening portion, and (B) is a side sectional view of a periphery of a second opening portion.

FIG. 6 is a control timing diagram representing control of defrosting work of the refrigerator according to one embodiment of the present invention.

FIG. 7 is a side sectional view representing the structure of a periphery of a cooling compartment of the refrigerator according to one embodiment of the present invention.

FIG. 8 is a control timing diagram representing control of defrosting of the refrigerator according to another embodiment of the present invention.

FIG. 9 represents an example of a refrigerator in a related art, where (A) is a main view, and (B) is a view showing a periphery of a fan.

DETAILED DESCRIPTION OF THE INVENTION

[0021] A refrigerator related in a first embodiment of the present invention is described below in detail with reference to the accompanying drawings.

[0022] FIG. 1 shows a general structure of a refrigerator 1 according to one embodiment of the present invention. FIG. 2 is a side sectional view of the refrigerator 1. FIG. 3 is a view schematically showing a cooling air passage of the refrigerator 1. FIG. 4 is a side sectional view of a structure of a periphery of a cooling compartment 13 of the refrigerator 1. FIG. 5 is a side sectional view showing a variation of the refrigerator 1, where (A) shows a periphery of a first opening portion 19, and (B) shows a periphery of a second opening portion 20. FIG. 6 is a general control timing diagram representing control of defrosting control of the refrigerator 1.

[0023] As shown in FIG. 1, the refrigerator 1 according to one embodiment is provided with an insulating case 2 serving as a body, and a storage chamber for storing food and the like is formed inside the insulating case 2. The storage chamber is divided into a plurality of storage compartments according to the preservation temperature or useage, and the arrangement of the storage compartments is as follows: the uppermost layer is a refrigerator compartment 3, an ice-making compartment 4 is at a left side of a next layer under the refrigerator compartment 3, an upper layer freezer compartment 5 is at a right side of the next layer under the refrigerator compartment 3, a freezer compartment 6 is at a further next layer under the refrigerator compartment 3, and the lowermost layer is a vegetable compartment 7.

[0024] An opening is provided in the front of the insulating case 2, and freely controllable insulating doors 8a, 8b, 9, 10, 11, and 12 are provided at opening portions corresponding to the storage compartments 3, 4, 5, 6, and 7, respectively. The refrigerator compartment doors 8a and 8b cover the front of the refrigerator compartment 3, upper and lower left portions of the refrigerator com-

partment door 8a and upper and lower right portions of the refrigerator compartment door 8b are supported on the insulating case 2 in a freely rotatable manner. In addition, the ice-making compartment door 9, the freezer compartment door 10, the freezer compartment door 11, and the vegetable compartment door 12 are integrally assembled to following storage containers, respectively, and the insulating case 2 is supported at the front of the refrigerator 1 in a freely slidable manner.

[0025] As shown in FIG. 2, the insulating case 2 serving as the body of the refrigerator 1 is formed by an outer layer 2a, an inner layer 2c, and an insulating layer 2b, where the outer layer 2a is provided with an opening portion in the front and is made of steel plates, the inner layer 2c is arranged inside the outer layer 2a and having a gap from the outer layer 2a, is provided with an opening portion in the front, and is made of synthetic resin, and the insulating layer 2b is filled and foamed in the gap between the outer layer 2a and the inner layer 2c and is made of polyurethane foam. In addition, a vacuum insulating layer 2d is provided at a back wall part of the insulating case 2.

[0026] As discussed above, the storage chamber is divided into a plurality of storage compartments. The refrigerator compartment 3 is separated by an insulating separating wall 34 from the ice-making compartment 4 and the upper layer freezer compartment 5 located at a next layer under the refrigerator compartment 3. In addition, the ice-making compartment 4 and the upper layer freezer compartment 5 are separated from each other by a separating wall (not shown) formed with an air vent for free circulation of cool air. Moreover, the ice-making compartment 4 and the upper layer freezer compartment 5 are separated by a separating wall 35 formed with an air vent for free circulation of cool air from the freezer compartment 6 disposed at a next layer under the ice-making compartment 4 and the upper layer freezer compartment 5. Moreover, the freezer compartment 6 and the vegetable compartment 7 are separated from each other by an insulating separating wall 36.

[0027] Moreover, a shelf 42 or a storage container 43 used for storage food and the like is provided inside the refrigerator compartment 3. In addition, storage shelves 44 and 45 for storing beverage containers and the like are provided at inner sides of the refrigerator compartment doors 8a, 8b. Moreover, storage containers 46, 47a, 47b, 48 that can be integrally drawn with the insulating layer doors 9, 10, 11, and 12 are provided in other storage compartments 4, 5, 6, and 7. In addition, a storage container disposed in the ice-making compartment 4 is not shown. In addition, the storage compartments 3 to 7 inside the storage chamber are further provided with other storage shelves and storage containers that are not shown. For example, the refrigerator compartment 3 is further arranged with a container for storing water for making ice.

[0028] In addition, a mechanical chamber 49 is further provided at a lower portion in the rear of the refrigerator

compartment 1. The mechanical chamber 49 is arranged with members such as a compressor 31 for compressing refrigerant, a heat sink (not shown), and a heat sink fan (not shown). The compressor 31, the heat sink, a capillary that serves as a decompression unit and is not shown, and a condenser 32 are sequentially connected through refrigerant piping, so as to form a vapor compression refrigeration circuit. In addition, in the refrigerator 1 according to this embodiment, isobutane (R600a) is used as a refrigerant. Furthermore, a decompression unit in another form such as a temperature-type expansion valve, an electronic expansion valve, and a constant pressure expansion valve may also be used in place of capillary to serve as a decompression unit.

[0029] A supply air passage 15 serving as a refrigerator supply air passage is formed at a rear surface and a top surface of the refrigerator compartment 3. The supply air passage 15 serving as the refrigerator supply air passage guides air cooled by using the condenser 32 inside the refrigerator compartment 3. The supply air passage 15 is a space sandwiched between an air passage separating wall 38 made of synthetic resin and the inner layer 2c of the insulating case 2. In addition, a blowing vent 21 used for providing cool air that circulates inside the supply air passage 15 to the refrigerator compartment 3 is formed on the air passage separating wall 38.

[0030] Similarly, a supply air passage 16 serving as a freezer supply air passage is formed on rear surfaces and top surfaces of the ice-making compartment 4 and the upper layer freezer compartment 5 and a rear surface of the freezer compartment 6. The supply air passage 16 is separated from the storage compartments 4 to 6 by an air passage separating wall 39 made of synthetic resin. Moreover, a blowing vent 22 that enables cool air to flow to the ice-making compartment 4, a blowing vent 23 that enables cool air to flow to the upper layer freezer compartment 5, and a blowing vent 24 that enables cool air to flow to the freezer compartment 6 are formed on the air passage separating wall 39. In addition, the blowing vents 22 to 24 are arranged at positions where cool air can be effectively provided to food and the like received in the storage containers 46, 47a, and 47b.

[0031] In addition, a space portion 14 separated from the supply air passage 16 is formed in the back surface, that is, the rear side of the supply air passage 16. The supply air passage 16 and the space portion 14 are separated from each other by a separator 40 made of synthetic resin.

[0032] In addition, the supply air passage 15 and the space portion 14 are connected through an air passage control device 18. The air passage control device 18 is a motorized shielding plate formed of a plate body of a control cover with one side being axially supported in a freely rotatable manner and a drive motor. In addition, the air passage control device 18 is not limited to the foregoing manner, and for example, a control apparatus in another form such as an air passage control device using a slide control board may also be used as the air

passage control device 18. By opening and closing the air passage control device 18, it can be adjusted whether to enable air to flow from the space portion 14 to the supply air passage 15. In addition, through enabling the air passage control device 18 to perform a suitable open/close action, a flow amount of cool air provided to the refrigerator compartment 3 can be adjusted.

[0033] In addition, a return air port 27 used for enabling air to return to the cooling compartment 13 is provided in the freezer compartment 6. For a similar objective, a return air port 28 is provided in the vegetable compartment 7.

[0034] As shown in FIG. 3, the supply air passage 15 providing cool air to the refrigerator compartment 3 is arranged to convey cool air to the uppermost portion at a central portion of the refrigerator compartment 3 and subsequently enable cool air to drop from two sides. In this way, cool air can be provided entirely and effectively into the refrigerator compartment 3.

[0035] In addition, the supply air passage 15 and a blowing vent 21 formed near an upper portion of the storage container 43 (referring to FIG. 2) are correspondingly provided with branch air passages that are from the central portion to left and right branches. In this way, the interior of the storage container 43 can be effectively cooled.

[0036] In addition, the refrigerator 1 according to this embodiment is provided with a connecting air passage 17 used for enabling cool air to flow from inside the refrigerator 1 to the vegetable compartment 7. A return air port 26 used for cool air in the refrigerator compartment 3 to flow in is formed at a side of the refrigerator compartment 3 of the connecting air passage 17, and a blowing vent 25 for providing cool air to the vegetable compartment 7 is provided at a side of the vegetable compartment 7.

[0037] As shown in FIG. 4, inside the insulating case 2, the cooling compartment 13 is disposed at a rear side of the space portion 14. Moreover, the cooling compartment 13 and the space portion 14 are separated from each other by a cooling compartment separating wall 37 made of synthetic resin.

[0038] The condenser 32 used for cooling circulated air is arranged inside the cooling compartment 13. The condenser 32 according to this embodiment is a so-called fin tube heat exchanger in which the interior of a round tube serving as a heat conduction tube is disposed to be a refrigerant flow path, and the exterior of the tube is disposed to be an air flow path. In the condenser 32, a liquid refrigerant inside the heat conduction tube evaporates. In this way, air outside the tube is cooled; in addition, a heat exchanger in other forms, for example, a heat exchanger in which an elongated porous tube or an irregularly-shaped tube is used may also be used as a condenser.

[0039] In addition, below the condenser 32, a defrosting heater 33 is provided to serve as a defrosting unit for melting and removing frost attached on the condenser

32. The defrosting heater 33 is a resistance heating-type heater using a glass tube for protection. In addition, other defrosting manners in which no electrical heater is used, for example, warm-air defogging, may also be used for the defrosting unit.

[0040] In addition, an air supply opening portion 13a used for sending out cool air obtained through cooling by the condenser 32 is formed in front above the cooling compartment 13, that is, on a surface of a side of the space portion 14. In another embodiment, a return air opening portion 13b used for sucking return cool air from the storage compartment into the cooling compartment 13 is formed below the cooling compartment 13. Moreover, the return air opening portion 13b is connected to the return air port 27 of the freezer compartment 6 and the return air port 28 of the vegetable compartment through the return air passage 29 (29a, 29b).

[0041] In addition, an air supply device 30 used for enabling circulation of cool air is installed on the air supply opening portion 13a. The air supply device 30 is an axial-flow air supply device having rotatable propeller blades, a fan motor (not shown), and a shell (not shown) formed with an air hole. In addition, other forms of an air supply device such as a combination of a fan in a form without a housing and a motor or a multiple-blade fan may also be used as the air supply device 30.

[0042] Here, as discussed above, the separator 40 divides a part of the supply air passage 16, so as to form the space portion 14 connected to the cooling compartment 13 through the air supply opening portion 13a. Specifically, the separator 40 made of synthetic resin is installed in front of the cooling compartment separating wall 37 such that a circumference portion abuts the cooling compartment separating wall 37, and the separator 40 made of synthetic resin is formed into a preset shape such that a surface opposite the cooling compartment 13 has a concave shape.

[0043] Moreover, the air passage separating wall 39 that is formed into a preset shape and made of synthetic resin is installed in front of a separator 14 so that the circumference portion abuts the cooling compartment separating wall 37.

[0044] In this way, the supply air passage 16 is formed on rear surfaces of the storage compartments 4 to 6 in a manner of being sandwiched between the air passage separating wall 39 and the separator 40. Moreover, on the rear surfaces of the storage compartments 4 to 6, the space portion 14 is formed in a manner of being sandwiched between the separator 40 and the cooling compartment separating wall 37. In this way, in the refrigerator 1 according to this embodiment, because the divide supply air passage 16 and space portion 14 are provided between the storage compartments 4 to 6 and the cooling compartment 13, heat transfer from the cooling compartment 13 to the storage compartments 4 to 6 can be reduced.

[0045] In addition, there are many variations to the abutting positions or joining methods of the separator 40,

the cooling compartment separating wall 37, and the air passage separating wall 39. For example, a structure in which the circumference portions of the separating members 37, 39, and 40 abut the inner side the inner layer 2c of the insulating case 2 (as shown in FIG. 2) or a lower surface of the insulating separating wall 34 may also be adopted.

[0046] In addition, an insulating member (not shown) such as a polystyrene foam (PS) sheet or a polyethylene foam (PE) sheet may also be added on the separator 40, the cooling compartment separating wall 37, and the air passage separating wall 39. In this way, heat resistance between the cooling compartment 13 and the storage compartments 4 to 6 can be increased, and heat transfer from the cooling compartment 13 to the storage compartments 4 to 6 can further be reduced.

[0047] In addition, the freely controllable first opening portion 19 is provided on the separator 40 serving as the separating region between the supply air passage 16 and the space portion 14. In addition, the freely controllable second opening portion 20 is provided in the separating region between the space portion 14 and the return air passage 29. In this embodiment, similar to the air passage control device 18, the so-called motorized shielding plate is used as the first opening portion 19 and the second opening portion 20. In addition, definitely, a control apparatus in another form may also be used as the first opening portion 19 and the second opening portion 20.

[0048] In this way, the refrigerator 1 according to this embodiment is provided with the space portion 14, the first opening portion 19, and the second opening portion 20. Therefore, when the first opening portion 19 and the second opening portion 20 are both set to a closed state, the air supply opening portion 13a can be blocked relative to the supply air passage 16, so as to prevent warm air of the cooling compartment 13 from flowing into the storage compartments 4 to 6.

[0049] In addition, in the refrigerator 1 according to this embodiment, the air passage control device 18 is provided in the supply air passage 15 connected to the space portion 14. Therefore, when the air passage control device 18 is set to a closed state, the supply air passage 15 can be blocked, so as to prevent warm air of the cooling compartment 13 from flowing into the refrigerator compartment 3.

[0050] In addition, the first opening portion 19 and the air passage control device 18 are both set to a closed state, and the second opening portion 20 is set to an open state; in this way, air that flows out from the air supply opening portion 13a sequentially flows through the space portion 14, the second opening portion 20, the return air passage 29, and the return air opening portion 13b, so as to form an air path for the return to the cooling compartment 13, that is, the space portion 14 becomes an air path used for enabling circulation of air of the cooling compartment 13 without flowing into the storage compartments.

[0051] In addition, as shown in FIG. 5(A), the air pas-

sage control device 18 can also be disposed at the separating region between the space portion 14 and the supply air passage 15 rather than being disposed inside the supply air passage 15. In this case, the separator 40 or a part of the cooling compartment separating wall 37 may also be processed and formed into a preset shape to form the separating region. In addition, a separating member may also be used.

[0052] In addition, as shown in FIG. 5(B), the second opening portion 20 may also be disposed on the cooling compartment separating wall 37 serving as the separating region between the space portion 14 and the cooling compartment 13. By using such a structure, the second opening portion 20 may also be set to an open state to enable air to flow from the space portion 14 to the cooling compartment 13.

[0053] In addition, the refrigerator 1 according to this embodiment is provided with a control apparatus that is programmed to control all components and is not shown in the accompanying drawings, and other various sensors, displays, and lighting that are not shown in the accompanying drawings.

[0054] Next, the actions of the refrigerator 1 according to this embodiment are described. First, cooling a storage compartment is described. During cooling, the first opening portion 19 is set to an open state, the second opening portion 20 is set to a closed state, and the air passage control device 18 is suitably opened and closed according to a cooling load of the refrigerator compartment.

[0055] First, the vapor compression freezer circuit is used to cool air that flows through the cooling compartment 13. That is, the compressor 31 as shown in FIG. 2 is used to compress a low-temperature, low-pressure refrigerant vapor into a high-temperature, high-pressure state, a heat sink (not shown) is used to release heat from the refrigerant vapor, and subsequently, a capillary that serves as a decompression unit (also not shown) is used to perform throttling expansion on a liquid refrigerant that is obtained through heat release and condensation by using the heat sink to enable the liquid refrigerant to flow to the condenser 32. In the condenser 32, the low-temperature, low-pressure liquid refrigerant performs heat exchange with the air to evaporate. The result is that air inside the cooling compartment 13 is cooled for latent heat in evaporation of the refrigerant. The vapor refrigerant through evaporation by using the condenser 32 is sucked into the compressor 31 again for compression. The described actions are continuously repeated, and the condenser 32 in the freezer circuit is used to cool the air.

[0056] As shown in FIG. 2 to FIG. 4, air cooled by using the condenser 32 is discharged by the air supply device 30 from the air supply opening portion 13a of the cooling compartment 13 to the space portion 14.

[0057] Moreover, a part of cool air discharged to the space portion 14 is adjusted by the air passage control device 18 to a suitable flow amount, flows to the supply air passage 15, and is provided from the blowing vent 21

to the refrigerator compartment 3. In this way, food and the like stored inside the refrigerator compartment 3 is cooled and preserved at a suitable temperature.

[0058] Cool air provided inside the refrigerator compartment 3 flows from the return air port 26 to the connecting air passage 17, and is provided from the blowing vent 25 to the vegetable compartment 7. Moreover, cool air circulated in the vegetable compartment 7 returns inside the cooling compartment 13 from the return air port 28 through the return air passage 29b and the return air opening portion 13b of the cooling compartment 13. Here, the condenser 32 performs cooling again.

[0059] In another aspect, a part of cool air that is discharged to the space portion 14 flows to the supply air passage 16 through the first opening portion 19, and is provided to the ice-making compartment 4 and the upper layer freezer compartment 5 through the blowing vents 22, 23, respectively. Moreover, the cool air flows to the freezer compartment 6 through the opening portion formed on the separating wall 35.

[0060] Moreover, a part of cool air that flows to the supply air passage 16 through the first opening portion 19 is provided by the blowing vent 24 to the freezer compartment 6. Moreover, air from inside the freezer compartment 6 flows inside the cooling compartment 13 from the return air port 27 through the return air passage 29a and the return air opening portion 13b of the cooling compartment 13. As described above, food and the like are cooled and preserved through circulation of air cooled by the condenser 32 inside the storage compartment.

[0061] Next, referring to FIG. 2 and FIG. 4, defrosting is described according to the control timing diagram in FIG. 6. When cooling continues, frost accumulates on a heat conduction surface on an air side of the condenser 32, which hinders thermal conduction and blocks the air flow path. Therefore, the control apparatus not shown determines frosting according to a drop of an evaporation temperature of a refrigerant and the like, or performs determination by using a defrosting timer, so as to start defrosting for removing frost accumulated on the condenser 32.

[0062] The time T0 in FIG. 6 represents the moment when defrosting starts. In a case of performing defrosting, the control apparatus (not shown) stops the compressor 31, and the air supply device 30, sets both the first opening portion 19 and the second opening portion 20 to a closed state, and sets the supply air passage 15 to a closed state by using the air passage control device 18. Moreover, the defrosting heater 33 is powered.

[0063] In this way, with the heating of the defrosting heater 33, frost attached inside the condenser 32 or the cooling compartment 13 melts. Water melted from the frost flows and drops to an evaporation plate that is disposed inside the mechanical chamber 49 and is not shown through a water discharge pipe that is disposed below the cooling compartment 13 and is not shown. Subsequently, the water in the evaporation plate evaporates with the heat from the compressor 31 and the like.

[0064] The heat generated by the defrosting heater 33 warms the air inside the cooling compartment 13. However, in the refrigerator 1 according to this embodiment, as discussed above, the separator 40 divides a part of the supply air passage 16, the first opening portion 19 and the second opening portion 20 are set to a closed state, and the supply air passage 15 is set to a closed state by using the air passage control device 18; in this way, warm air can be prevented from flowing out to the supply air passages 15, and 16. Therefore, warm air for defrosting can be prevented from warming the interior of the supply air passages 15, and 16.

[0065] The time T1 represents the moment when defrosting stops. The control apparatus detects whether a temperature detected by using a temperature sensor (not shown) installed on the piping of the condenser 32 is at a preset value, so as to determine whether defrosting is complete. In addition, a timer and the like may also be used to perform defrosting at a preset time interval.

[0066] When defrosting of the condenser 32 is complete (time T1), the control apparatus (not shown) stops supplying power to the defrosting heater 33, and stays on standby without performing a next action till preset time (till time T2). In this way, standby time is set to reduce residual frost and cool air inside the condenser.

[0067] Next, at the time T2, the control apparatus starts the compressor 31. In this case, the air supply device 30 is still stopped. In this way, air around the condenser 32 and whose temperature rises because the defrosting heater 33 becomes warm can be effectively cooled without having the air flow outside the cooling compartment 13 (a first pre-cooling step).

[0068] Next, at time T3, the control apparatus sets the second opening portion 20 to an open state, and the air supply device 30 starts to supply air. In this way, the space portion 14 can be used as an air circulation path to enable air circulation inside the cooling compartment 13, and the condenser 32 performs cooling and adjusts the temperature of air inside the space portion 14 and the cooling compartment 13 (a second pre-cooling step).

[0069] Here, in the second pre-cooling step, heat exchange between the heat conduction surface on the air side of the condenser 32 and air is forced-convection heat transfer. Therefore, efficient heat exchange can be performed, and air inside the space portion 14 and the cooling compartment 13 can be effectively cooled within a short time.

[0070] Time T4 represents a moment when the second pre-cooling step ends. Here, the control apparatus detects whether a temperature detected by using a temperature sensor (not shown) disposed inside the cooling compartment 13 is at a preset value (a target cooling temperature), and determines whether the adjustment of the temperature of the air is complete, that is, determines whether the second pre-cooling step ends. In addition, a timer and the like may also be used to perform the second pre-cooling step at a preset time interval.

[0071] When the second pre-cooling step ends (time

T4), the control apparatus sets the first opening portion 19 to an open state, sets the second opening portion 20 to a closed state, sets the air passage control device 18 to an open state, and sends the air that undergoes the adjustment of temperature into the supply air passages 15, 16. Subsequently, cooling is performed.

[0072] In addition, a suitable preferred value may be set for the target cooling temperature in the second pre-cooling step according to a cooling load. Moreover, timing of opening and closing the first opening portion 19, the second opening portion 20, and the air passage control device 18 may also be suitably changed in association with the target cooling temperature. For example, after the cooling is performed to a first target cooling temperature that is set to a high temperature, the first opening portion 19 may also be kept in a closed state, the second opening portion 20 is set to a closed state, and the air passage control device 18 is set to an open state; in this way, the supply air passage 15 enables cool air to flow to the refrigerator compartment 3 only.

[0073] Moreover, when the temperature is further lowered and the cooling is performed to a second target cooling temperature that is lower than the first target cooling temperature, the first opening portion 19 may also be set to an open state, and the supply air passage 16 provides cool air to the ice-making compartment 4, the upper layer freezer compartment 5, and the freezer compartment 6. In this way, efficient cooling may be performed.

[0074] Next, a refrigerator related in a second embodiment of the present invention is described in detail according to the accompanying drawings.

[0075] FIG. 7 is a side sectional view representing the structure of a periphery of a cooling compartment 13 of the refrigerator 1 according to another embodiment. FIG. 8 is a general control timing diagram representing control of defrosting of the refrigerator 1. In addition, for structural elements having the same or similar effects and efficacy as the described refrigerator 1 related in the first embodiment, same reference numerals are marked in FIG. 7 and FIG. 8, and the description of these structural elements are omitted.

[0076] As shown in FIG. 7, in the refrigerator 1 according to this embodiment, inside a return air passage 29a of a freezer compartment 6, an air passage control device 50 is provided at an upstream side of a second opening portion 20, that is, at a side of the freezer compartment 6.

[0077] The air passage control device 50 according to this embodiment and an air passage control device 18 disposed in a supply air passage 15 are both a motorized air gate. In addition, the present invention is not limited thereto, and various other control apparatuses can be used as the air passage control device 50.

[0078] Next, an open/close action of the air passage control device 50 is described according to FIG. 8 and by properly referring to FIG. 7. First, during cooling (after time T4), a control apparatus (not shown) sets the air passage control device 50 to an open state. In this way, air inside the freezer compartment 6 flows through the

return air passage 29a and returns to the cooling compartment 13.

[0079] In another aspect, from when defrosting starts (the time T0) to when the second pre-cooling step ends (the time T4), the control apparatus sets the air passage control device 50 to a closed state and blocks the return air passage 29a. In this way, air inside the cooling compartment 13 in which a defrosting heater is used as a heat source can be prevented or air that is in adjustment of temperature and uses a space portion 14 as an air path from flowing into (flowing back) the freezer compartment 6. The result is that a temperature rise in storage compartments 4 to 6 caused by defrosting can be restricted.

[0080] In addition, in the second embodiment described above, the structure of the air passage control device 18 or the second opening portion 20 may also be implemented as the variation shown in FIG. 5.

[0081] As set forth above, the refrigerator 1 according to the embodiments of the present invention is described. However, the present invention is not limited thereto, and various changes may be made without departing from the scope of the concept of the present invention.

Claims

1. A refrigerator, comprising:

a storage compartment;
a supply air passage, adapted for enabling air to flow into the storage compartment;
a return air passage, adapted for enabling the air from the storage compartment to flow through;
a cooling compartment, having an air supply opening portion adapted for enabling the air to flow out from the supply air passage and a return air opening portion for enabling the air from the return air passage to flow in;
a condenser, disposed inside the cooling compartment adapted for cooling the air that flows in from the return air opening portion; and
an air supply device, disposed on the air supply opening portion,
wherein, in the refrigerator, the exterior of the cooling compartment comprises:

a separator, at least dividing a part of the supply air passage to form a space portion, the space portion being connected to the cooling compartment through the air supply opening portion;
a freely controllable first opening portion, disposed in a separating region between the space portion and the divided supply air passage; and
a freely controllable second opening por-

tion, disposed in a separating region between the space portion and the return air passage or between the space portion and the cooling compartment.

2. The refrigerator according to claim 1, wherein the storage compartment is at least divided into a refrigerator compartment and a freezer compartment, and the supply air passage is at least provided with a freezer supply air passage used for enabling the air to flow to the freezer compartment; the separator is configured to divide the freezer supply air passage and the idle portion; and the first opening portion is through enabled to be in a closed state, and the second opening portion is enabled to be in an open state, so that the space portion becomes an air path used for the air that flows out from the air supply opening portion of the cooling compartment to flow from the return air opening portion to the cooling compartment.

3. The refrigerator according to claim 2, wherein the supply air passage is provided with a refrigerator supply air passage for enabling the air to flow to the refrigerator compartment; and the refrigerator supply air passage is connected to the space portion, and an air passage control device is provided in the refrigerator supply air passage.

4. An operating method of a refrigerator, wherein the refrigerator comprises:

a storage compartment;
a supply air passage, adapted for enabling air to flow into the storage compartment;
a return air passage, adapted for enabling the air from the storage compartment to flow through;
a cooling compartment, having an air supply opening portion adapted for enabling the air to flow out from the supply air passage and a return air opening portion used for enabling the air from the return air passage to flow in;
a condenser, disposed inside the cooling compartment, and used for cooling the air that flows in from the return air opening portion; and
an air supply device, disposed on the air supply opening portion,
wherein, in the refrigerator, the exterior of the cooling compartment comprises:

a separator, at least dividing a part of the supply air passage to form a space portion, the space portion being connected to the cooling compartment through the air supply opening portion;
a freely controllable first opening portion, disposed in a separating region between

the space portion and the divided supply air passage; and

a freely controllable second opening portion, disposed in a separating region between the space portion and the return air passage or between the space portion and the cooling compartment; and

wherein, in operation, the first opening portion is set to a closed state, the second opening portion is set to an open state, the space portion is used as an air path for circulation of the air to the cooling compartment, the condenser performs cooling, and the air supply device supplies air, so as to adjust the temperature of the air inside the space portion and the cooling compartment.

5. The operating method of the refrigerator according to claim 4, wherein after the temperature of the air inside the space portion and the cooling compartment are adjusted, the first opening portion is set to an open state, the second opening portion is set to a closed state, and the supply air passage provides the air that undergoes the adjustment of temperature to the storage compartment. 20
6. The operating method of the refrigerator according to claim 5, wherein 30
the refrigerator is provided with a defrosting unit for defrosting the cooling compartment; and
the first opening portion and the second opening portion are both set to a closed state, the defrosting unit performs defrosting, and after the defrosting stops, the second opening portion is set to an open state, so as to adjust the temperature of the air inside the space portion and the cooling compartment. 35
7. The operating method of the refrigerator according to claim 4, wherein, in the refrigerator, the storage compartment is at least divided into a refrigerator compartment and a freezer compartment, the supply air passage is at least provided with: 40

a freezer supply air passage, adapted for enabling the air to flow into the freezer compartment, and being separated by the separator and the space portion; and 45

a refrigerator supply air passage, adapted for enabling the air to flow into the refrigerator compartment, connected to the space portion, and an air passage control device being provided inside the refrigerator supply air passage, wherein the first opening portion is set to a closed state, the second opening portion is set to an open state, and the refrigerator supply air passage is set to a closed state by using the air passage control device, so as to adjust the tem- 50 55

perature of the air inside the space portion and the cooling compartment.

8. The operating method of the refrigerator according to claim 7, wherein after the temperature of the air inside the space portion and the cooling compartment is adjusted, the first opening portion is set to an open state, the second opening portion is set to a closed state, the refrigerator supply air passage is set to an open state by using the air passage control device, and the freezer supply air passage or the refrigerator supply air passage provides the air that undergoes the adjustment of temperature to the freezer compartment or the refrigerator compartment, respectively. 5
9. The operating method of the refrigerator according to claim 8, wherein 10
the refrigerator is provided with a defrosting unit for defrosting the cooling compartment; and
the first opening portion and the second opening portion are both set to a closed state, the refrigerator supply air passage is set to a closed state by using the air passage control device, the defrosting unit performs defrosting, and after the defrosting stops, the second opening portion is set to an open state, so as to adjust the temperature of the air inside the space portion and the cooling compartment. 15

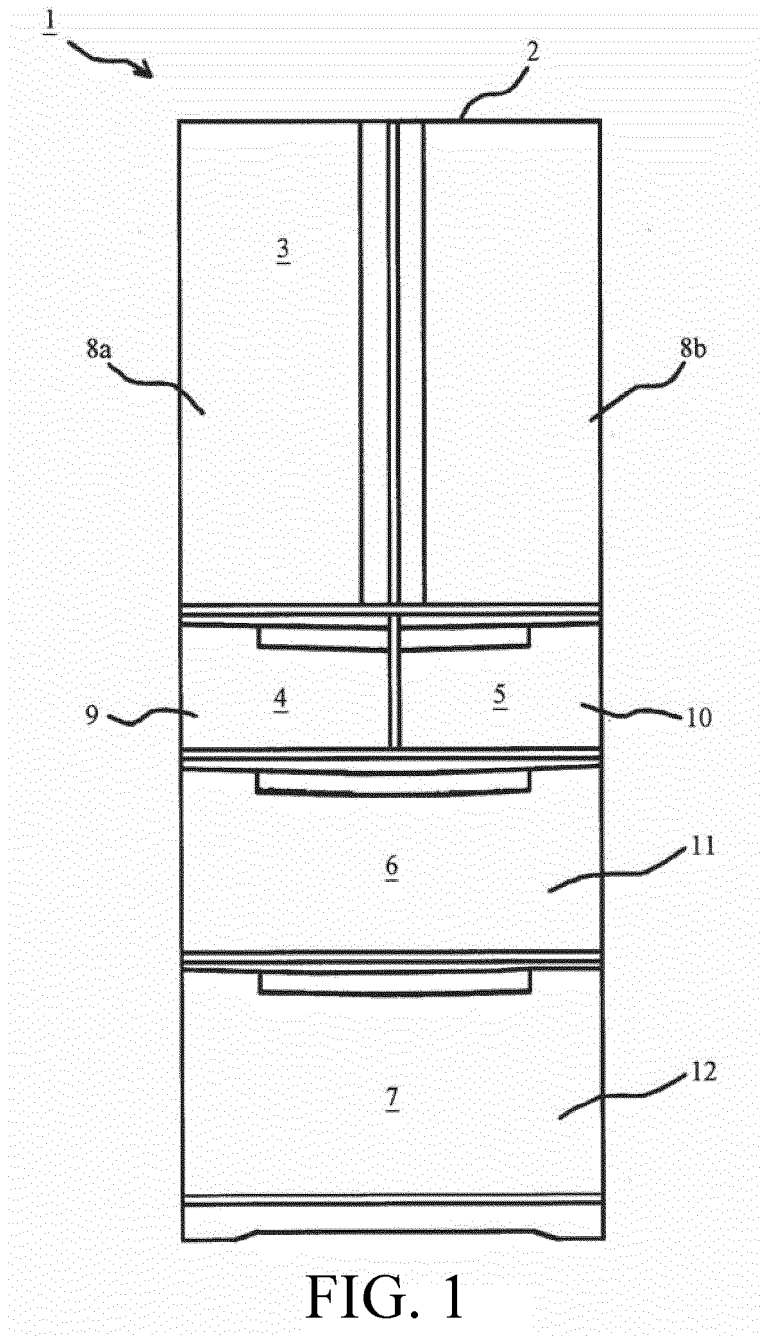
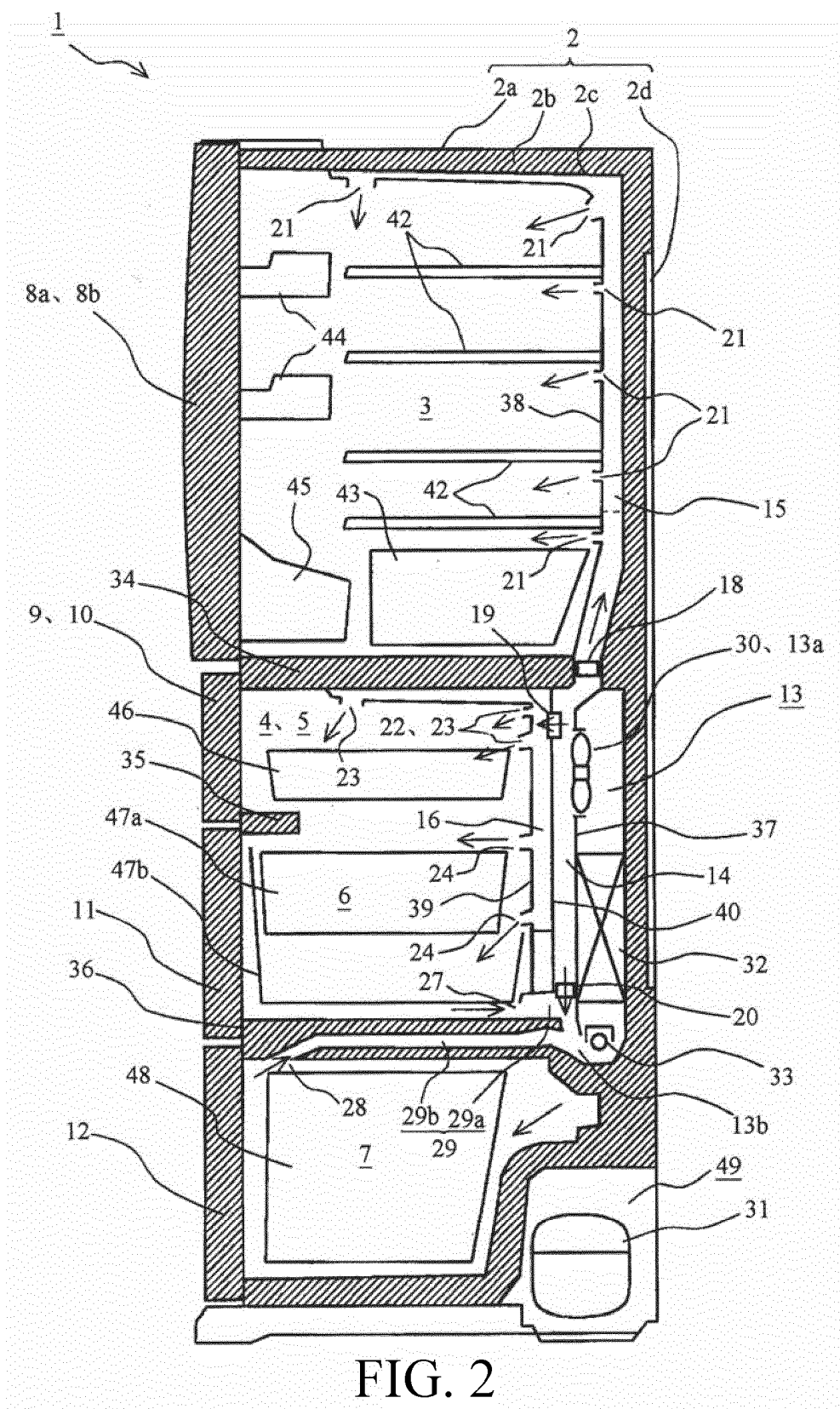


FIG. 1



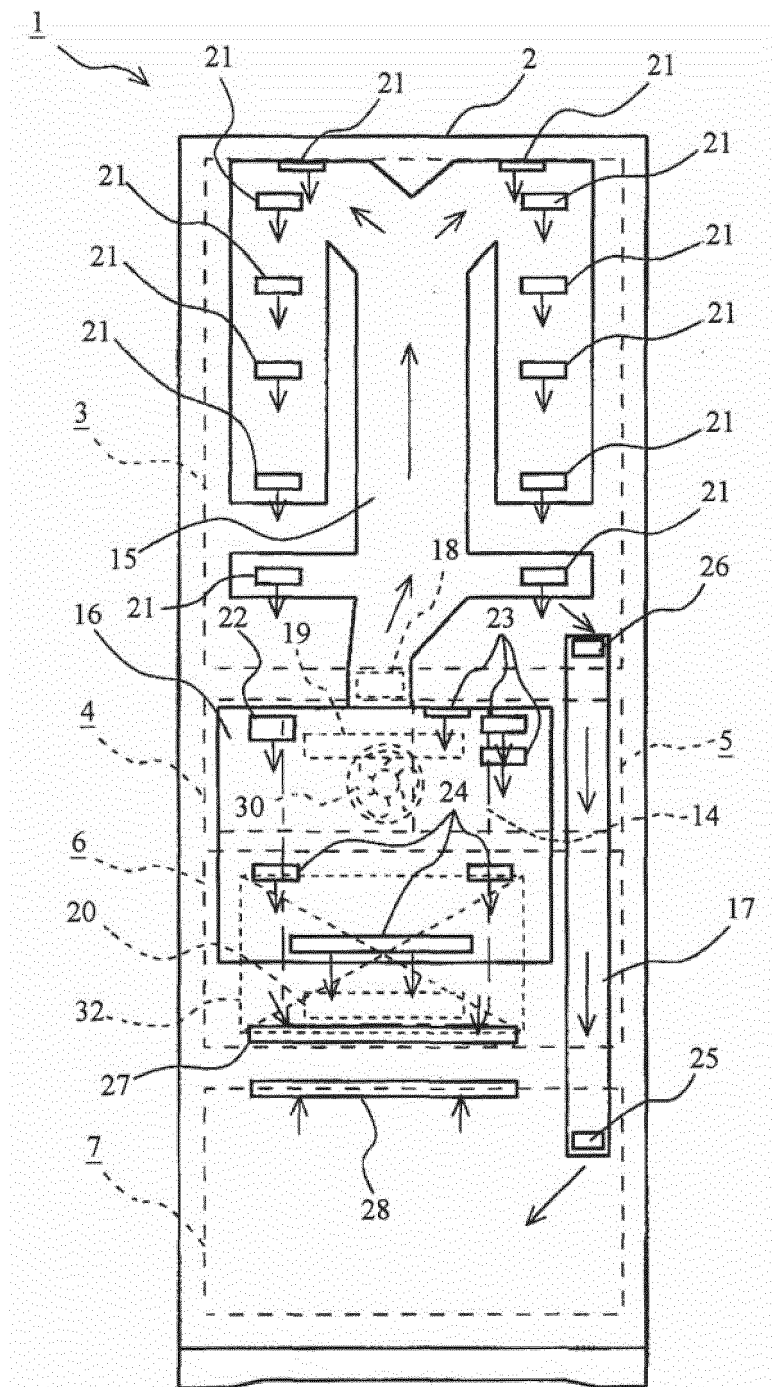


FIG. 3

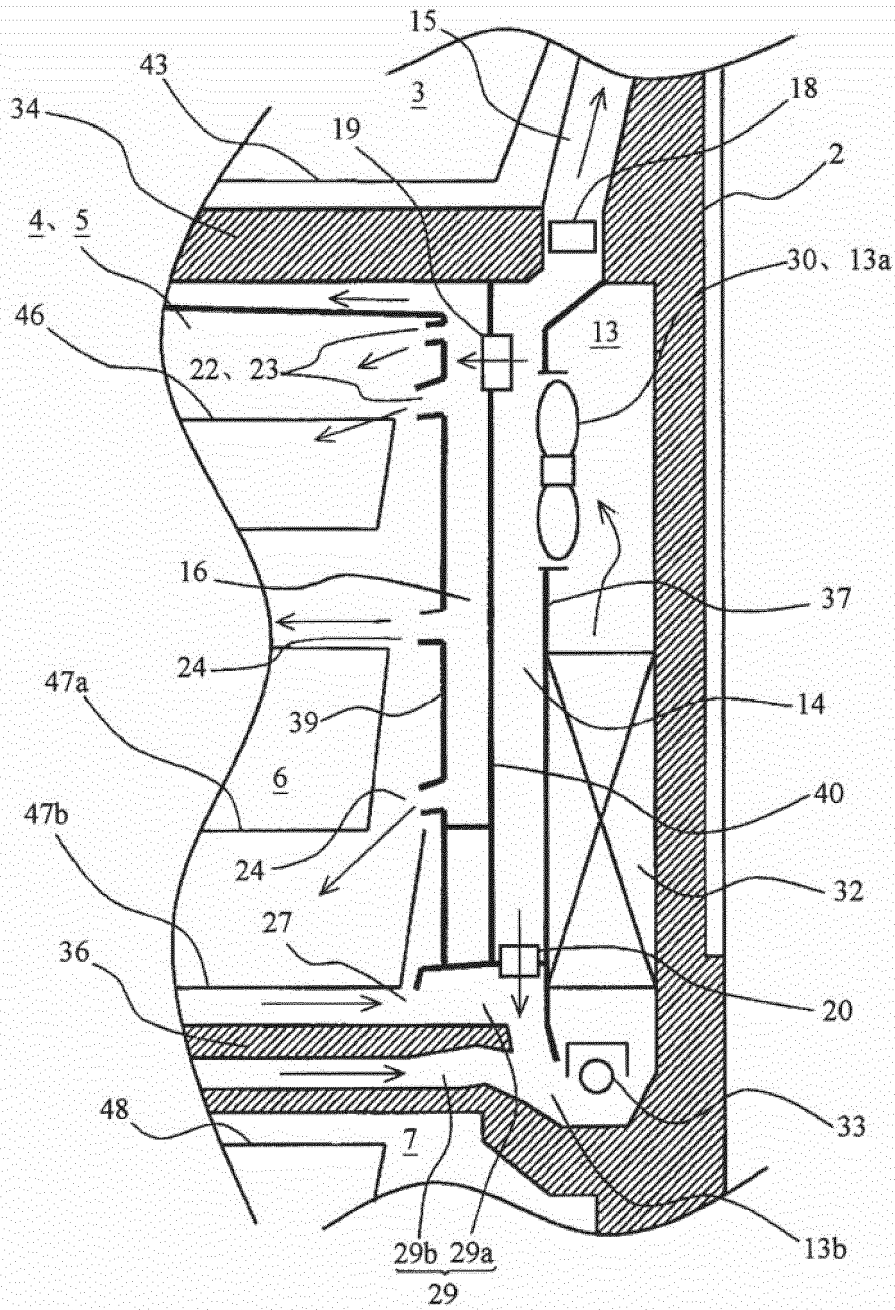
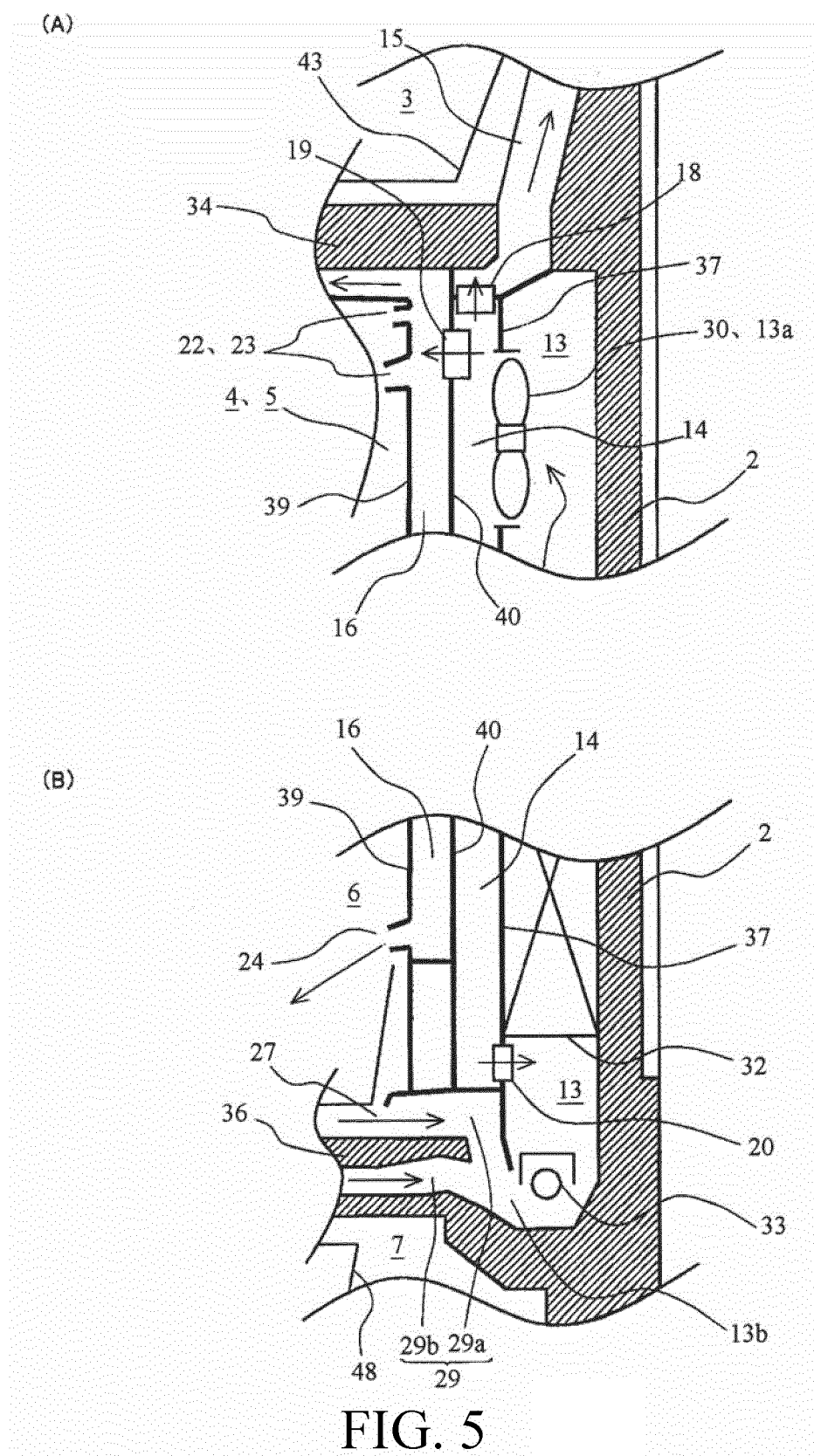


FIG. 4



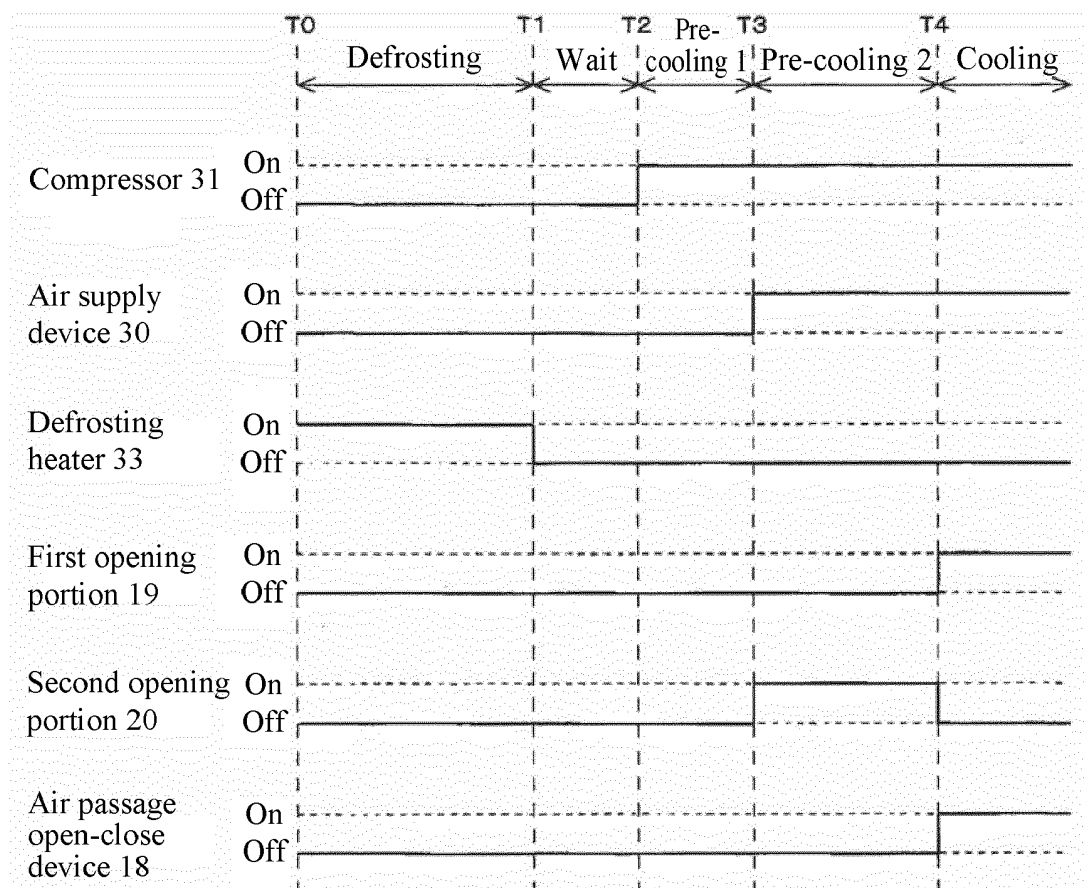


FIG. 6

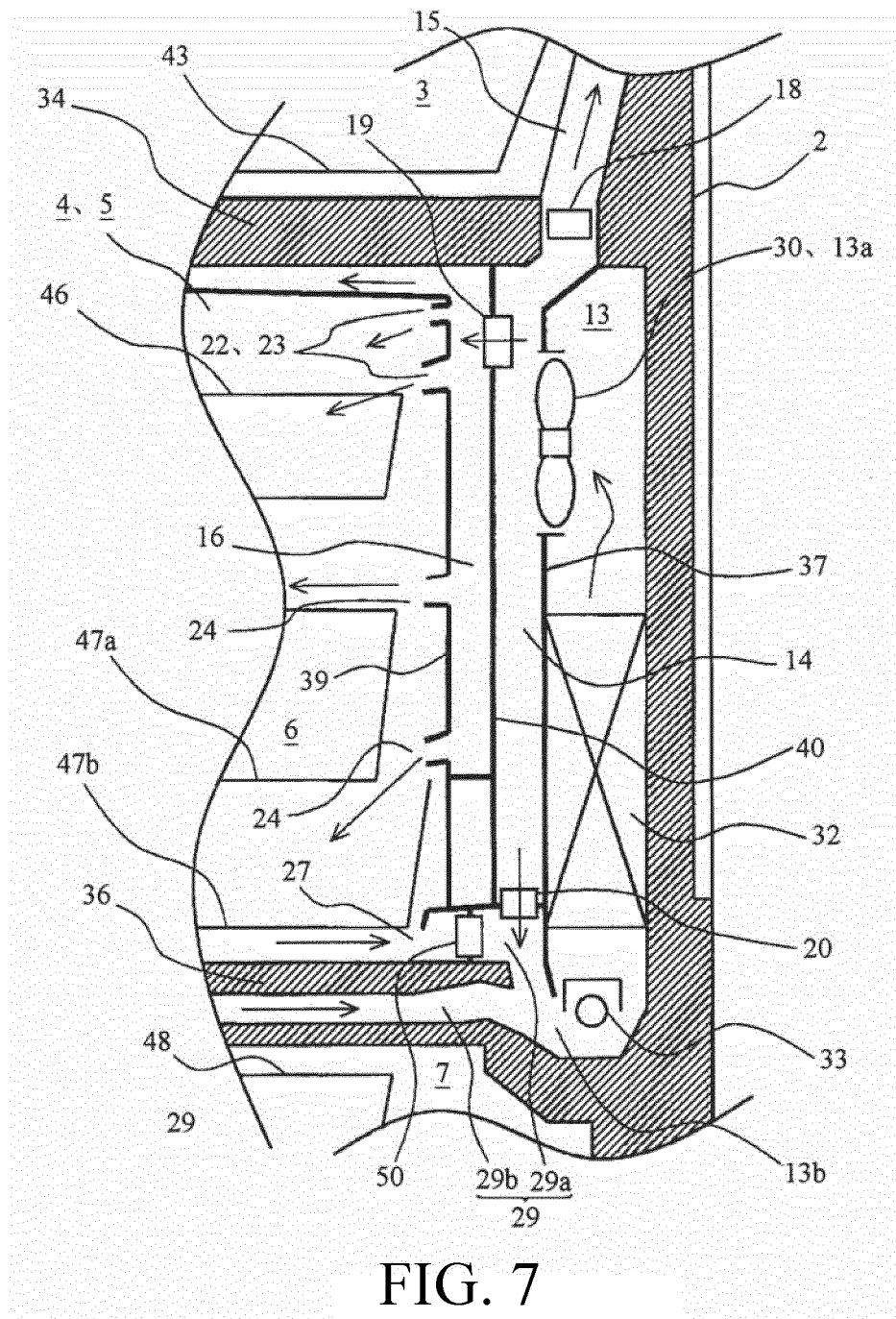
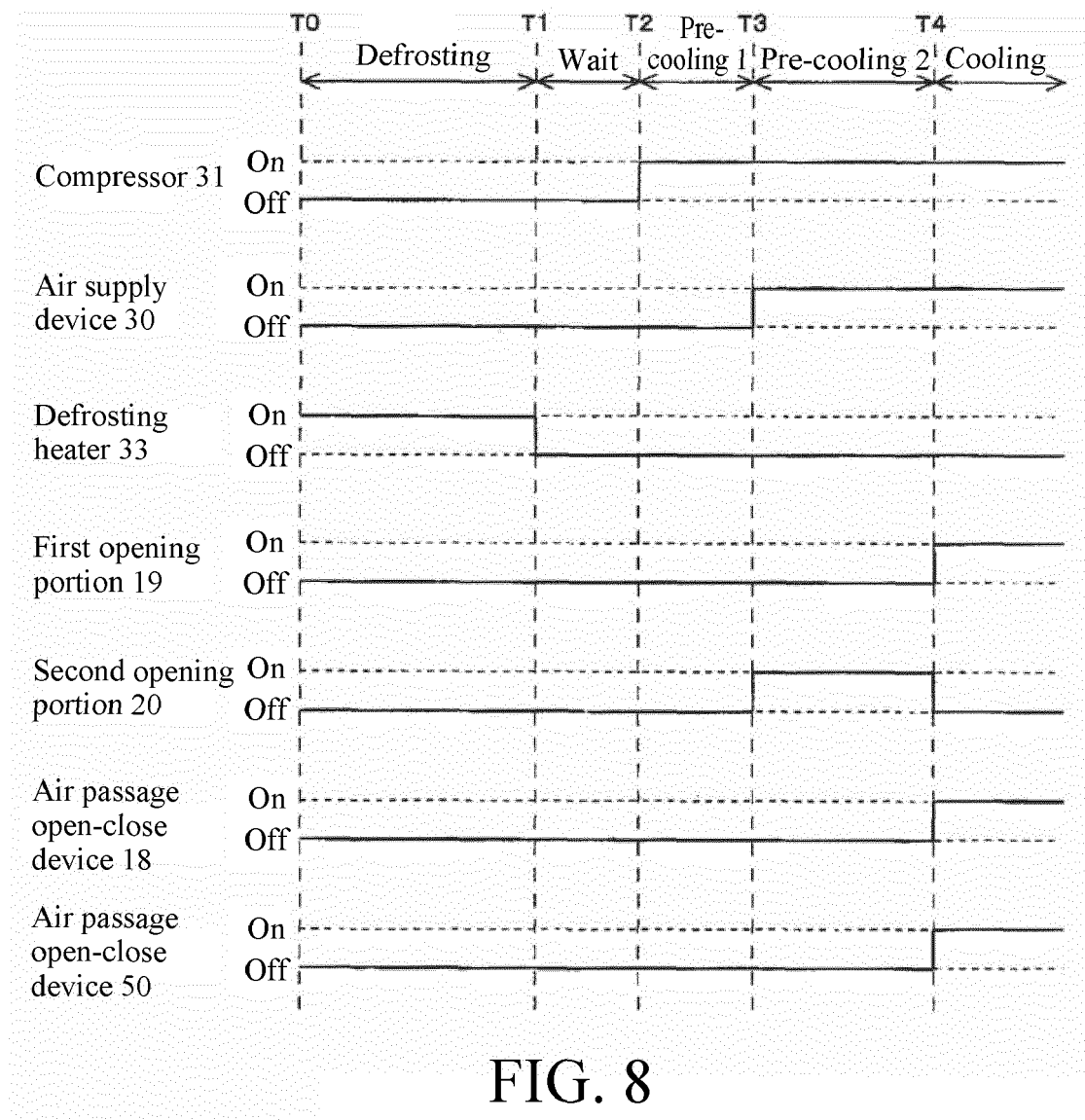
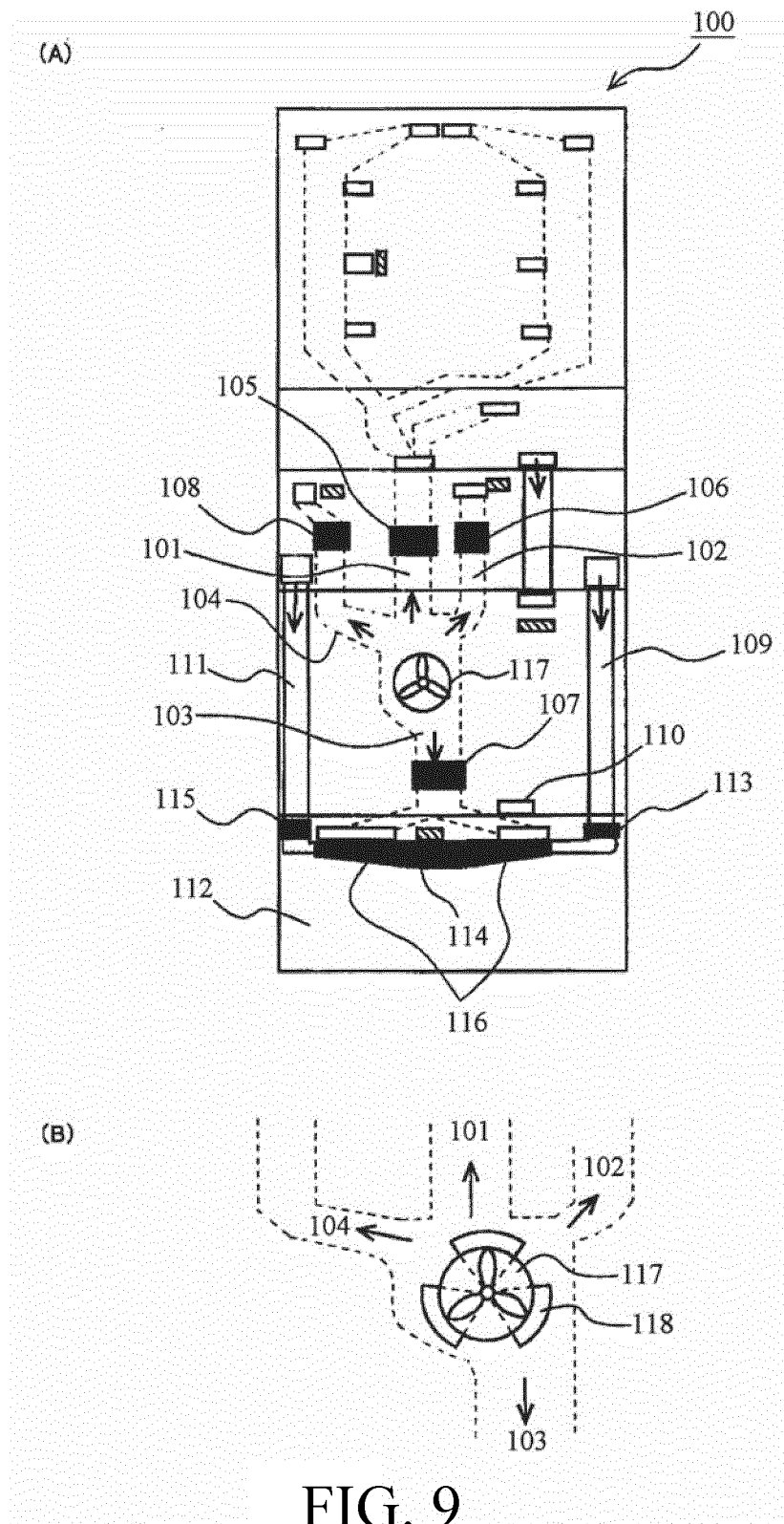


FIG. 7





INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/073215

A. CLASSIFICATION OF SUBJECT MATTER

F25D 17/06 (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)

IPC: F25D 17/-

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

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

CNPAT, CNKI, CNTXT, WPI, EPODOC: CA, ISI web of knowledge, Elsevier Science Direct, air feeding, refrigerator, compart, spacing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102261790 A (HITACHI APPLIANCES, INC.), 30 November 2011 (30.11.2011), claim 1, and figure 2	1-9
A	CN 102022888 A (HITACHI APPLIANCES, INC.), 20 April 2011 (20.04.2011), abstract, and figure of the abstract	1-9
A	CN 101968295 A (HITACHI APPLIANCES, INC.), 09 February 2011 (09.02.2011), abstract, and figure of the abstract	1-9
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☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search 07 June 2013 (07.06.2013)	Date of mailing of the international search report 04 July 2013 (04.07.2013)
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer SHI, Yanwei Telephone No.: (86-10) 82245730

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

INTERNATIONAL SEARCH REPORT
 Information on patent family members

International application No.

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Form PCT/ISA/210 (patent family annex) (July 2009)

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