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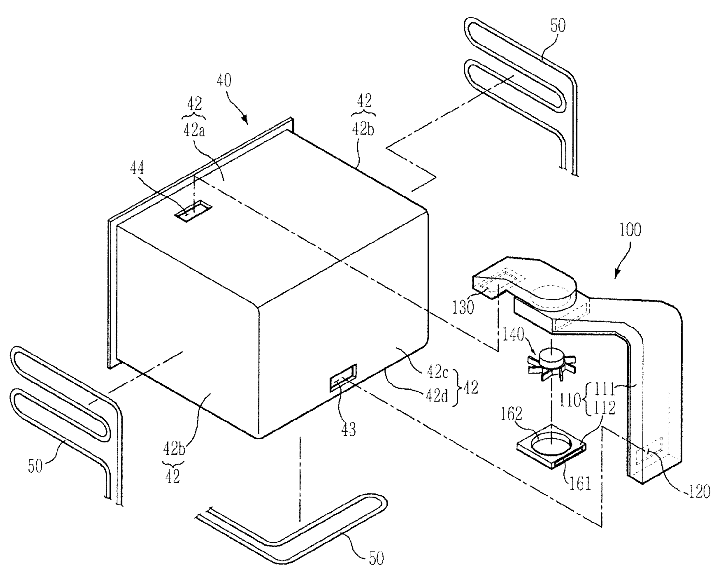
(54) Direct cooling refrigerator and control method thereof

(57) A direct cooling refrigerator having a circulation duct. The direct cooling refrigerator includes a cabinet, an inner case arranged in the cabinet and having an inlet and an outlet, a circulation duct coupled to the inner case at the outside of the inner case and having a suction port communicating with the outlet and a discharge port communicating with the inlet, and a fan to move air from the suction port to the discharge port within the circulation duct. The inlet is located at an upper wall of the inner case so as to be located closer to a front surface of the inner case than a rear wall of the inner case, and the outlet is located at the rear wall of the inner case so as to be located close to a lower wall of the inner case.

FIG. 3



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Description

BACKGROUND

1. Field

[0001] Embodiments of the present disclosure relate to a direct cooling refrigerator which includes a circulation duct to reduce temperature deviation in a storage compartment and performs natural defrosting without a heater attached to an evaporator.

2. Description of the Related Art

[0002] In general, a refrigerator includes a compressor, condenser, expansion valve and evaporator and is designed to keep various kinds of food fresh for a long time using heat transfer depending on phase change of a refrigerant.

[0003] Cooling types of refrigerators may be classified into a direct cooling type and an indirect cooling type. Direct cooling type refrigerators cool the interior of a storage compartment via natural convection of cold air generated from an evaporator. Indirect cooling type refrigerators cool the interior of a storage compartment by forcibly circulating cold air using a fan.

[0004] In recent years, a kimchi refrigerator, which is designed to ripen kimchi and keep the ripened kimchi fresh, has been marketed. Such a kimchi refrigerator generally employs the direct cooling type using natural convection of an evaporator in order to keep food fresh.

[0005] The direct cooling type kimchi refrigerator, however, exhibits temperature deviation between an upper region and a lower region of the storage compartment. Moreover, in the case of a kimchi refrigerator provided with a drawer type door, a front region of the storage compartment adjacent to the door is exposed when the door is opened, causing significant loss of cold air therefrom.

[0006] Thus, natural convection of the evaporator and the drawer type door cause temperature deviation between a front upper region and a front lower region of the storage compartment. To reduce such temperature deviation, a method of raising the temperature of the lower region of the storage compartment using a heater installed near the bottom of the storage compartment to allow air to move from the lower region to the upper region of the storage compartment has been used.

[0007] An evaporator is installed at the outside of the upper region of the storage compartment so as to cool the upper region of the storage compartment having a relatively high-temperature. Temperature difference between the exterior of the storage compartment where the evaporator is installed and an upper inner wall of the storage compartment causes water vapor to condense on the upper inner wall of the storage compartment. To prevent condensed water from falling upon food, the upper inner wall of the storage compartment is provided with a dew condensation structure.

[0008] A conventional direct cooling type kimchi refrigerator includes an extra heater to remove frost from the inner wall of the storage compartment, thus requiring additional power to operate the heater.

[0009] Most conventional refrigerators provide an evaporator with an extra heater or operate a fan in order to remove frost generated on a surface of the evaporator, but operating the heater or fan increases power consumption.

SUMMARY

[0010] Therefore, it is one aspect of the present disclosure to provide a direct cooling type refrigerator having a circulation duct.

[0011] It is another aspect of the present disclosure to provide a direct cooling type refrigerator to reduce temperature deviation within a storage compartment without operating a heater.

[0012] It is a further aspect of the present disclosure to provide a direct cooling type refrigerator to defrost an evaporator without installing an extra heater to the evaporator.

[0013] Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

[0014] In accordance with one aspect of the present disclosure, a direct cooling type refrigerator includes a cabinet, an inner case arranged in the cabinet and having an inlet and an outlet, a circulation duct coupled to the inner case at the outside of the inner case and having a suction port communicating with the outlet and a discharge port communicating with the inlet, and a fan to move air from the suction port to the discharge port within the circulation duct, wherein the inlet is located at an upper wall of the inner case so as to be located closer to a front surface of the inner case than a rear wall of the inner case, and wherein the outlet is located at the rear wall of the inner case so as to be located close to a lower wall of the inner case.

[0015] The fan may be located at the outside of the upper wall of the inner case.

[0016] The fan may be spaced apart from the discharge port by a predetermined distance rearward of the inner case.

[0017] The fan may be a centrifugal fan to discharge air in a radial direction thereof.

[0018] The refrigerator may further include an evaporator to cool a storage compartment, and the evaporator may be arranged close to a left wall, a right wall and the lower wall of the inner case.

[0019] In accordance with another aspect of the present disclosure, a direct cooling type refrigerator includes a cabinet, a storage compartment defined in the cabinet, an inner case in which the storage compartment is defined, the inner case having an opening at a front surface thereof, and a circulation duct arranged at the outside of the inner case to communicate with the inner case so as to circulate air of the storage compartment.

[0020] The circulation duct may extend from the outside of a rear wall of the inner case to the outside of an upper wall of the inner case.

[0021] The circulation duct may include a suction path into which the air of the storage compartment is suctioned, a discharge path from which the air is discharged into the storage compartment and a fan mounting region located between the suction path and the discharge path.

[0022] The circulation duct may further include a fan mounted in the fan mounting region to move the air from the suction path to the discharge path.

[0023] The fan mounting region may have an open bottom to allow the fan to be installed therein.

[0024] A length of the suction path may be greater than a length of the discharge path.

[0025] The discharge path may be located at the outside of an upper wall of the inner case to guide the air in a longitudinal direction of the upper wall of the inner case.

[0026] The refrigerator may further include an evaporator to cool the storage compartment, and the evaporator may be arranged close to a left wall, a right wall and a lower wall of the inner case.

[0027] In accordance with another aspect of the present disclosure, a direct cooling type refrigerator includes a cabinet, an inner case arranged in the cabinet and having an opening at a front surface thereof, a storage compartment defined in the inner case, a door slidably coupled to the inner case to open or close the opening, an outlet formed in a rear wall of the inner case, through which air is discharged from the storage compartment, an inlet formed in an upper wall of the inner case, through which air is suctioned into the storage compartment, a circulation duct arranged at the outside of the inner case and having a suction port communicating with the outlet and a discharge port communicating with the inlet, and a fan arranged around the discharge hole to move air within the circulation duct.

[0028] In accordance with a further aspect of the present disclosure, a control method of a direct cooling type refrigerator includes sensing temperature of an evaporator using an evaporator sensor installed to the evaporator, sensing interior temperature of the refrigerator using a temperature sensor, and controlling On/Off operations of a cooling system and a fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator, enabling natural defrosting of the evaporator.

[0029] The evaporator sensor may be closely attached to the evaporator without a gap.

[0030] Controlling On/Off operations of the cooling system and the fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator may include controlling the cooling system and the fan to be turned on only when the temperature sensed by the evaporator sensor is equal to or greater than a predetermined reference temperature.

[0031] Controlling On/Off operations of the cooling system and the fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator may include starting a cooling operation when the interior temperature of the refrigerator sensed by the temperature sensor reaches an On temperature of the temperature sensor if the interior temperature of the refrigerator reaches the On temperature later than the temperature sensed by the evaporator sensor.

[0032] Controlling the On/Off operations of the cooling system and the fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator may include starting a cooling operation after waiting until the temperature sensed by the evaporator sensor reaches the On temperature of the temperature sensor if the interior temperature of the refrigerator reaches the On temperature faster than the temperature sensed by the evaporator sensor.

[0033] Controlling the On/Off operations of the cooling system and the fan may include repeating a cycle consisting of a natural defrosting period from Off time of the cooling system to Off time of the fan and a rest period from Off time of the fan to time when the cooling system and the fan are again turned on.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a perspective view illustrating a kimchi refrigerator in accordance with an embodiment of the present disclosure;

FIG. 2 is an exploded perspective view illustrating major components of the kimchi refrigerator in accordance with the embodiment of the present disclosure;

FIG. 3 is a perspective view illustrating a circulation duct mounted to an inner case of the kimchi refrigerator in accordance with the embodiment of the present disclosure;

FIG. 4 is a sectional view of the kimchi refrigerator in accordance with the embodiment of the present disclosure;

FIG. 5 is a view illustrating operation of the circulation duct in the kimchi refrigerator in accordance with the embodiment of the present disclosure;

FIG. 6 is a schematic view illustrating a defrosting device of a kimchi refrigerator in accordance with another embodiment of the present disclosure; and

FIGS. 7A to 7C are timing diagrams illustrating defrosting operations of the kimchi refrigerator in accordance with another embodiment of the present disclosure.

DETAILED DESCRIPTION

[0035] Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. Hereinafter, a direct cooling type kimchi refrigerator will be described as an example of a direct cooling type refrigerator.

[0036] FIG. 1 is a perspective view illustrating a kimchi refrigerator in accordance with an embodiment of the present disclosure, and FIG. 2 is an exploded perspective view illustrating major components of the kimchi refrigerator in accordance with the embodiment of the present disclosure.

[0037] As illustrated in FIGS. 1 and 2, the kimchi refrigerator 1 includes a cabinet 10, a first storage compartment 11 in which food such as kimchi is stored, and a door 30 to open or close the storage compartment 11.

[0038] The cabinet 10 defines the external appearance of the kimchi refrigerator 1. A machine room (not shown) in which a plurality of machine parts is accommodated may be defined in the cabinet 10. An operating panel (not shown) may be provided at one side of the cabinet 10 to allow a user to input, e.g., kinds, ripening time and storage temperature conditions of food stored in the storage compartment 11.

[0039] The machine room may accommodate a compressor (not shown) to compress a refrigerant and a condenser (not shown) to condense the refrigerant fed from the compressor. The machine room (not shown) is isolated from a storage compartment 12.

[0040] The first storage compartment 11 is defined in the cabinet 10. A storage container 80 in which food such as kimchi is stored is put into a basket 70 and the basket 70 is in turn accommodated in the storage compartment 12. In addition to the first storage compartment 11, the kimchi refrigerator 1 may further include second and third storage compartments 12 and 12'.

[0041] The first, second and third storage compartments 11, 12 and 12' are opened or closed respectively by first, second and third doors 20, 30 and 30'. The first door 20 may be pivoted to or from the cabinet 10 so as to open or close the first storage compartment 11. The first door 20 may be hinged to the cabinet 10 using a hinge device 21. The second door 30 and the third door 30' may be drawer type doors. The second door 30 and the third door 30 are slidable into or from the cabinet 10 so as to open or close the second storage compartment 12 and the third storage compartment 12'.

[0042] The first door 20 of a pivoting opening/closing type is provided with a home-bar 22 to assist in storing food that is frequently accessed.

[0043] Hereinafter, the second storage compartment 12 and the second door 30 are simply named respectively as the storage compartment 12 and the door 30 and will be described in more detail below.

[0044] The storage compartment 12 is defined in an inner case 40, a front side of which is open. The inner case 40 is mounted in the cabinet 10. A foam material 14 to thermally insulate the storage compartment 12, such as foamed polyurethane, fills a space between the cabinet 10 and the inner case 40.

[0045] The space filled with the foam material 14 is provided with the evaporator 50 through which refrigerant moves to keep the interior of the storage compartment 12 at a low temperature. The evaporator 50 may take the form of a refrigerant pipe. Also, the evaporator 50 is arranged to come into close contact with an outer wall surface of the inner case 40 so as to surround left and right sides and a lower side of the storage compartment 12.

[0046] A framed support member 31 is coupled to a rear surface of the door 30. The basket 70 is separably disposed and supported on the framed support member 31.

[0047] The basket 70 may be made of plastic and may have a top-opened box shape. The basket 70 provides a storage space and the storage container 80 in which, e.g., kimchi is stored is accommodated in the storage space.

[0048] The basket 70 has flanges 71 formed at left and right upper ends thereof to extend outward by a length suitable to allow the basket 70 to be separably disposed on the framed support member 31. The flanges 71 may be integrally formed with the basket 70.

[0049] The basket 70 may undergo repeated expansion and contraction. Thus, to prevent the plastic basket 70 from being deformed due to the repeated expansion and contraction, a deformation-proof member 72 may be provided at the basket 70. The deformation-proof member 72 may be mounted to a lower outer surface of the basket 70.

[0050] The framed support member 30 may be provided at left and right frames thereof with moving rails 61 to allow the door 30 to slide relative to the inner case 40 so as to open or close the storage compartment 12. Also, stationary rails 62 may be mounted to left and right inner surfaces of the inner case 40 such that the moving rails 61 of the framed support member 31 are slidably coupled to the stationary rails 62. The stationary rails 62 may extend in a direction in which the door 30 moves. As the moving rails 61 mounted to the framed support member 30 slide on the stationary rails 62, the basket 70 supported on the framed support member 30 is moved forward or rearward.

[0051] If the kimchi refrigerator 1 begins to be operated, the temperature of the storage compartment 12 rapidly drops by the evaporator 50 installed to come into contact with the outer wall surface of the inner case 40. In this case, convection of air within the storage compartment 12 causes temperature deviation between an upper region and a lower region of the storage compartment 12. In particular, significant temperature difference occurs between a front upper region of the storage compartment 12 adjacent to the door 30 and a rear lower region of the storage compartment 12.

[0052] To solve the temperature deviation by circulating the interior air of the storage compartment 12, the kimchi refrigerator 1 includes a circulation duct 100.

[0053] FIG. 3 is a perspective view illustrating the circulation duct mounted to the inner case of the kimchi refrigerator in accordance with the embodiment of the present disclosure, and FIG. 4 is a sectional view of the kimchi refrigerator in accordance with the embodiment of the present disclosure.

[0054] As illustrated in FIGS. 3 and 4, the circulation duct 100 is mounted to the inner case 40.

[0055] The inner case 40 includes a front opening 41 and walls 42 including an upper wall 42a, left and right walls 42b, a rear wall 42c and a lower wall 42d. The rear wall 42c may be separably coupled.

[0056] The evaporator 50 is arranged at the left and right walls 42b and the lower wall 42d. The evaporator 50 may come into contact with the respective walls 42b and 42d to cool the walls 42b and 42d. Since low-temperature cold air may be fed to the upper region of the storage compartment 12 by the circulation duct 100 which will be described hereinafter, the evaporator 50 is not present on the upper wall 42a of the inner case 40. Thus, the upper wall 42a of the inner case 40 is free from formation of frost, which eliminates the necessity of a conventional dew condensation structure used to prevent condensed water from falling upon food.

[0057] The rear wall 42c and the upper wall 42a may be respectively provided with an outlet 43 and an inlet 44, both of which communicate with the circulation duct 100 located at the outside of the inner case 40. As such, the low-temperature air of the storage compartment 12 can circulate through the outlet 43, the circulation duct 100 and the inlet 44 in order.

[0058] The low-temperature air of the storage compartment 12 cooled by the evaporator 50 is present in the lower region of the storage compartment 12 by natural convection. Also, due to the fact that the storage compartment 12 has an open front side, the temperature of air present in the rear region of the storage compartment 12 may be less than the temperature of air present in the front region of the storage compartment 12. Thus, the outlet 43 may be located at a lower position of the rear wall 42c, to allow the low-temperature air present in the rear lower region of the storage compartment 12 to be fed into the circulation duct 100. The outlet 43 may be located close to the lower wall 42d.

[0059] On the contrary, the air present in the front upper region of the storage compartment 12 has a relatively high temperature. Thus, as a result that the low-temperature air discharged from the outlet 43 is guided into the front upper region of the storage compartment 12, the entire storage compartment 12 may have a uniform interior temperature. The inlet 44 may be located at a front position of the upper wall 42a to communicate the front upper region of the storage compartment 12 with the outside of the storage compartment 12. That is to say, the inlet 44 may be located closer to the opening 41 than the rear wall 42c.

[0060] The circulation duct 100 is coupled to the inner case 40 at the outside of the inner case 40. If the circulation duct 100 is placed within the inner case 40, the interior space of the storage compartment 12 is reduced, resulting in a reduced food storage capacity.

[0061] The circulation duct 100 includes a housing 110 defining the external appearance of the circulation duct 100, a suction port 120 and a discharge port 130 communicating with the outside of the circulation duct 100, and a blower 140.

[0062] The housing 110 may include a first housing 111 and a second housing 112 coupled to each other. In this case, the suction port 120 and the discharge port 130 may be arranged at the first housing 111 and the blower 140 may be provided at the second housing 112.

[0063] The suction port 120 has a shape corresponding to the outlet 43 of the inner case 40 so as to communicate with the outlet 43. The low-temperature air of the storage compartment 12 is discharged from the inner case 40 through the outlet 43 and is suctioned into the inner case 40 through the inlet 44.

[0064] The discharge port 130 has a shape corresponding to the inlet 44 of the inner case so as to communicate with the inlet 44. The interior air of the circulation duct 100 is discharged from the discharge port 130 to the inner case 40 and is introduced into the storage compartment 12 through the inlet 44 of the inner case 40.

[0065] The circulation duct 100 extends upward from a lower end of the rear wall 42c of the inner case 40 and is bent near a corner at which the rear wall 42c and the upper wall 42a meet so as to extend forward of the inner case 40.

[0066] The blower 140 serves to circulate the interior air of the storage compartment 12 through the circulation duct 100. The blower 140 may include a fan 142 to move the air through the circulation duct 100 and a fan motor 141 coupled to the fan 142 to drive the fan 142.

[0067] The blower 140 generates heat during operation thereof. To minimize transfer of the generated heat into the storage compartment 12, the blower 140 may be arranged at the outside of the upper wall 42a of the inner case 40. The blower 140 may be spaced apart rearward from the inner case 40 by a predetermined distance.

[0068] The fan 142 is arranged within the housing 110 and serves to suction air through the suction port 120 and discharge the air through the discharge port 130. The fan 142 may be a centrifugal fan to discharge air in a radial direction.

[0069] The housing 110 internally defines a circulation path 150 connecting the suction port 120 and the discharge port 130 to each other and a fan mounting region 153 in which the blower 140 is mounted. The circulation path 150 and the fan mounting region 153 may be defined in the first housing 111.

[0070] The circulation path 150 may include a suction path 151 to suction air through the suction port 120 and a discharge path 152 to discharge the air through the discharge port 130. The fan mounting region 153 is located between the suction path 151 and the discharge path 152.

[0071] The fan mounting region 153 communicates with the suction path 151 and the discharge path 152. The first housing 111 may have a bottom opening having a shape corresponding to the second housing 112. The blower 140 may be mounted in the fan mounting region 153 and then, the second housing 112 may be coupled to the opening of the first housing 111 below the fan mounting region 153.

[0072] The second housing 112 has an entrance 161 communicating with the suction path 151 and an exit 162 communicating with the discharge path 152. The second housing 112 may also have a blowing path 160 defined therein to connect the entrance 161 and the exit 162 to each other. The entrance 161 may be perforated in a lateral surface of the second housing 112 so as to communicate with the suction path 151 and the exit 162 may be perforated in an upper surface of the second housing 112.

[0073] The blower 140 may be located above the exit 162. If the air having passed through the blowing path 160 is discharged from the exit 162, the air is suctioned to the fan 142 in an axial direction thereof and then, is discharged from the fan 142 in a radial direction thereof to thereby be introduced into the discharge path 153.

[0074] The low-temperature air of the storage compartment 12 having passed through the suction port 120 moves through the suction path 151, the fan mounting region 153 and the discharge path 152 in order, thereby being introduced into the storage compartment 12 through the discharge port 130.

[0075] The discharge path 152 may be located at the outside of the upper wall 42a of the inner case 40. Also, the discharge path 152 may radially extend outward from the fan 142 so as to guide the low-temperature air in a longitudinal direction of the upper wall 42a.

[0076] FIG. 5 is a view illustrating operation of the circulation duct in the kimchi refrigerator in accordance with the embodiment of the present disclosure.

[0077] If the fan motor 141 drives the fan 142, the low-temperature air present in the rear lower region of the storage compartment 12 is suctioned into the suction path 151 of the circulation duct 100 through the outlet 43 and the suction port 120. The low-temperature air having passed through the suction path 151 is moved to the discharge path 152 by way of the fan mounting region 153. Then, the low-temperature air is discharged from the discharge path 152 through the discharge port 130 and is introduced into the front upper region of the storage compartment 12 through the inlet 44. In this way, the low-temperature air present in the rear lower region of the storage compartment 12 is guided to the front upper region of the storage compartment 12 having a relatively high temperature, which may reduce temperature deviation within the storage compartment 12.

[0078] FIG. 6 is a schematic view illustrating a defrosting device of a kimchi refrigerator in accordance with another embodiment of the present disclosure.

[0079] The defrosting device of the kimchi refrigerator in accordance with another embodiment of the present disclosure may be applied to an upright type kimchi refrigerator because a top lid type kimchi refrigerator has difficulty in installing a fan. The defrosting device of the upright type kimchi refrigerator in accordance with another embodiment of the present disclosure is designed to control the interior temperature of the indirect cooling type refrigerator and defrost the evaporator 50 instead of a defrosting heater. In addition, the defrosting device in accordance with the present embodiment may be applied to refrigerators which have an extra refrigerating compartment evaporator 50 or have only a refrigerating compartment and may perform a defrosting operation based on temperature sensed by an evaporator sensor 277 attached to the evaporator 50 and interior temperature of a refrigerating compartment.

[0080] As liquid-phase refrigerant having passed through a compressor 230 and a condenser 240 is introduced into the evaporator 50 via a valve 245 so as to be changed into gas-phase refrigerant by the evaporator 50, the defrosting device of the kimchi refrigerator functions to remove frost around the evaporator 50 generated as the refrigerant absorbs heat from the surroundings during evaporation.

[0081] A conventional defrosting device directly applies heat to the evaporator 50 to defrost the evaporator 50 and thus, has the necessity of an evaporator heater mounted to the evaporator 50 to periodically apply heat to the evaporator 50 so as to defrost the evaporator 50.

[0082] Differently from the above-described conventional defrosting device, the defrosting device of the kimchi refrigerator in accordance with the present embodiment does not need evaporator heater. Otherwise, the evaporator sensor 277 is installed to the evaporator 50 to sense the surrounding temperature of the evaporator 50, enabling natural defrosting. Thus, the defrosting device of the kimchi refrigerator in accordance with the present embodiment can defrost the evaporator 50 without the evaporator heater, which may be advantageous in view of space utilization and cost and power consumption reduction owing to the absence of the evaporator heater.

[0083] The evaporator sensor 277 installed to the evaporator 50 may be positioned to come into close contact with the evaporator 50. This enables precise measurement of the temperature of the evaporator 50. Otherwise, frost may be present between the evaporator 50 and the evaporator sensor 277, which causes the evaporator sensor 277 to sense the wrong temperature and consequently, prevents the defrosting device from precisely performing natural defrosting. Accordingly, the evaporator sensor 277 may come into close contact with the evaporator 50 without a gap. That is to say, the evaporator sensor 277 may come into direct contact with the evaporator 50 in the form of a refrigerant pipe so as to monitor melting of frost based on the sensed temperature.

[0084] FIGS. 7A to 7C are timing diagrams illustrating defrosting operations of the kimchi refrigerator in accordance with another embodiment of the present disclosure.

[0085] The timing diagrams illustrate defrosting operations performed on a per cycle basis, which are realized using only the evaporator sensor 277 and a temperature sensor installed within the refrigerator to sense temperature of the refrigerator without an extra defrosting heater. More specifically, a cooling system and a fan are appropriately turned on or off based on On/Off temperatures of the temperature sensor and temperature sensed by the evaporator sensor 277, which enables natural defrosting without an extra defrosting heater. Here, the cooling system includes the compressor 230, the condenser 240 and the evaporator 50.

[0086] In every cycle, the cooling system and the fan are turned on to perform defrosting only when the temperature sensed by the evaporator sensor 277 is equal to or greater than a predetermined reference temperature. FIGS. 7A to 7C illustrate a control mode in which the predetermined reference temperature is an absolute temperature of 4°C and a natural defrosting temperature of 2°C.

[0087] FIG. 7A illustrates a defrosting operation in which the temperature of the refrigerator sensed by the temperature sensor arranged within the refrigerator reaches the On temperature later than the temperature sensed by the evaporator sensor 277. In this case, the control unit operates the cooling system to begin a cooling operation when the temperature of the refrigerator reaches the On temperature of the temperature sensor. In other words, as illustrated in FIG. 7A, the control unit does not operate the cooling system until the temperature of the refrigerator sensed by the temperature sensor reaches the On temperature (zero period of the timing diagram of FIG. 7A), enabling defrosting of the evaporator 50 while the cooling system is not operated (natural defrosting).

[0088] FIG. 7B illustrates a defrosting operation in which the temperature of the refrigerator sensed by the temperature sensor arranged within the refrigerator reaches the On temperature faster than the temperature sensed by the evaporator sensor 277. In this case, the temperature sensor is controlled to be turned on at the temperature of 4°C sensed by the evaporator sensor 277 and

[0089] be turned off at a lower temperature. Thus, the cooling system begins a cooling operation after waiting until the temperature sensed by the evaporator sensor 277 reaches the On temperature of the temperature sensor. Similarly, the cooling system (compressor) is controlled to be turned on at the temperature of 4°C sensed by the evaporator sensor 277 and be turned off at a lower temperature. That is to say, differently from that illustrated in FIG. 7A, FIG. 7B illustrates a situation in which temperature is changed. In FIG. 7B, natural defrosting may be performed by further lowering the Off temperature of the cooling system (compressor). Here, the changed temperature corresponds to the sensed temperature of the refrigerator and the lowering of the Off temperature of the cooling system depends on the change of the temperature. A database of detailed temperature values (e.g., 4°C as mentioned above) may be experimentally obtained.

[0090] The database may be stored in a memory and be used to control defrosting of the refrigerator.

[0091] FIG. 7C illustrates that frost generated on the evaporator 50 can be naturally removed by the defrosting operations of FIGS. 7A and 7B (natural defrosting). If the cooling system is turned on and the fan is turned on, the interior temperature of the refrigerator drops, causing frost to be formed on the evaporator 50. Next, if the cooling system is turned off and the fan is kept in an On state, the interior temperature of the refrigerator rises. If the interior temperature of the refrigerator reaches a zero point, the frost on the evaporator begins to melt. The temperature of the refrigerator again rises after the frost is completely melted and the fan is turned off when the temperature of the refrigerator begins to rise again. The temperature of the refrigerator rises to the On temperature of the temperature sensor within the refrigerator. This series of operations constitute a cycle. As such, the cooling system and the fan are controlled to perform the defrosting operation on a per cycle basis, enabling natural defrosting.

[0092] More particularly, natural defrosting is performed for an interval between off time of the cooling system and off time of the fan. In addition, an interval between off time of the fan and time when the cooling system and the fan are again turned on is a rest interval. Appropriately adjusting On/Off times of the cooling system and the fan based on temperature so as to repeat the natural defrosting interval and the rest interval on a per cycle basis may prevent the evaporator from being frosted.

[0093] As is apparent from the above description, a direct cooling type refrigerator in accordance with one embodiment of the present disclosure is configured in such a way that low-temperature air present in a lower region of a storage compartment is circulated to an upper region of the storage compartment having a relatively high temperature through a circulation duct, which may reduce temperature deviation in the storage compartment. Further, due to the fact that the circulation duct is mounted at the outside of the storage compartment, circulation of cold air of the storage compartment may be accomplished without reduction in the storage capacity of the storage compartment.

[0094] Furthermore, as a result of eliminating a heater used to heat the lower region of the storage compartment, power to operate the heater is unnecessary and it is possible to prevent deterioration in storage efficiency due to repeated temperature rising and drop.

[0095] The direct cooling type refrigerator performs natural defrosting without an extra heater, which achieves reduction in material costs and power consumption.

[0096] Although a few embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A direct cooling type refrigerator comprising:

a cabinet;
an inner case arranged in the cabinet and having an inlet and an outlet;
a circulation duct coupled to the inner case at the outside of the inner case and having a suction port communicating with the outlet and a discharge port communicating with the inlet; and
a fan to move air from the suction port to the discharge port within the circulation duct,

wherein the inlet is located at an upper wall of the inner case so as to be located closer to a front surface of the inner case than a rear wall of the inner case, and
wherein the outlet is located at the rear wall of the inner case so as to be located close to a lower wall of the inner case.

2. The refrigerator according to claim 1, wherein the fan is located at the outside of the upper wall of the inner case.

3. The refrigerator according to claim 1, wherein the fan is spaced apart from the discharge port by a predetermined distance rearward of the inner case.

4. The refrigerator according to claim 1, wherein the fan is a centrifugal fan to discharge air in a radial direction thereof.

5. The refrigerator according to claim 1, further comprising an evaporator to cool a storage compartment, wherein the evaporator is arranged close to a left wall, a right wall and the lower wall of the inner case.

6. The refrigerator according to claim 1, wherein the circulation duct extends from the outside of a rear wall of the inner case to the outside of an upper wall of the inner case.

7. The refrigerator according to claim 1, further comprising a storage compartment provided in the cabinet,
wherein the circulation duct includes a suction path into which the air of the storage compartment is suctioned, a discharge path from which the air is discharged into the storage compartment and a fan mounting region located between the suction path and the discharge path.

8. The refrigerator according to claim 7, wherein the fan mounting region has an open bottom to allow the fan to be installed therein.

9. The refrigerator according to claim 7, wherein the discharge path is located at the outside of an upper wall of the inner case to guide the air in a longitudinal direction of the upper wall of the inner case.

10. A control method of a direct cooling type refrigerator comprising:

sensing temperature of an evaporator using an evaporator sensor installed to the evaporator;
sensing interior temperature of the refrigerator using a temperature sensor; and
controlling On/Off operations of a cooling system and a fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator, enabling natural defrosting of the evaporator.

11. The control method according to claim 10, wherein the evaporator sensor is closely attached to the evaporator without a gap.

12. The control method according to claim 10, wherein controlling On/Off operations of the cooling system and the fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator includes controlling the cooling system and the fan to be turned on only when the temperature sensed by the evaporator sensor is equal to or greater than a predetermined reference temperature.

13. The control method according to claim 10, wherein controlling On/Off operations of the cooling system and the fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator includes starting a cooling operation when the interior temperature of the refrigerator sensed by the temperature sensor reaches an On temperature of the temperature sensor if the interior temperature of the refrigerator reaches the On temperature later than the temperature sensed by the evaporator sensor.

14. The control method according to claim 10, wherein controlling the On/Off operations of the cooling system and the fan based on the sensed temperature of the evaporator and the sensed interior temperature of the refrigerator includes starting a cooling operation after waiting until the temperature sensed by the evaporator sensor reaches an On temperature of the temperature sensor if the interior temperature of the refrigerator reaches the On temperature faster than the temperature sensed by the evaporator sensor.

15. The control method according to claim 10, wherein controlling the On/Off operations of the cooling system and the fan includes repeating a cycle consisting of a natural defrosting period from Off time of the cooling system to Off time of the fan and a rest period from Off time of the fan to time when the cooling system and the fan are again turned on.

FIG. 1

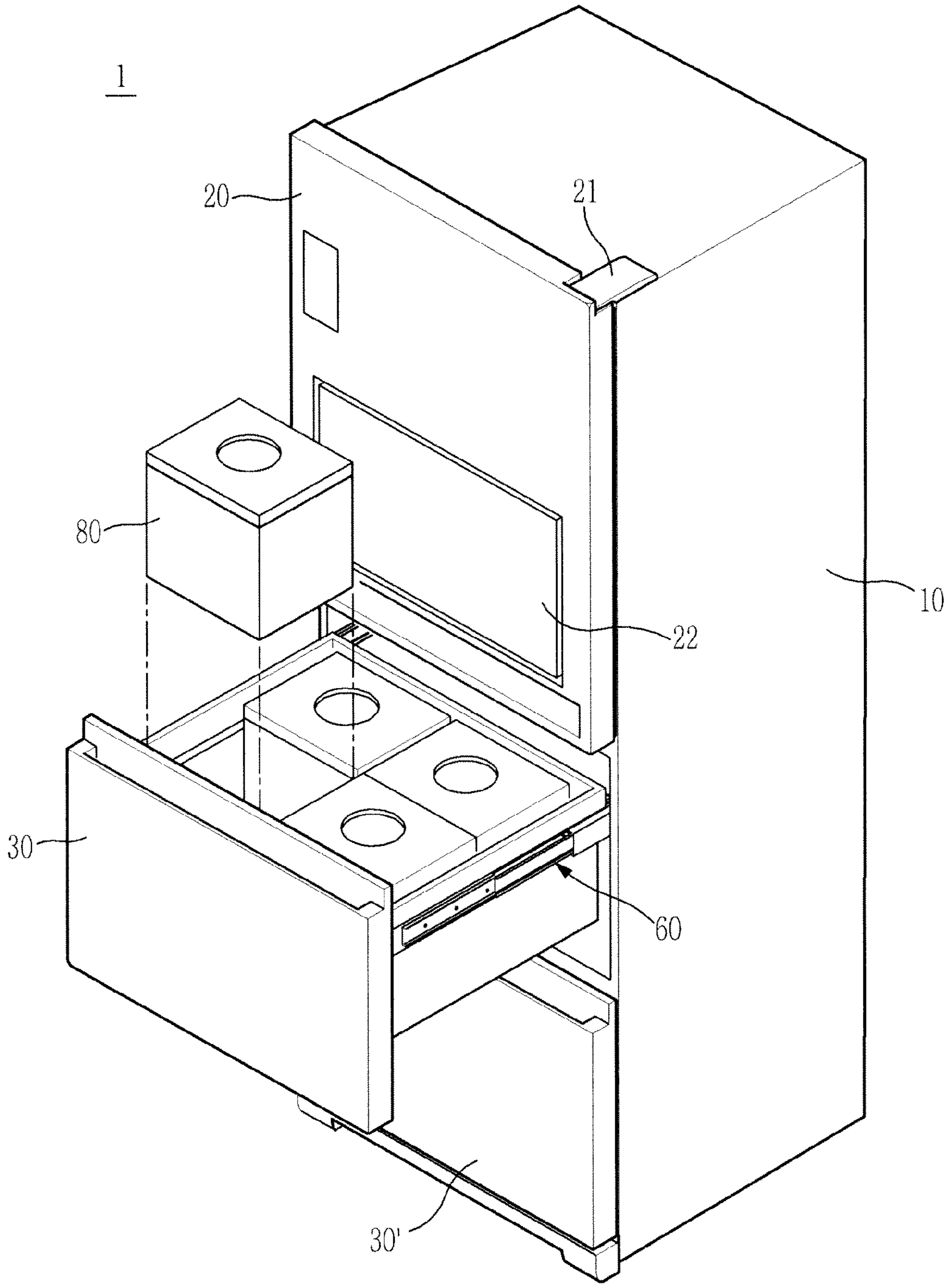


FIG. 2

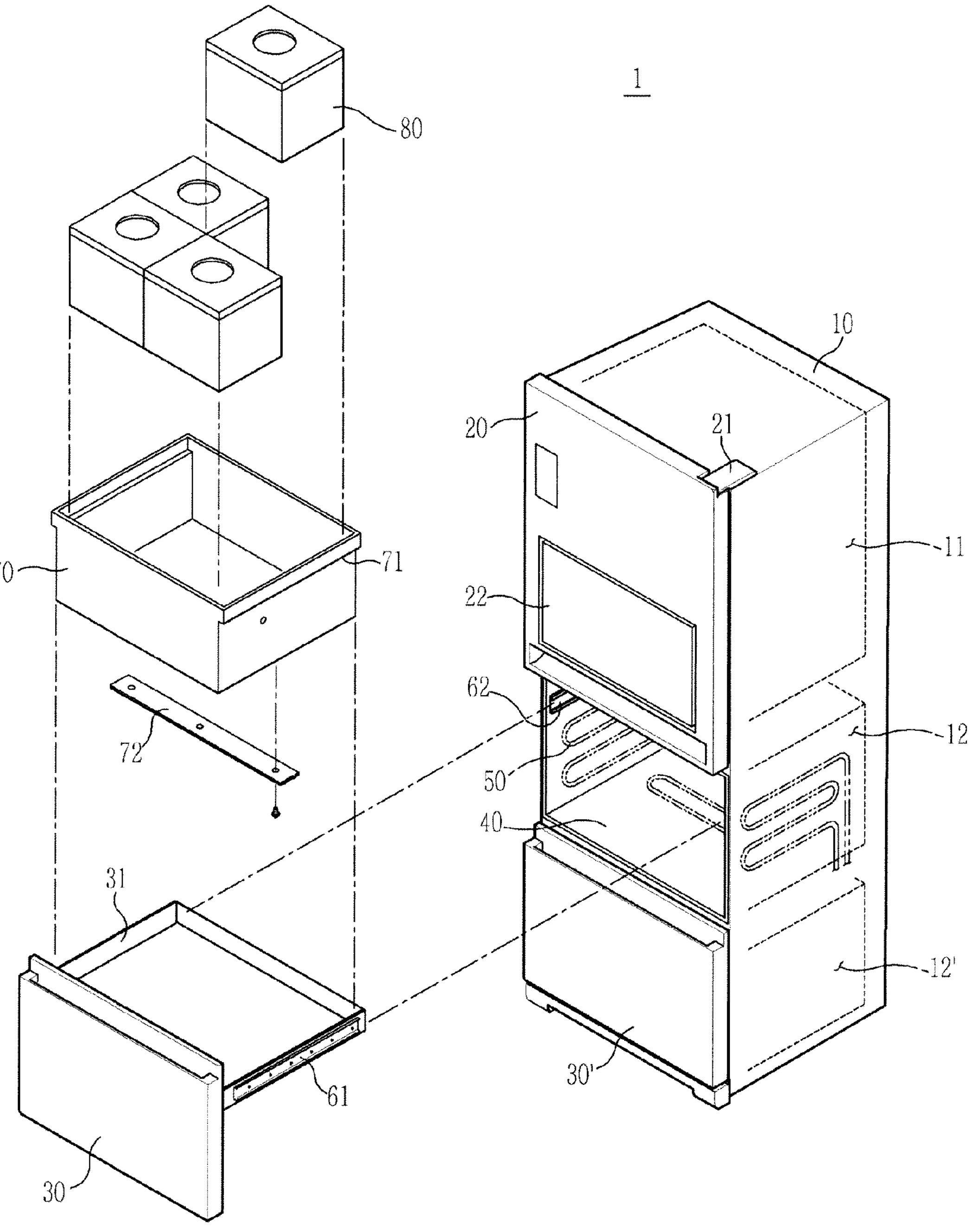
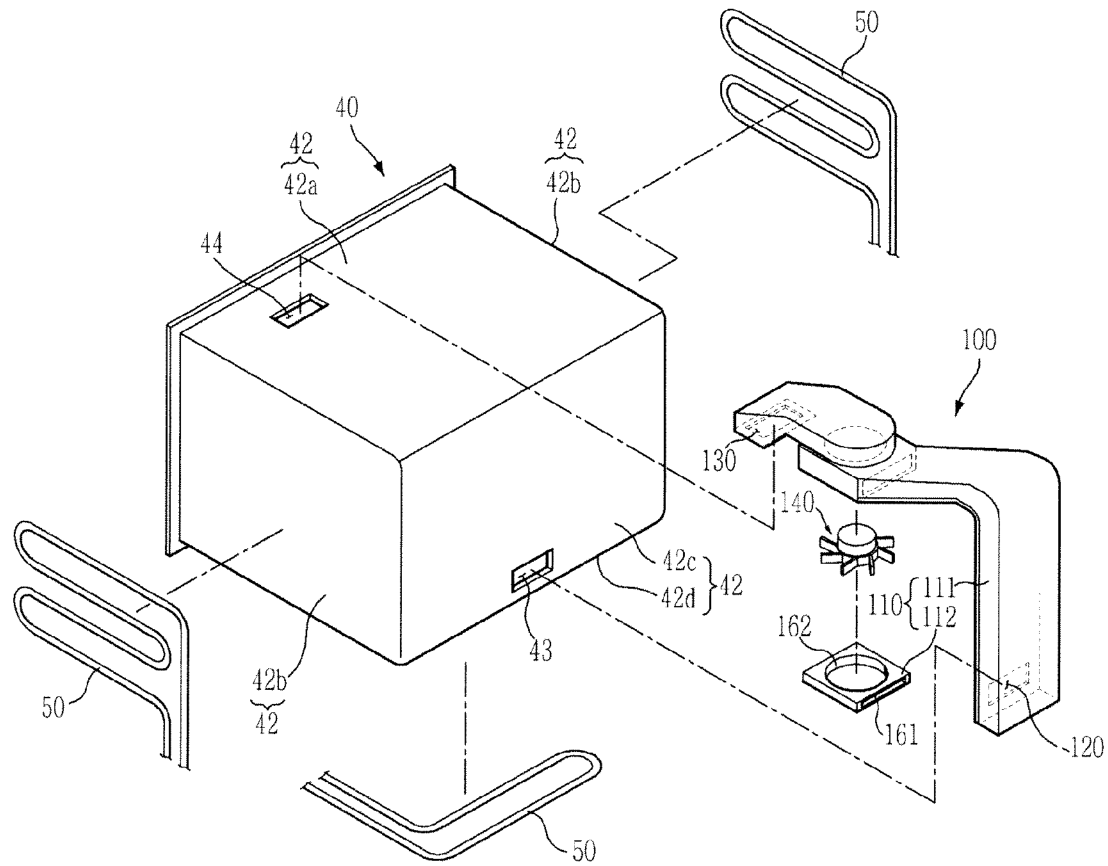


FIG. 3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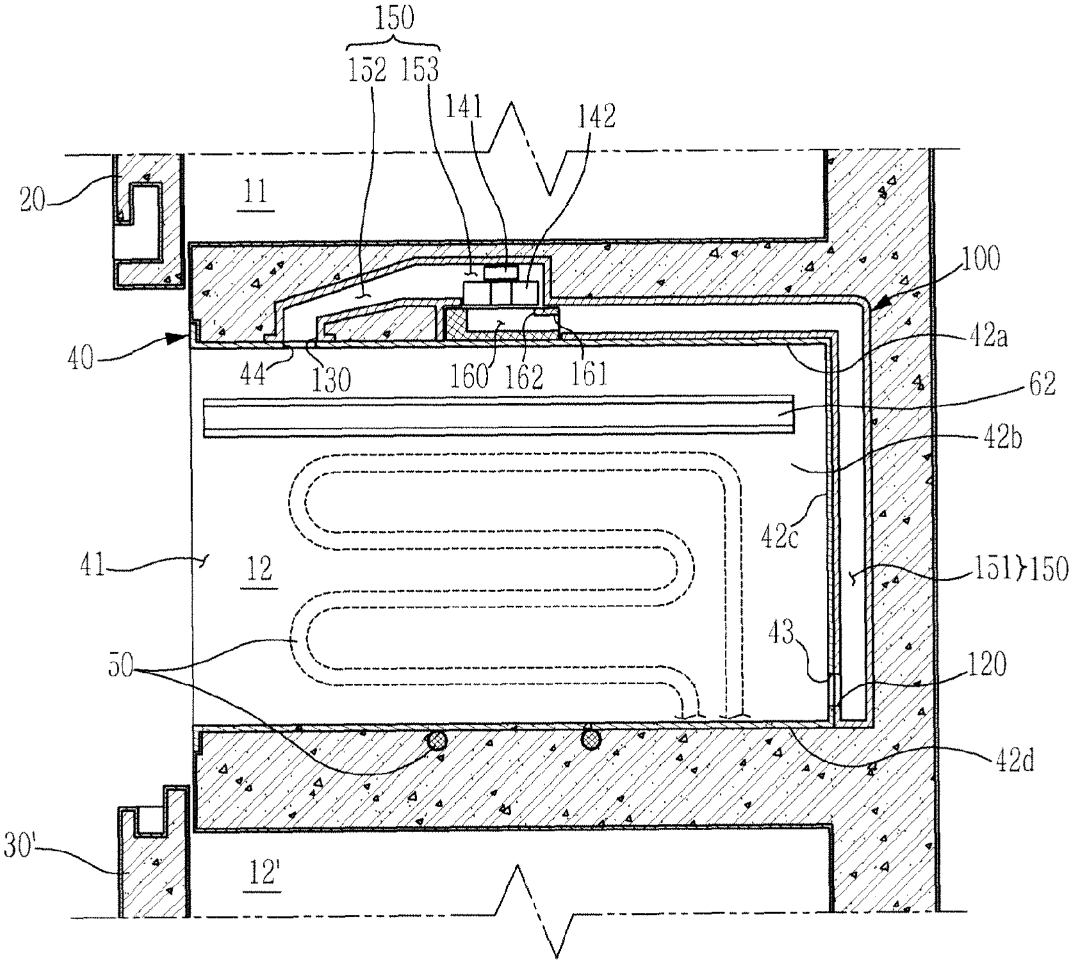
40
42
42a
42
42b
44
100
130
140
42c
42d
42
111
110
112
162
43
161
42b
42
50
120
50

FIG. 4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152
153
141
142
20
11
100
40
42a
44
130
160
162
161
62
42b
42c
41
12
151
150
43
50
120
42d
30'
12'

FIG. 5

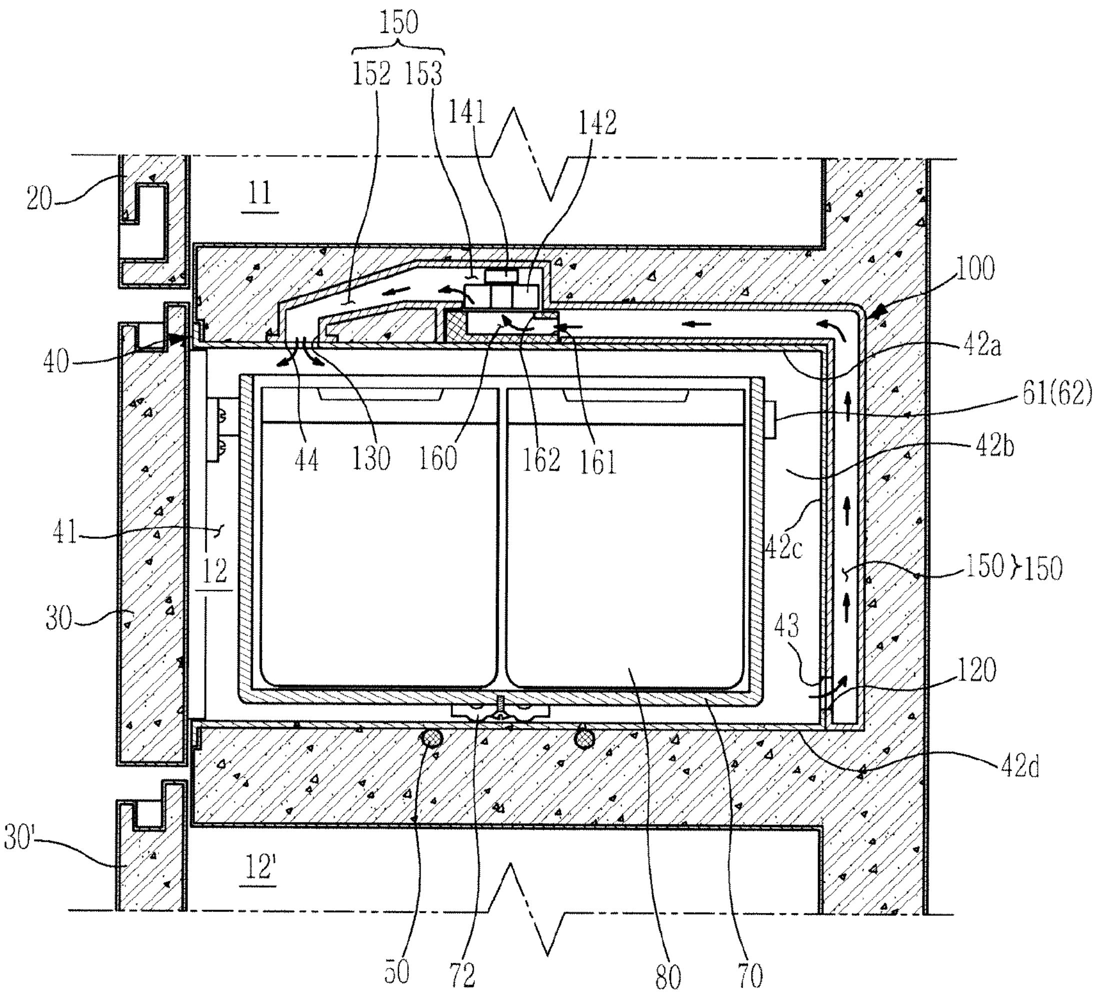

150
152 153
141
142
20
11
100
40
42a
61(62)
44
130
160
162
161
42b
41
12
42c
150
150
30
43
120
42d
30'
12'
50
72
80
70

FIG. 6

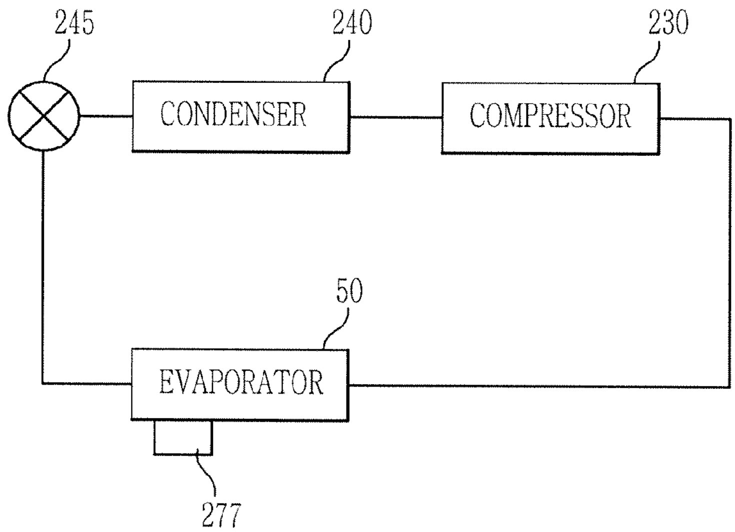


FIG. 7A

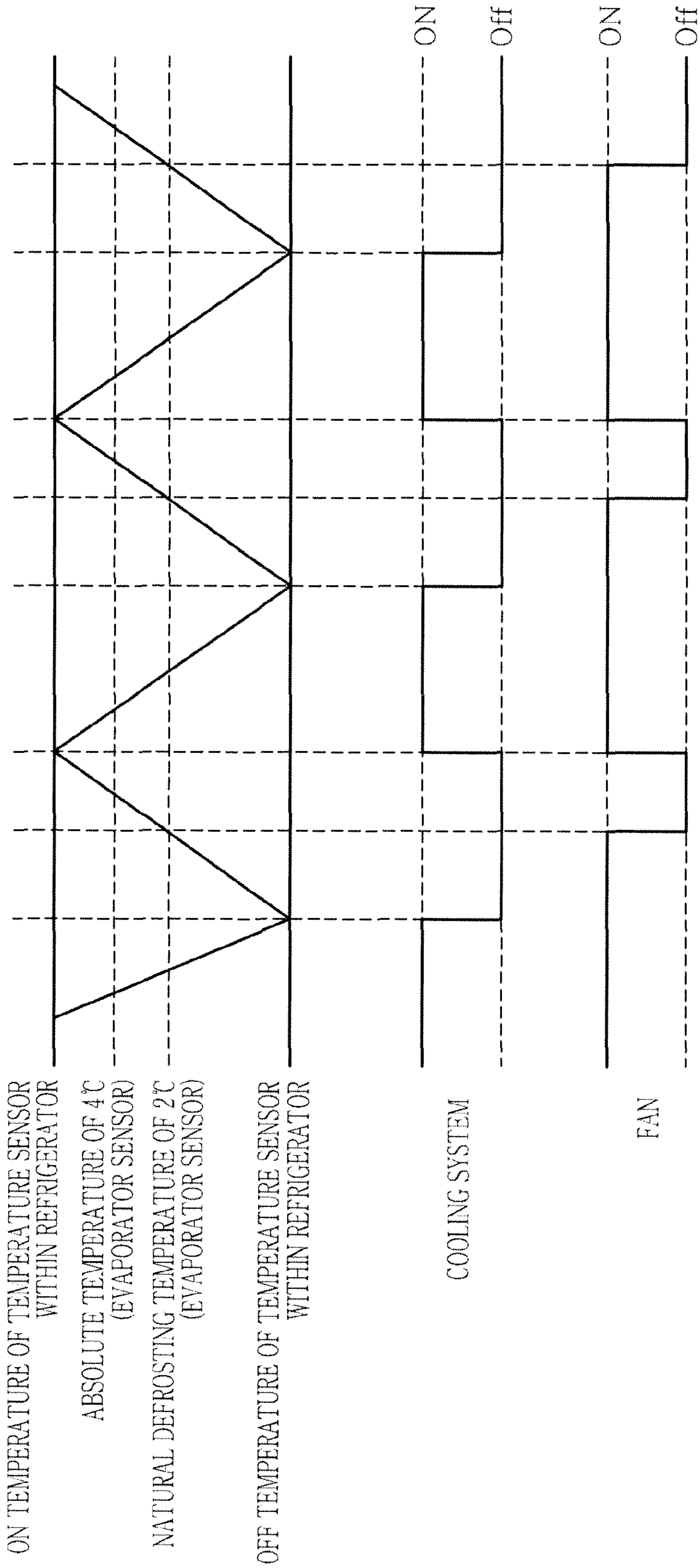

ON TEMPERATURE OF TEMPERATURE SENSOR WITHIN REFRIGERATOR
ABSOLUTE TEMPERATURE OF 4℃ (EVAPORATOR SENSOR)
NATURAL DEFROSTING TEMPERATURE OF 2℃ (EVAPORATOR SENSOR)
OFF TEMPERATURE OF TEMPERATURE SENSOR WITHIN REFRIGERATOR
COOLING SYSTEM
FAN
ON
Off
ON
Off

FIG. 7B

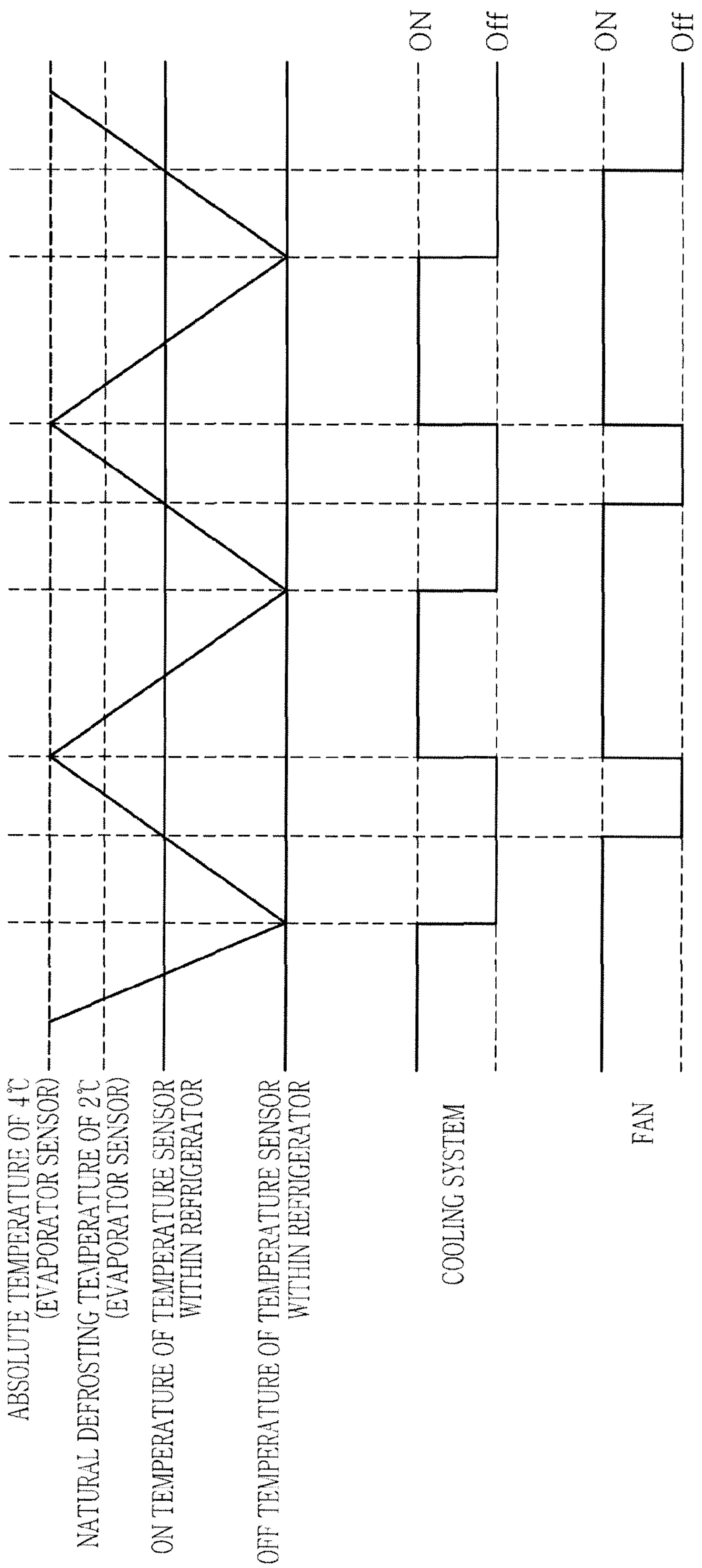
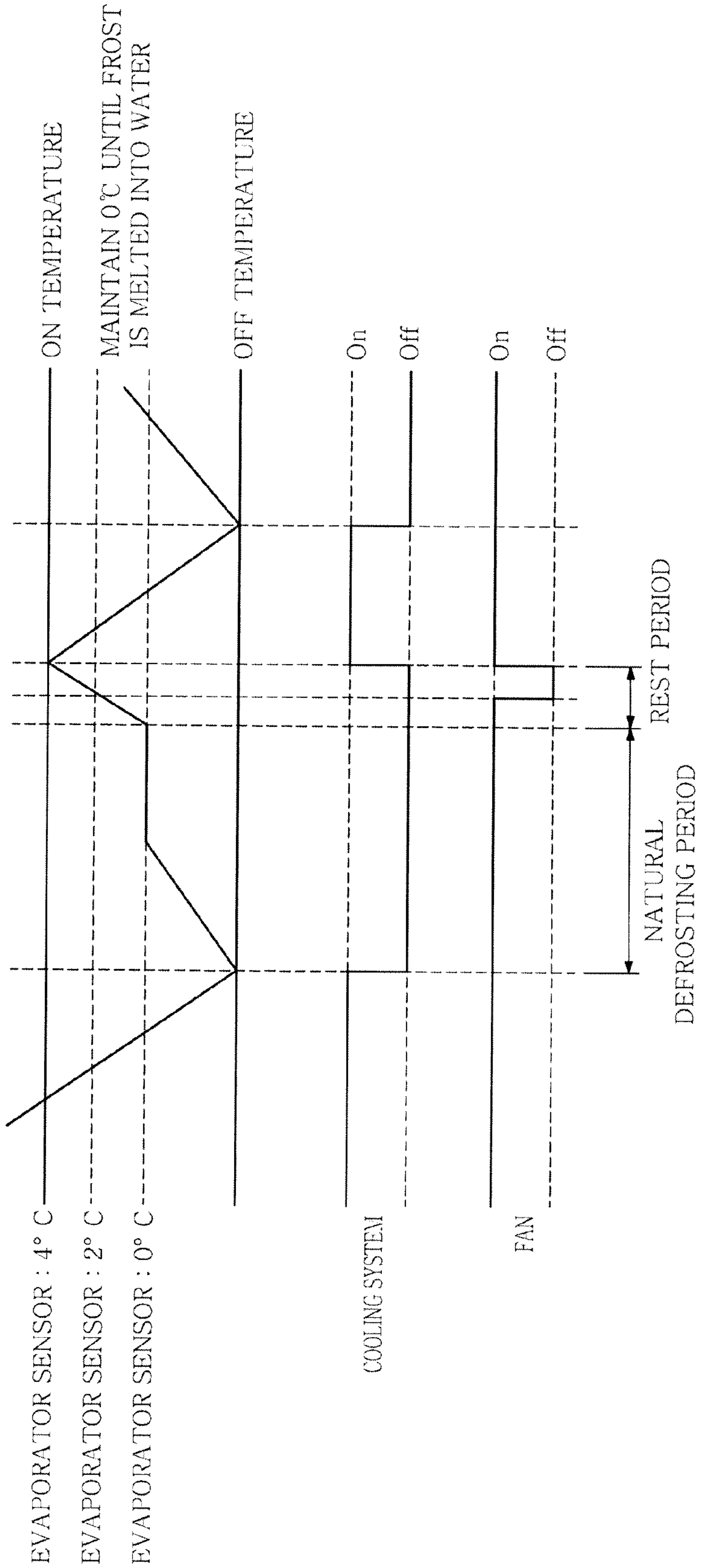

ABSOLUTE TEMPERATURE OF 4℃ (EVAPORATOR SENSOR)
NATURAL DEFROSTING TEMPERATURE OF 2℃ (EVAPORATOR SENSOR)
ON TEMPERATURE OF TEMPERATURE SENSOR WITHIN REFRIGERATOR
OFF TEMPERATURE OF TEMPERATURE SENSOR WITHIN REFRIGERATOR
COOLING SYSTEM
FAN
ON
Off
ON
Off

FIG. 7C


ON TEMPERATURE
MAINTAIN 0℃ UNTIL FROST IS MELTED INTO WATER
OFF TEMPERATURE
On
Off
On
Off
REST PERIOD
NATURAL DEFROSTING PERIOD
EVAPORATOR SENSOR : 4° C
EVAPORATOR SENSOR : 2° C
EVAPORATOR SENSOR : 0° C
COOLING SYSTEM
FAN