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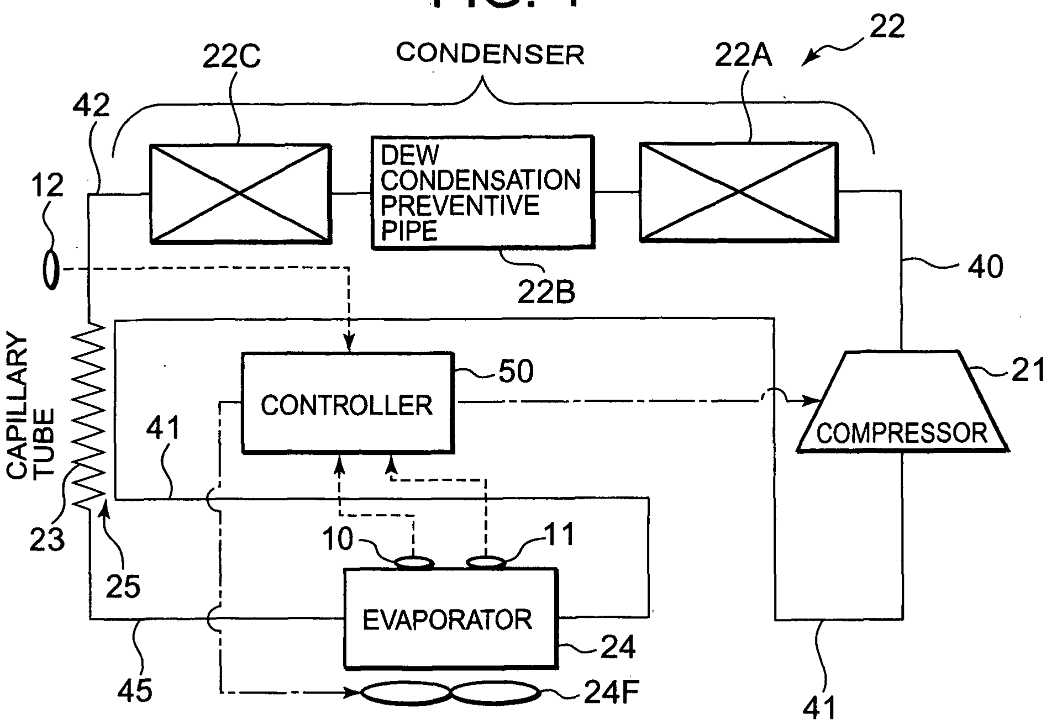
(54) **Refrigerator**

(57) There is disclosed a refrigerator in which a refrigerant circuit on a high-pressure side is operated in a supercritical state, and an object of the refrigerator is to improve a freezing capacity while securely preventing dew condensation at an opening edge by a condenser (22). In the refrigerator including the refrigerant circuit constituted of a compressor (21), the condenser (22), a throttle means (23) and an evaporator (24): and a dew condensation preventive pipe (22B) constituting a part of the condenser and disposed along the opening edge of an insulation box member, the refrigerant circuit on the high-pressure side is operated in the supercritical state, and the dew condensation preventive pipe is positioned on an upstream side of a refrigerant downstream region of the condenser.

FIG. 1



EP 1 835 242 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a refrigerator in which a dew condensation preventive pipe constituting a part of a condenser (or gas cooler or condensing heat exchanger or gas cooling heat exchanger) of a refrigerant circuit is disposed along an opening edge of an insulation box member in order to prevent dew condensation of a main body. The present invention more particularly relates to a refrigerator in which a refrigerant circuit on a high-pressure side is operated in a supercritical state.

[0002] Heretofore, in this type of refrigerator, an insulation box member is constituted of a metallic outer box, an inner box made of a hard synthetic resin and an insulation material foamed and filled between both the boxes. In the inner box, a freezing chamber and a refrigerating chamber are constituted so as to freeze or refrigerate and store food and the like in the inner box. An insulation door is disposed on a front surface of this insulation box member, and the freezing and refrigerating chambers are openably closed by the insulation door. Moreover, a mechanical chamber in which a compressor and the like are to be installed is constituted in a lower part of the insulation box member.

[0003] Furthermore, when the compressor is operated, a refrigerant is sucked into the compressor and compressed to constitute a high-temperature high-pressure gas, and the gas enters a condenser. While the refrigerant flows through the condenser, heat exchange between the refrigerant and ambient air is performed. The refrigerant rejects (or transfers) heat and is condensed. After a pressure of the refrigerant which has condensed in the condenser is reduced, by a throttle means, the refrigerant enters an evaporator and evaporates. At this time, the refrigerant absorbs the heat from a surrounding to exhibit a cooling function. The air subjected to the heat exchange between the air and the refrigerant and cooled in the evaporator is circulated through chambers such as the freezing chamber and the refrigerating chamber by blowing means such as a fan to cool objects stored in the chambers.

[0004] In such a refrigerator, when the heat leaks from a portion between the insulation box member and the insulation door, a surface temperature in the vicinity of this portion drops below a temperature (outside air temperature) around a position where the refrigerator is installed, and the temperature is not more than a dew point. In this case, a disadvantage occurs that a moisture in the air is attached, that is, so-called dew condensation is generated. Therefore, a heater is installed in a portion of the refrigerator in which the dew condensation is easily generated to thereby heat the portion. In consequence, the generation of the dew condensation in such a portion has been prevented.

[0005] However, a disadvantage occurs that a cooling performance deteriorates or power consumption increases owing to the heat of the heater. To solve such a problem, a refrigerant downstream region of the condenser of the refrigerant circuit is disposed in the portion in which the dew condensation is easily generated. The portion is thus heated to thereby prevent the generation of the dew condensation. Specifically, for example, a pipe constituting the refrigerant downstream region of the condenser of the refrigerator is disposed along an opening edge of the insulation box member, that is, the refrigerant pipe of the refrigerant downstream region of the condenser is used, as the dew condensation preventive pipe. In consequence, a high-temperature high-pressure refrigerant gas compressed by the compressor is allowed to condense in the condenser. The refrigerant condenses at a constant temperature (a predetermined condensation temperature without any temperature change). Therefore, the opening edge can be heated by the heat of the refrigerant passed through the condenser (including a dew condensation preventive pipe) to prevent such dew condensation (see, e.g., Japanese Patent Application Laid-Open Nos. 7-239178, 10-197122).

[0006] In addition, in recent years, such a refrigerator cannot use a heretofore used chlorofluorocarbon-based refrigerant owing to a problem of global environment destruction. Therefore, an attempt to use carbon dioxide (CO_2) which is a natural refrigerant as a substitute for the chlorofluorocarbon-based refrigerant.

[0007] When the carbon dioxide refrigerant is compressed, the refrigerant circuit on the high-pressure side is sometimes brought into a supercritical state. When the refrigerant circuit on the high-pressure side is brought into the supercritical state in this manner, the refrigerant does not condense in the condenser, and rejects the heat while maintaining the supercritical state. Therefore, the temperature of the refrigerant drops owing to the hat rejection. To solve this problem, a refrigerant temperature at an outlet of the dew condensation preventive pipe in the refrigerant downstream region of the condenser needs to be maintained at a value sufficient for preventing the dew condensation along the opening edge. That is, the refrigerant temperature at an outlet of the condenser has to be maintained at a temperature which is not less than the dew point so that the dew condensation is not generated. Therefore, the refrigerant temperature at the outlet of the condenser cannot be lowered to a value sufficient for securing a freezing capability, and specific enthalpy of the refrigerant flowing through the evaporator also increases. In consequence, a problem has occurred that the freezing capability of the evaporator remarkably deteriorates, and the cooling in the freezing chamber and the refrigerating chamber is obstructed.

SUMMARY OF THE INVENTION

[0008] The present invention has been developed to solve the problem of such a conventional technology, and an object is to improve a freezing capability while securely preventing dew condensation along an opening edge by a condenser in a refrigerator in which a refrigerant circuit on a high-pressure side is operated in a supercritical state.

[0009] This is, a refrigerator of a first invention comprises: a refrigerant circuit constituted of a compressor, a condenser, a throttle means and an evaporator and operated on a high-pressure side in a supercritical state; and a dew condensation preventive pipe constituting a part of the condenser and disposed along an opening edge of an insulation box member. The refrigerator is characterized in that the condenser includes at least a first condenser and a second condenser and that the dew condensation preventive pipe is positioned between the first condenser and the second condenser.

[0010] A second invention is characterized in that the above invention further comprises: a bypass pipe connected in parallel with the dew condensation preventive pipe; and a channel control unit which controls whether to pass a refrigerant through the dew condensation preventive pipe or the bypass pipe.

[0011] According to a third invention, the above inventions are characterized in that carbon dioxide is used as the refrigerant of the refrigerant circuit.

[0012] According to the first invention, in the refrigerator comprising: the refrigerant circuit constituted of the compressor, the condenser, the throttle means and the evaporator and operated on the high-pressure side in the supercritical state; and the dew condensation preventive pipe constituting a part of the condenser and disposed along the opening edge of the insulation box member, the condenser includes at least the first condenser and the second condenser, and the dew condensation preventive pipe is positioned between the first condenser and the second condenser. Therefore, while a temperature at an outlet of the dew condensation preventive pipe is set to a value sufficient for preventing dew condensation along the opening edge, a temperature of the refrigerant in a refrigerant downstream region can sufficiently be lowered.

[0013] In consequence, a refrigerant temperature at an outlet of the condenser can be lowered to a value sufficient for securing a freezing capacity. While the dew condensation along the opening edge is prevented, the freezing capacity can be improved.

[0014] Moreover, in the present invention, since the dew condensation preventive pipe is disposed between the first condenser and the second condenser, a temperature of the dew condensation preventive pipe sometimes rises more than necessary during pull-down or the like. However, in a case where the refrigerator further comprises: the bypass pipe connected in parallel with the dew condensation preventive pipe; and the channel control unit which controls whether to pass the refrigerant through the dew condensation preventive pipe or the bypass pipe as in the second invention, when the temperature of the dew condensation preventive pipe rises more than necessary, the refrigerant can be passed through the bypass pipe to prevent an excessive temperature rise of the dew condensation preventive pipe.

[0015] In consequence, a disadvantage can be avoided in advance that owing to the excessive temperature rise of the dew condensation preventive pipe, a feeling of discomfort is given to a user or the user gets burnt when touching the pipe. Moreover, safety can be secured.

[0016] Especially, according to the present invention, carbon dioxide can be used as the refrigerant of the refrigerator as in the third invention. This also contributes to solution of an environmental problem.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a refrigerant circuit diagram of a refrigerator according to one embodiment of the present invention;

FIG. 2 is a schematic diagram schematically showing a refrigerant circuit of the refrigerator of FIG. 1;

FIG. 3 is the Mollier diagram of the refrigerator of the present embodiment;

FIG. 4 is a refrigerant circuit diagram of a refrigerator according to another embodiment of the present invention;

FIG. 5 is the Mollier diagram of the refrigerator of FIG. 5;

FIG. 6 is a refrigerant circuit diagram of a refrigerator according to still another embodiment of the present invention;

FIG. 7 is a refrigerant circuit diagram of a conventional refrigerator;

FIG. 8 is a schematic diagram schematically showing a refrigerant circuit of the refrigerator of FIG. 7;

FIG. 9 is the Mollier diagram of the refrigerator of FIG. 7 in a case where a conventional refrigerant is used (in a case where a supercritical pressure is not achieved in a refrigerant circuit on a high-pressure side); and

FIG. 10 is the Mollier diagram of the refrigerator of FIG. 7 in a case where a refrigerant circuit on a high-pressure side is operated in a supercritical state.

DESCRIPTION OF THE PREFERABLE EMBODIMENTS

[0018] The present invention is directed to a refrigerator in which a refrigerant circuit on a high-pressure side is operated in a supercritical state and in which a dew condensation preventive pipe constituting a part of a condenser is disposed along an opening edge of an insulation box member to prevent dew condensation along the opening edge. The present invention has been developed to eliminate a disadvantage that specific enthalpy of a refrigerant flowing through an evaporator increases and a freezing capacity deteriorates in a case where a temperature of the refrigerant flowing through the dew condensation preventive pipe is maintained at a value sufficient for preventing dew condensation along the opening edge. An object to improve the freezing capacity while securely preventing dew condensation along the opening edge of the refrigerator is realized by positioning the dew condensation preventive pipe constituting a part of the condenser between a first condenser and a second condenser. Embodiments of the present invention will hereinafter be described with reference to the drawings.

(Embodiment 1)

[0019] FIG. 1 shows a refrigerant circuit diagram of a refrigerator according to one embodiment of the present invention, and FIG. 2 shows a schematic diagram of a dew condensation preventive pipe disposed along an opening edge of an insulation box member of the refrigerator, respectively. A main body of a refrigerator 1 of the embodiment is constituted of an outer box 2 having a front opening and formed of a steel plate; an inner box 3 made of a thin hard synthetic resin (e.g., an ABS resin); an insulation box member 4 made of foamed polyurethane foamed and filled between both the boxes; and an insulation door (not shown) which openably closes the front opening of the insulation box member 4.

[0020] The inside of the insulation box member 4 is vertically divided by a partition wall 5 into, for example, a refrigerating chamber 6 cooled at a refrigerating temperature (e.g., about +5°C) above the partition wall 5 and a freezing chamber 7 frozen at a freezing temperature (e.g., about -20°C) under the partition wall 5.

[0021] An indoor temperature sensor 10 for detecting a temperature in the refrigerating chamber 6 is disposed in the refrigerating chamber 6, and an indoor temperature sensor 11 for detecting a temperature in the freezing chamber 7 is disposed in the freezing chamber 7. These indoor temperature sensors 10, 11 are connected to a controller 50 described later, respectively.

[0022] Moreover, a door switch for detecting opening/closing of the insulation door (not shown) is disposed on an inner portion of the front surface of the insulation box member 4. An outside air temperature sensor 12 (not shown in FIG. 2) for detecting an outside air temperature around the refrigerator 1 is disposed in the vicinity of this door switch. The outside air temperature sensor 12 is connected to the controller 50.

[0023] Furthermore, a mechanical chamber (not shown) is constituted in an outer lower part of the inner box 3 which is a lower part of the insulation box member 4. The mechanical chamber contains a compressor 21 constituting a part of a refrigerant circuit of a cooling device of the refrigerator 1 according to the present invention and the like.

[0024] In the cooling device of the refrigerator 1 of the present invention, as shown in FIG. 1, the refrigerant circuit is constituted of the compressor 21, a condenser 22, a capillary tube 23 as a throttle means and an evaporator 24. In this case, a discharge-side pipe 40 of the compressor 21 is connected to a refrigerant pipe 22A constituting a first condenser which is a refrigerant upstream region of the condenser 22. A refrigerant pipe 22C constituting a second condenser which is a refrigerant downstream region of the condenser 22 is connected to a refrigerant pipe 42 connected to an inlet of the capillary tube 23. Moreover, a refrigerant-inlet-side pipe 45 of the evaporator 24 is connected to an outlet of the capillary tube 23. An outlet of the evaporator 24 is connected to a suction-side pipe 41 of the compressor 21 to constitute the refrigerant circuit.

[0025] Moreover, a part of the suction-side pipe 41 which connects the evaporator 24 to the compressor 21 on a suction side is disposed so that heat exchange between the part and the capillary tube 23 is performed. In consequence, an internal heat exchanger 25 is constituted. The internal heat exchanger 25 is formed by arranging the capillary tube 23 and the suction-side pipe 41 connected to the outlet of the evaporator 24 so that the heat exchange between the tube and the pipe can be performed. While the refrigerant flows through the internal heat exchanger 25, the refrigerant exits from the condenser 22 and enters the capillary tube 23. The refrigerant is subjected to heat exchange between the refrigerant and a refrigerant flowing through the suction-side pipe 41 disposed so as to perform heat exchange, the refrigerant rejects the heat, and a pressure of the refrigerant drops. Conversely, while the refrigerant exiting from the evaporator 24 flows through the suction-side pipe 41 of the internal heat exchanger 25, heat exchange between the refrigerant and the refrigerant flowing through the capillary tube 23 is performed, and the refrigerant is heated.

[0026] Here, the condenser 22 will be described. The condenser 22 is constituted by successively connecting the refrigerant pipe 22A (the first condenser) extended along a side surface of the metallic outer box 2 of the insulation box member 4 and a top surface on an insulation material side; a dew condensation preventive pipe 22B disposed along an opening edge 4A of the insulation box member 4; and the refrigerant pipe 22C (the second condenser) disposed on a bottom surface of the mechanical chamber constituted in a lowermost part of the insulation box member 4. While the refrigerant flows through the refrigerant pipes 22A, 22B and 22C of the condenser 22, heat exchange between the refrigerant and a surrounding is performed so that the refrigerant rejects the heat. Moreover, the refrigerant pipe 22A extended along the side surface of the metallic outer box 2 of the insulation box member 4 and the top surface on the insulation material side constitutes the refrigerant upstream region of the condenser 22. The dew condensation preventive pipe 22B disposed along the opening edge 4A of the insulation box member 4 constitutes a refrigerant midstream region of the condenser 22. The refrigerant pipe 22C disposed on the bottom surface of the mechanical chamber constituted in the lowermost part of the insulation box member 4 constitutes the refrigerant downstream region of the condenser 22. That is, the condenser 22 of the present embodiment is divided into three flow regions including the refrigerant upstream region, the refrigerant midstream region and the refrigerant downstream region. The refrigerant rejects the heat in the flow regions.

[0027] Moreover, the dew condensation preventive pipe 22B disposed along the opening edge 4A of the insulation box member 4 is positioned in a position on an upstream side of the refrigerant downstream region, that is, in the refrigerant midstream region. The dew condensation preventive pipe 22B of the present embodiment is formed of a material such as copper or aluminum, and stored in a groove (not shown) formed between the outer box 2 and the inner box 3. Furthermore, one end of the dew condensation preventive pipe 22B is connected to the refrigerant pipe 22A which is the refrigerant upstream region of the condenser 22 at a lower portion of one end (A in FIG. 2) of the front surface of the insulation box member 4. The other end of the pipe is connected to the refrigerant pipe 22C which is the refrigerant downstream region of the condenser 22 at a lower portion of the other end (B in FIG. 2) of the front surface of the insulation box member 4.

[0028] Specifically, as shown in FIG.. 2, the dew condensation preventive pipe 22B of the refrigerator 1 of the present embodiment rises upwards from a right lower end of the insulation box member 4 to a predetermined height, then bends at 90º in a left direction, extends in a horizontal direction to reach a left end, turns from the left end in a U-shape, and extends to the right side along a pipe extended from the right end to the left end. Moreover, the dew condensation preventive pipe rises upwards from the right end to a predetermined height, bends at 90º in the left direction, extends in the horizontal direction, turns from the left end in the U-shape, and extends along a pipe extended from the right end to the left end to extend toward the right side. Furthermore, the dew condensation preventive pipe rises upwards from the right end, extends to an upper end, and bends at 90º from the upper end toward the left side to extend in the left direction. In addition, the pipe lowers from a left upper end to a lower end in a vertical direction. The pipe is extended in the groove (not shown) of the opening edge 4A in this manner.

[0029] The controller 50 is control means for controlling the refrigerator of the present embodiment, and is constituted of a general-purpose microcomputer. Moreover, the controller 50 on an input side is connected to the indoor temperature sensors 10, 11, the outside air temperature sensor 12 and the like. The controller on an outlet side is connected to the compressor 21, and a fan 24F of the evaporator 24.

[0030] Moreover, the controller 50 controls an operation of the compressor 21 and the number of rotations of the fan 24F of the evaporator 24 based on the temperatures in the freezing chamber and the refrigerating chamber detected by the indoor temperature sensors 10, 11.

[0031] It is to be noted that carbon dioxide which is a natural refrigerant is used as the refrigerant of the refrigerator 1 of the present embodiment, and the refrigerant circuit 20 on a high-pressure side is operated in a supercritical state.

[0032] Next, an operation of the refrigerator 1 of the present invention constituted as described above will be described with reference to the Mollier diagram of FIG. 3. The controller 50 basically operates the compressor 21 based on outputs of the indoor temperature sensors 10, 11. Especially, the controller performs ON-OFF control of the compressor 21 based on the temperature in the freezing chamber 7 detected by the indoor temperature sensor 11. In consequence, the operation is performed so that the temperatures in the chambers are in a range of an upper limit temperature set above a target temperature to a lower limit temperature set below the target temperature.

[0033] Moreover, if the temperature in the freezing chamber 7 rises in excess of the upper limit temperature of the target temperature (the target temperature is, e.g., -20°C), the controller 50 drives the compressor 21 to start a compressing operation. In consequence, a low-temperature low-pressure carbon dioxide refrigerant is sucked into the compressor 21 (a state A of FIG . 3), compressed by the compressor 21 to constitute a high-temperature high-pressure refrigerant gas, and discharged from the compressor 21 to the refrigerant pipe 40. At this time, the carbon dioxide refrigerant is compressed and brought into the supercritical state (a state B of FIG. 3).

[0034] The refrigerant entering the refrigerant pipe 40 and having the supercritical state enters the refrigerant pipe 22A extended along the side surface of the metallic outer box 2 of the insulation box member 4 and the top surface on the insulation material side and constituting the refrigerant upstream region of the condenser 22. While the refrigerant flows through the refrigerant pipe 22A, the refrigerant rejects the heat. At this time, in the refrigerant pipe 22A, the refrigerant rejects the heat while maintaining the supercritical state. In consequence, enthalpy of the refrigerant drops as much as $\Delta H1$. That is, in the refrigerant pipe 22A, the only temperature of the refrigerant drops without any state change. The refrigerant is brought into a state C of FIG. 3.

[0035] Moreover, the refrigerant which has rejected the heat in the refrigerant pipe 22A then passes through the dew condensation preventive pipe 22B which is disposed along the opening edge 4A of the insulation box member 4 and which is the refrigerant midstream region of the condenser 22. In this process, the refrigerant rejects the heat while maintaining the supercritical state. In consequence, the enthalpy of the refrigerant drops as much as $\Delta H2$. Therefore , in the dew condensation preventive pipe 22B, the only temperature of the refrigerant drops without any state change, and the refrigerant is brought into a state D of FIG. 3.

[0036] The refrigerant which has rejected the heat in the dew condensation preventive pipe 22B then passes through the refrigerant pipe 22C which is disposed on the bottom surface of the mechanical chamber constituted in the lowermost part of the insulation box member 4 and which is the refrigerant downstream region of the condenser 22, and the refrigerant rejects the heat. At this time, the refrigerant still maintains the supercritical state. The enthalpy further drops as much as ΔH3 owing to the heat rejection in the refrigerant pipe 22C. Therefore, in the refrigerant pipe 22C, the only temperature of the refrigerant drops without any state change, and the refrigerant is brought into a state E of FIG. 3.

[0037] Subsequently, the refrigerant exiting from the condenser 22 enters the capillary tube 23, and the heat exchange between the refrigerant and a refrigerant flowing through the suction-side pipe 41 is performed, the pipe being disposed so as to perform the heat exchange between the pipe and the capillary tube 23. The refrigerant is thus further cooled (the enthalpy of the refrigerant further drops as much as ΔH4). Moreover, the refrigerant expands owing to the pressure drop in the capillary tube 23, is brought into a state F of FIG. 3, and reaches the evaporator 24. The refrigerant at the inlet of the evaporator 24 has a two-phase mixed state in which a liquid refrigerant and a vapor refrigerant are mixed. Moreover, in the evaporator 24, the liquid-phase refrigerant evaporates to constitute the vapor refrigerant. Ambient air is cooled by a heat absorbing function of this refrigerant during the evaporation. The cooled air is circulated through the chambers 6, 7 by the fan 24F (a state G of FIG. 3).

[0038] Moreover, the low-temperature low-pressure refrigerant exiting from the evaporator 24 enters the suction-side pipe 41, and passes through the internal heat exchanger 25. In the internal heat exchanger 25, the low-temperature low-pressure refrigerant exiting from the evaporator 24 is subjected to the heat exchange between this refrigerant and the refrigerant flowing through the capillary tube 23 (the state A of FIG. 3) and heated. Subsequently, the refrigerant exits from the internal heat exchanger 25, and is sucked into the compressor. This cycle is repeated. When such an operation is repeated, the chambers 6, 7 are gradually cooled.

[0039] In addition, when the refrigerant circuit on the high-pressure side is brought into the supercritical state as described above, the refrigerant does not condense in the condenser 22. Therefore, while the refrigerant maintains the supercritical state, the refrigerant rejects the heat, and the only temperature of the refrigerant drops.

[0040] Here, a conventional refrigerator will be described with reference to FIGS. 7 and 8. It is to be noted that in FIGS. 7 and 8, components denoted with the same numerals as those of FIGS. 1 and 2 perform the same or similar functions or produce the same or similar effects. Therefore, detailed description thereof is omitted. In a conventional refrigerator 100, a condenser 122 is divided into two flow regions including a refrigerant upstream region and a refrigerant downstream region. In consideration of a refrigerant temperature rise on a high-pressure side during pull-down or under a high load, a dew condensation preventive pipe 122B is disposed in the refrigerant downstream region of the condenser 122. That is, the refrigerant upstream region of the condenser 122 is constituted by a refrigerant pipe 122A disposed along a side surface of a metallic outer box 102, a top surface on an insulation material side and a bottom surface of a mechanical chamber constituted in a lowermost part, and the refrigerant downstream region is constituted by the dew condensation preventive pipe 122B of an insulation box member 4.

[0041] In the refrigerator 100 including the refrigerant circuit constituted as described above, a compressor 21 is driven to perform a compressing operation by use of a conventional refrigerant, that is, a refrigerant (e.g., a chlorofluorocarbon-based refrigerant or the like) which is not brought into a supercritical state on a high-pressure side. In this case, as shown in the Mollier diagram of FIG. 9, the refrigerant condenses in the condenser 122. Much of the refrigerant rejects heat in a two-phase region (a two-phase mixed state) of a gas and a liquid. Therefore, a refrigerant temperature in the condenser 122 hardly changes, and the refrigerant temperature at an outlet of the dew condensation preventive pipe 122B is a predetermined condensation temperature which is not less than a dew point. In consequence, dew condensation along an opening edge 4A can securely be eliminated.

[0042] However, when a carbon dioxide refrigerant or the like is used as in the present embodiment, the refrigerator on the high-pressure side is sometimes brought into the supercritical state. In this case, since the refrigerant does not condense in the condenser 122, the temperature drops. In the refrigerator 100 including the conventional constitution, the refrigerant temperature at the outlet of the dew condensation preventive pipe 122B might drop below the dew point. When the refrigerant temperature at the outlet of the dew condensation preventive pipe 122B drops below the dew point, a moisture in air around the refrigerator 1 is attached in the vicinity of the dew condensation preventive pipe 122B, and the dew condensation is generated along the opening edge 4A.

[0043] To prevent such dew condensation, the refrigerant temperature at the outlet-of the dew condensation preventive pipe 122B needs to be maintained at a value sufficient for preventing dew condensation along the opening edge 4A, that is, a dew point or more, specifically at a temperature which is about at least +4°C higher than a temperature around the refrigerator 100 (e.g., in a case where the ambient temperature is +30°C, the refrigerant temperature at the outlet of the dew condensation preventive pipe 122B needs to be maintained at +34°C or more). However, in the refrigerator 100 having the conventional constitution, when the refrigerant temperature at the outlet of the dew condensation preventive pipe 122B is set to the above temperature or more (e.g., +34°C or more), as shown in the Mollier diagram of FIG. 10, the refrigerant temperature at an outlet of the condenser 122 rises, and the temperature cannot be lowered to a value sufficient for securing a freezing capacity of an evaporator 24. As a result, specific enthalpy of the refrigerant flowing through the evaporator 24 rises, and an enthalpy difference (q of FIG. 10) of the evaporator 24 cannot sufficiently be secured. Therefore, a problem has occurred that the freezing capacity of the evaporator 24 remarkably deteriorates, and cooling in a refrigerating chamber 6 or a freezing chamber 7 is obstructed.

[0044] To solve such a problem, it is preferable that the dew condensation preventive pipe 122B is disposed in a position where the refrigerant temperature at the outlet of the dew condensation preventive pipe 122B is not more than the dew point. However, for example, when the dew condensation preventive pipe 122B is disposed in the refrigerant upstream region of the condenser 122, the high-temperature high-pressure refrigerant compressed by the compressor 21 enter the dew condensation preventive pipe 122B as it is. Therefore, the temperature along the opening edge 4A rises. When performing an operation such as opening or closing of the refrigerator 1, a user might feel uncomfortable. When toughing the opening edge 4A, the user might get burnt. Furthermore, since the opening edge 4A has an excessively high temperature, there is a disadvantage that a cooling capacity of the refrigerator 100 deteriorates.

[0045] To solve the problem, in the present invention, the dew condensation preventive pipe 22B is disposed in a position on an upstream side of the refrigerant downstream region of the condenser 22. Specifically, as described above, it is constituted that the condenser 22 is divided into three flow regions including the refrigerant upstream region, the refrigerant midstream region and the refrigerant downstream region and that the dew condensation preventive pipe 22B is disposed in the refrigerant midstream region of the condenser 22. The dew condensation preventive pipe 22B is positioned on the upstream side of the refrigerant downstream region of the condenser 22 in this manner. In consequence, the temperature at the outlet of the dew condensation preventive pipe 22B can be set to a value sufficient for preventing the dew condensation along the opening edge 4A. Furthermore, when the dew condensation preventive pipe 22B is positioned on a downstream side of the refrigerant upstream region of the condenser 22, it is possible to avoid the above-described disadvantage that the refrigerant temperature at the inlet of the dew condensation preventive pipe 22B excessively rises. Furthermore, in a case where the refrigerant pipe 22C constituting the refrigerant downstream region of the condenser 22 is disposed at the outlet of the dew condensation preventive pipe 22B, even if the temperature of the refrigerant cannot sufficiently be lowered in the dew condensation preventive pipe 22B, the refrigerant is further allowed to reject the heat. The temperature is sufficiently lowered, and the refrigerant temperature at the outlet of the condenser 22 can be lowered to a value sufficient for securing the freezing capacity of the evaporator 24.

[0046] That is, as compared with a case where the conventional refrigerator 100 is used as shown in FIG. 3, the enthalpy difference in the evaporator 24 can be enlarged. That is, the enthalpy difference of the evaporator 24 is q' larger than that in the conventional refrigerator 100 shown in FIG. 10, and the freezing capacity of the evaporator 24 can be improved.

[0047] As described above in detail, while securely preventing the dew condensation along the opening edge 4A in the refrigerator 1 of the present invention, the freezing capacity of the evaporator 24 can be improved.

(Embodiment 2)

[0048] It is to be noted that it has been described in Embodiment 1 that the capillary tube 23 is used as a throttle means. However, as shown in FIG. 4, an expansion valve 26 may be used as the throttle means, and an open degree of the expansion valve 26 may be controlled by a controller 50. In this embodiment, a refrigerant pipe 42 before the expansion valve 26 (on an upstream side of the expansion valve 26) and a suction-side pipe 41 exiting from an evaporator 24 are arranged so as to perform heat exchange. In consequence, an internal heat exchanger 27 is constituted. A refrigerant circuit of a refrigerator of the present embodiment shown in FIG. 4 is common to Embodiment 1 described above in many respects. Therefore, detailed description of a constitution which performs the same function as that of the refrigerator 1 of Embodiment 1 and a function similar to that of the refrigerator or which produces the same effect or a similar effect is omitted.

[0049] Next, an operation of the refrigerator 1 of the present embodiment will be described with reference to the Mollier diagram of FIG. 5. Since a basic control operation of the controller 50 is common to Embodiment 1, detailed description thereof is omitted.

[0050] Moreover, if a temperature in a freezing chamber 7 rises in excess of an upper limit temperature of a target temperature (e.g., the target temperature is -20°C), the controller 50 drives a compressor 21 to start a compressing operation. In consequence, a low-temperature low-pressure carbon dioxide refrigerant is sucked into the compressor 21 (a state A of FIG. 5), compressed by the compressor 21 to constitute a high-temperature high-pressure refrigerant gas, and discharged from the compressor 21 to a refrigerant pipe 40. At this time, the carbon dioxide refrigerant is compressed and brought into a the supercritical state (a state B of FIG. 5).

[0051] The refrigerant entering the refrigerant pipe 40 and having the supercritical state enters a refrigerant pipe 22A extended along a side surface of a metallic outer box 2 of an insulation box member 4 and a top surface on an insulation material side and constituting a refrigerant upstream region of a condenser 22. While the refrigerant flows through the refrigerant pipe 22A, the refrigerant rejects heat. At this time, in the refrigerant pipe 22A, the refrigerant rejects the heat while maintaining the supercritical state. In consequence, enthalpy of the refrigerant drops as much as ΔH1. Therefore, in the refrigerant pipe 22A, the only temperature of the refrigerant drops without any state change. The refrigerant is brought into a state C of FIG. 5).

[0052] Moreover, the refrigerant which has rejected the heat in the refrigerant pipe 22A then passes through a dew condensation preventive pipe 22B which is disposed along an opening edge 4A of the insulation box member 4 and which is a refrigerant midstream region of the condenser 22. In this process, the refrigerant rejects the heat while maintaining the supercritical state. In consequence, the enthalpy of the refrigerant drops as much as ΔH2. Therefore, in the dew condensation preventive pipe 22B, the only temperature of the refrigerant drops without any state change, and the refrigerant is brought into a state D of FIG. 5**.**

[0053] The refrigerant which has rejected the heat in the dew condensation preventive pipe 22B then passes through a refrigerant pipe 22C which is disposed on a bottom surface of a mechanical chamber constituted in a lowermost part of the insulation box member 4 and which is a refrigerant downstream region of the condenser 22. Furthermore, the refrigerant rejects the heat. At this time, the refrigerant still maintains the supercritical state. Since the refrigerant rejects the heat in the refrigerant pipe 22C, the enthalpy of the refrigerant further drops as much as ΔH3. Therefore, in the refrigerant pipe 22C, the refrigerant further rejects the heat in this process without any state change, the temperature drops, and the refrigerant is brought into a state EI of FIG. 5.

[0054] Moreover, the refrigerant exiting from the condenser 22 enters the refrigerant pipe 42, and passing through the internal heat exchanger 27. While the refrigerant passes through the internal heat exchanger 27, the heat exchange between the refrigerant exiting from the condenser 22 and a refrigerant flowing through a suction-side pipe 41 is performed to further cool the refrigerant (the enthalpy of the refrigerant further drops as much as ΔH4). The refrigerant is brought into a state EII of FIG. 5.

[0055] Subsequently, the refrigerant exiting from the internal heat exchanger 27 expands owing to the pressure drop in the expansion valve 26, is brought into a state F of FIG. 5, and reaches the evaporator 24. Here, the refrigerant has a two-phase mixed state in which a liquid refrigerant and a vapor refrigerant are mixed. Moreover, in the evaporator 24, the liquid-phase refrigerant evaporates to constitute the vapor refrigerant. Ambient air is cooled by a heat absorbing function of this refrigerant during the evaporation. The cooled air is circulated through the chambers 6, 7 by a fan (a state G of FIG. 5).

[0056] Moreover, the low-temperature low-pressure refrigerant exiting from the evaporator 24 enters the suction-side pipe 41, and passes through the internal heat exchanger 27. In the internal heat exchanger 27, the low-temperature low-pressure refrigerant exiting from the evaporator 24 is subjected to the heat exchange between this refrigerant and the refrigerant flowing through the refrigerant pipe 42 and heated. Subsequently, the refrigerant exits from the internal heat exchanger 27, and is sucked into the compressor 21. This, cycle is repeated. When such an operation is repeated, the chambers 6, 7 are gradually cooled.

[0057] Even in the refrigerator of the present embodiment described above in detail, the dew condensation preventive pipe 22B is disposed in the refrigerant midstream region on the upstream side of the refrigerant downstream region of the condenser 22 in the same manner as in the above embodiment. In consequence, the temperature at the outlet of the dew condensation preventive pipe 22B can be set to a value sufficient for preventing the dew condensation along the opening edge 4A. Furthermore, it is possible to avoid a disadvantage that the refrigerant temperature at the inlet of the dew condensation preventive pipe 22B excessively rises. In addition, in a case where the refrigerant pipe 22C constituting the refrigerant downstream region of the condenser 22 is disposed at the outlet of the dew condensation preventive pipe 22B, even if the temperature of the refrigerant cannot sufficiently be lowered in the dew condensation preventive pipe 22B, the refrigerant is further allowed to reject the heat. The temperature is sufficiently lowered, and the refrigerant temperature at the outlet of the condenser 22 can be lowered to a value sufficient for securing a freezing capacity of the evaporator 24.

[0058] That is, as compared with a case where the conventional refrigerator 100 is used as shown in FIG. 5, an enthalpy difference in the evaporator 24 can be enlarged. That is, the enthalpy difference of the evaporator is q' larger than that in the conventional refrigerator 100 shown in FIG. 10, and the freezing capacity of the evaporator 24 can be improved. In consequence, while securely preventing the dew condensation along the opening edge 4A, the freezing capacity of the evaporator 24 can be improved.

(Embodiment 3)

[0059] In addition, when a dew condensation preventive pipe 22B is moved from a refrigerant downstream region of a conventional condenser to an upstream side as in the above embodiments, a usual operation is not especially obstructed. However, a temperature of a refrigerant flowing through the dew condensation preventive pipe 22B might rise more than necessary during pull-down or under a high load. That is, if the refrigerant temperature of a refrigerant circuit on a high-pressure side abnormally rises during the pull-down or under the high load, during heat rejection in a refrigerant pipe 22A which is a refrigerant upstream region of a condenser 22, the refrigerant cannot sufficiently reject heat and the temperature cannot be lowered. Therefore, a high-temperature refrigerant sometimes enters the dew condensation preventive pipe 22B. Since the dew condensation preventive pipe 22B is positioned along an opening edge 4A of an insulation box member 4, a user might tough the pipe when opening or closing a refrigerator 1. If such a high-temperature refrigerant flows through the dew condensation preventive pipe 22B, a feeling of discomfort might be given to the user. Moreover, the user might touch the opening edge 4A to get burnt.

[0060] To solve the problem, a bypass pipe 28 is connected in parallel with the dew condensation preventive pipe 22B so as to extend around the dew condensation preventive pipe 22B (one end of the bypass pipe 28 is connected to a position A shown in FIG. 6, and the other end of the bypass pipe 28 is connected to a position B so that the bypass pipe extends around the dew condensation preventive pipe 22B). Moreover, a channel control unit is disposed which controls whether to pass the refrigerant through the dew condensation preventive pipe 22B or the bypass pipe 28. When a temperature of the dew condensation preventive pipe 22B rises more than necessary, the channel control unit executes control so that the refrigerant flows through the bypass pipe 28, and prevents an excess temperature rise of the dew condensation preventive pipe 22B. In the present embodiment, a three way valve 29 is disposed as the channel control unit on an inlet side of the bypass pipe 28, that is, the position A shown in FIG. 6. Moreover, a refrigerant temperature sensor 13 for detecting the temperature of the refrigerant flowing through the dew condensation preventive pipe 22B is disposed at an inlet of the dew condensation preventive pipe 22B or an outlet of the refrigerant pipe 22A of the condenser 22 which is the refrigerant upstream region of the dew condensation preventive pipe 22B. The three way valve 29 is operated by a controller 50 based on the refrigerant temperature detected by the refrigerant temperature sensor 13. In consequence, it is controlled whether to pass the refrigerant from the refrigerant pipe 22A which is the refrigerant upstream region of the condenser 22 through the dew condensation preventive pipe 22B or the bypass pipe 28.

[0061] Specifically, the controller 50 usually controls the three way valve 29 so that the refrigerant from the refrigerant pipe 22A constituting the refrigerant upstream region of the condenser 22 flows through the dew condensation preventive pipe 22B. Moreover, when the refrigerant temperature detected by the refrigerant temperature sensor 13 rises to a predetermined upper limit value set beforehand, the three way valve 29 is switched so that the refrigerant from the refrigerant pipe 22A constituting the refrigerant upstream region of the condenser 22 flows through the bypass pipe 28. Moreover, after elapse of a predetermined time, the three way valve 29 is switched so that the refrigerant from the refrigerant pipe 22A constituting the refrigerant upstream region of the condenser 22 flows through the dew condensation preventive pipe 22B.

[0062] In a case where the refrigerant temperature detected by the refrigerant temperature sensor 13 rises to a predetermined upper limit value, when the refrigerant is not passed through the dew condensation preventive pipe 22B, and is passed through the bypass pipe 28, the excessive temperature rise of the dew condensation preventive pipe 22B can be prevented. In consequence, it is possible to avoid in advance a disadvantage that owing to the excessive temperature rise of the dew condensation preventive pipe 22B, a feeling of discomfort is given to a user or the user touches the pipe to get burnt. In addition, safety of the refrigerator 1 can be secured.

[0063] It is to be noted that in the present embodiment, it has been described that the refrigerant temperature sensor 13 for detecting the temperature of the refrigerant flowing through the dew condensation preventive pipe 22B is disposed at the inlet of the dew condensation preventive pipe 22B or the outlet of the refrigerant pipe 22A of the condenser 22 constituting the refrigerant upstream region of the dew condensation preventive pipe 22B. A refrigerant channel is controlled so as to pass the refrigerant through the dew condensation preventive pipe 22B or the bypass pipe 28 based on the refrigerant temperature detected by the refrigerant temperature sensor 13. However, the present invention is not limited to this embodiment. The refrigerant channel may be controlled based on, for example, the number of rotations of a compressor 21, or the refrigerant may be passed through the bypass pipe 28 during pull-down of the compressor 21 or for a predetermined time.

Claims

1. A refrigerator comprising:

   a refrigerant circuit constituted of a compressor, a condenser, a throttle means and an evaporator and operated on a high-pressure side in a supercritical state; and
   a dew condensation preventive pipe constituting a part of the condenser and disposed along an opening edge of an insulation box member,
   the condenser including at least a first condenser and a second condenser,
   the dew condensation preventive pipe being positioned between the first condenser and the second condenser.

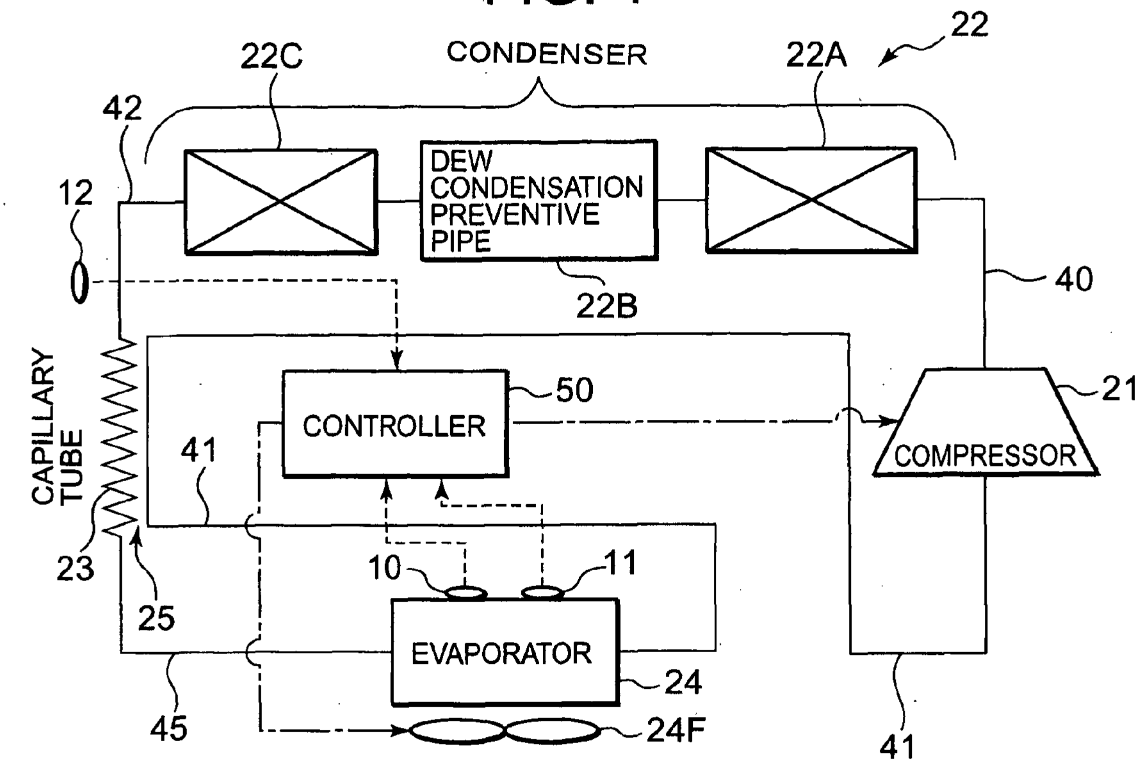
2. The refrigerator according to claim 1, further comprising:

   a bypass pipe connected in parallel with the dew condensation preventive pipe; and
   a channel control unit which controls whether to pass a refrigerant through the dew condensation preventive pipe or the bypass pipe.

3. The refrigerator according to claim 1 or 2, wherein carbon dioxide is used as the refrigerant of the re-

frigerant circuit.

FIG. 1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22C
CONDENSER
22A
42
12
DEW CONDENSATION PREVENTIVE PIPE
40
22B
50
21
CAPILLARY TUBE
CONTROLLER
COMPRESSOR
41
23
10
11
25
EVAPORATOR
24
45
24F
41

FIG. 4

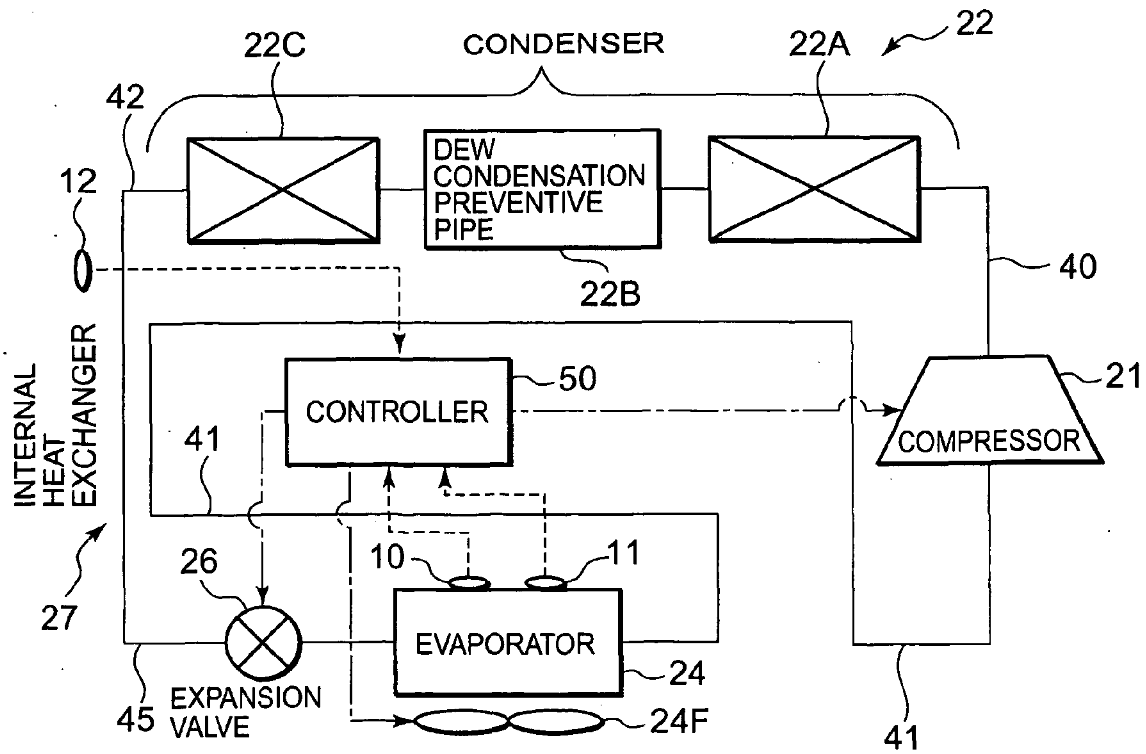

22
22C
CONDENSER
22A
42
12
DEW CONDENSATION PREVENTIVE PIPE
40
22B
INTERNAL HEAT EXCHANGER
50
21
CONTROLLER
COMPRESSOR
41
27
26
10
11
EVAPORATOR
24
45
EXPANSION VALVE
24F
41

FIG. 2

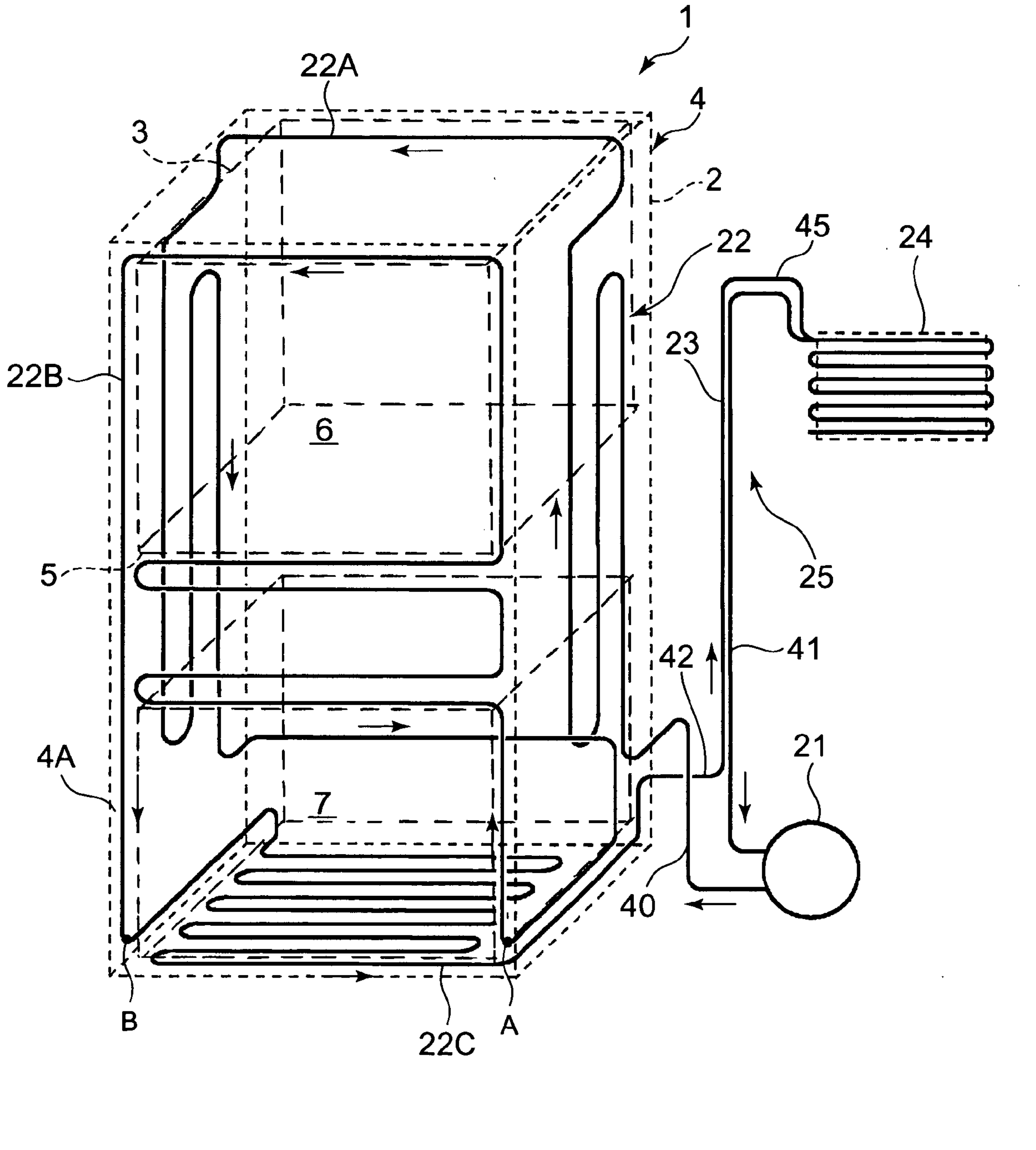


FIG. 3

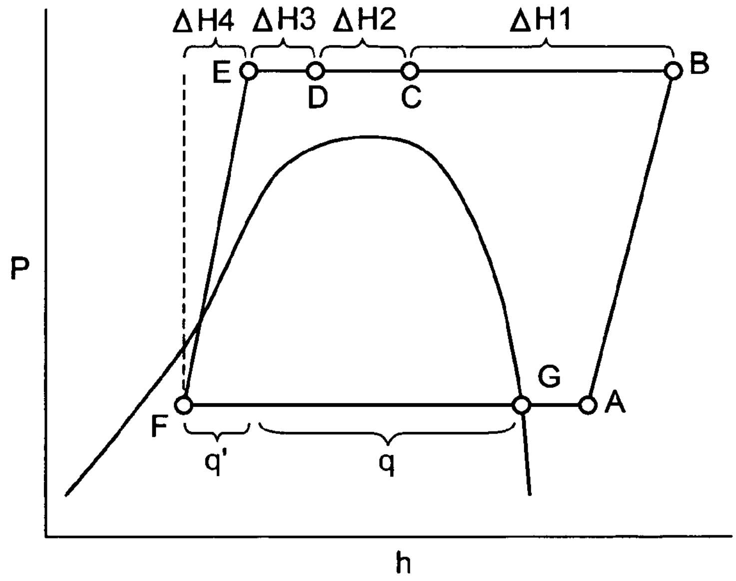

ΔH4
ΔH3
ΔH2
ΔH1
E
D
C
B
P
G
A
F
q'
q
h

FIG. 5

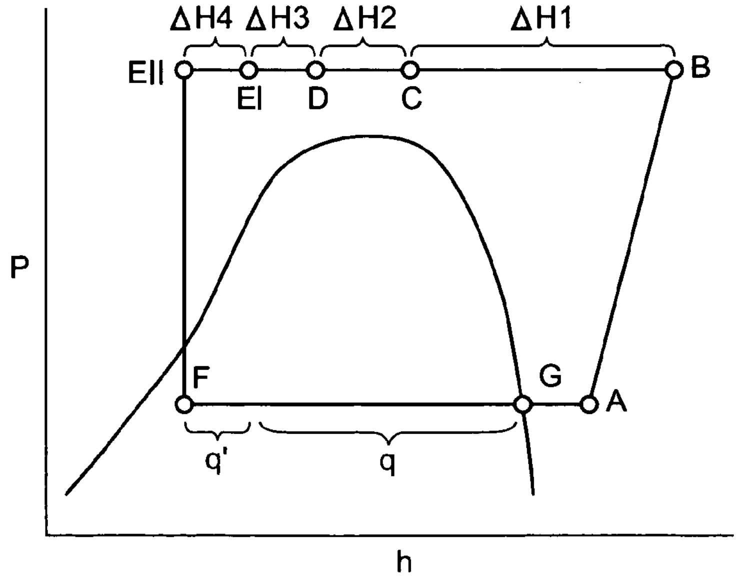
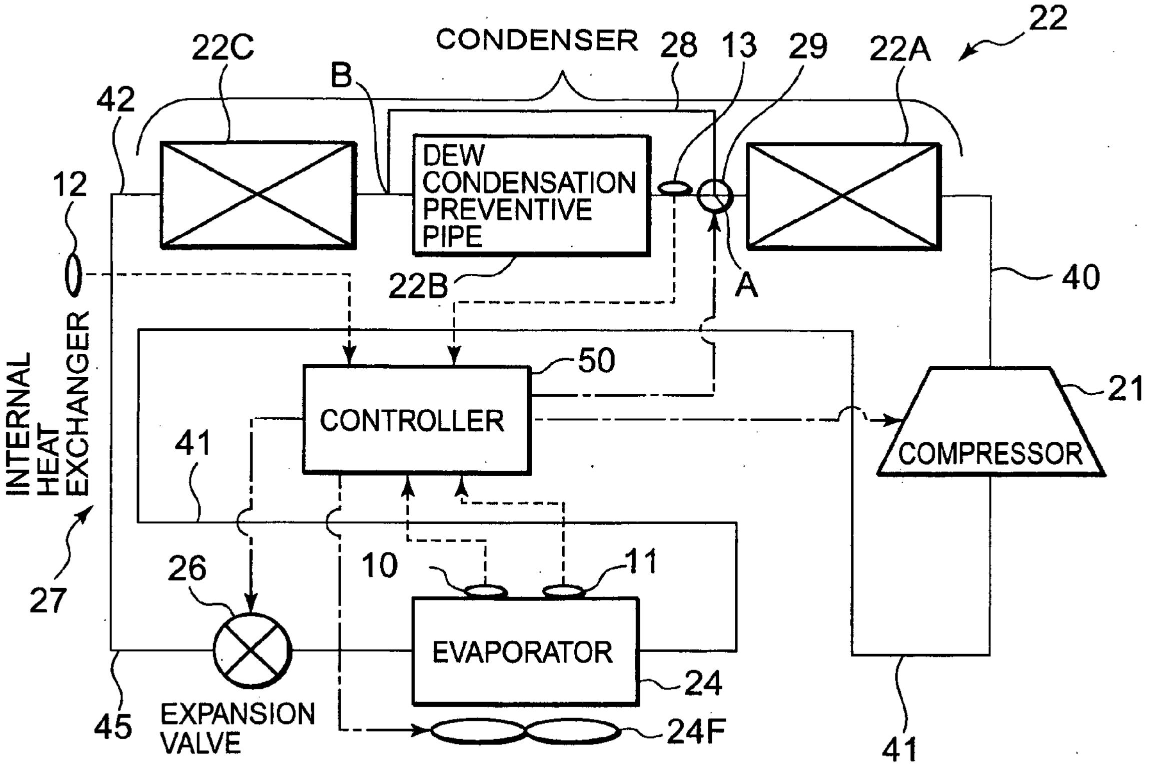

ΔH4
ΔH3
ΔH2
ΔH1
EII
EI
D
C
B
P
F
G
A
q'
q
h

FIG. 6


CONDENSER
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B
28
13
29
22A
22
42
12
DEW
CONDENSATION
PREVENTIVE
PIPE
22B
A
40
INTERNAL
HEAT
EXCHANGER
50
CONTROLLER
21
COMPRESSOR
41
27
26
10
11
EVAPORATOR
24
45
EXPANSION
VALVE
24F
41

FIG. 7

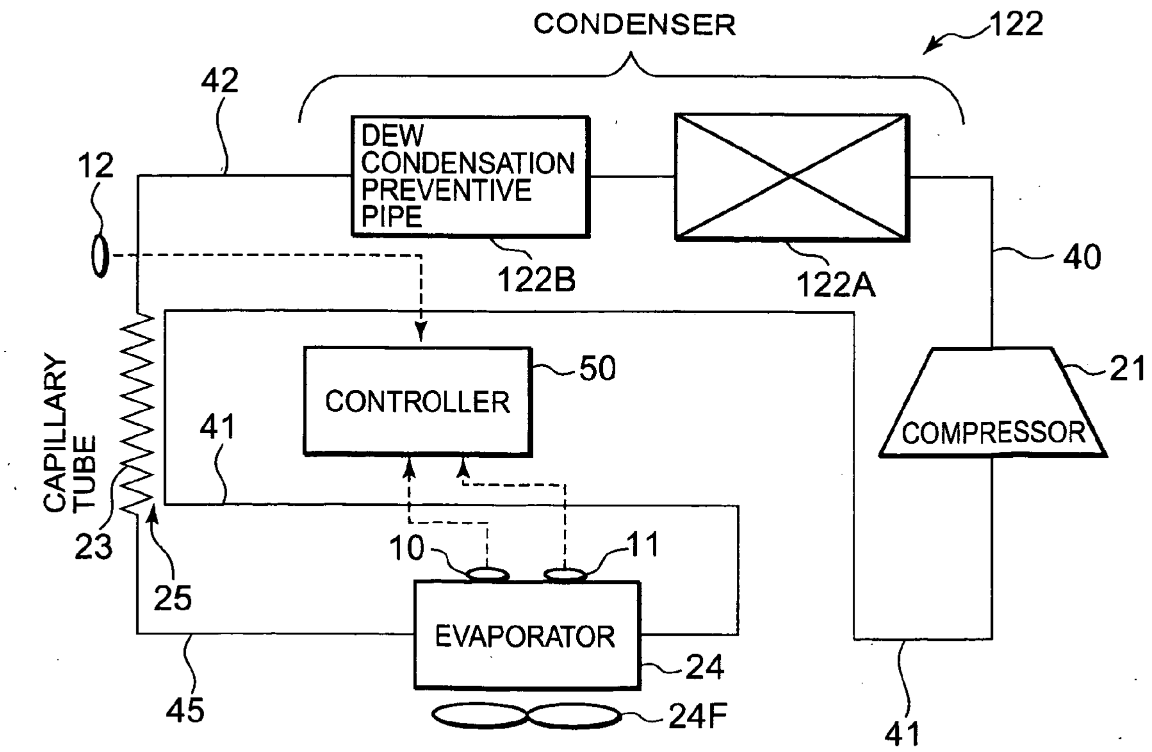

CONDENSER
122
42
12
DEW
CONDENSATION
PREVENTIVE
PIPE
122B
122A
40
50
CONTROLLER
21
COMPRESSOR
CAPILLARY
TUBE
41
23
25
10
11
EVAPORATOR
24
45
24F
41

FIG. 8

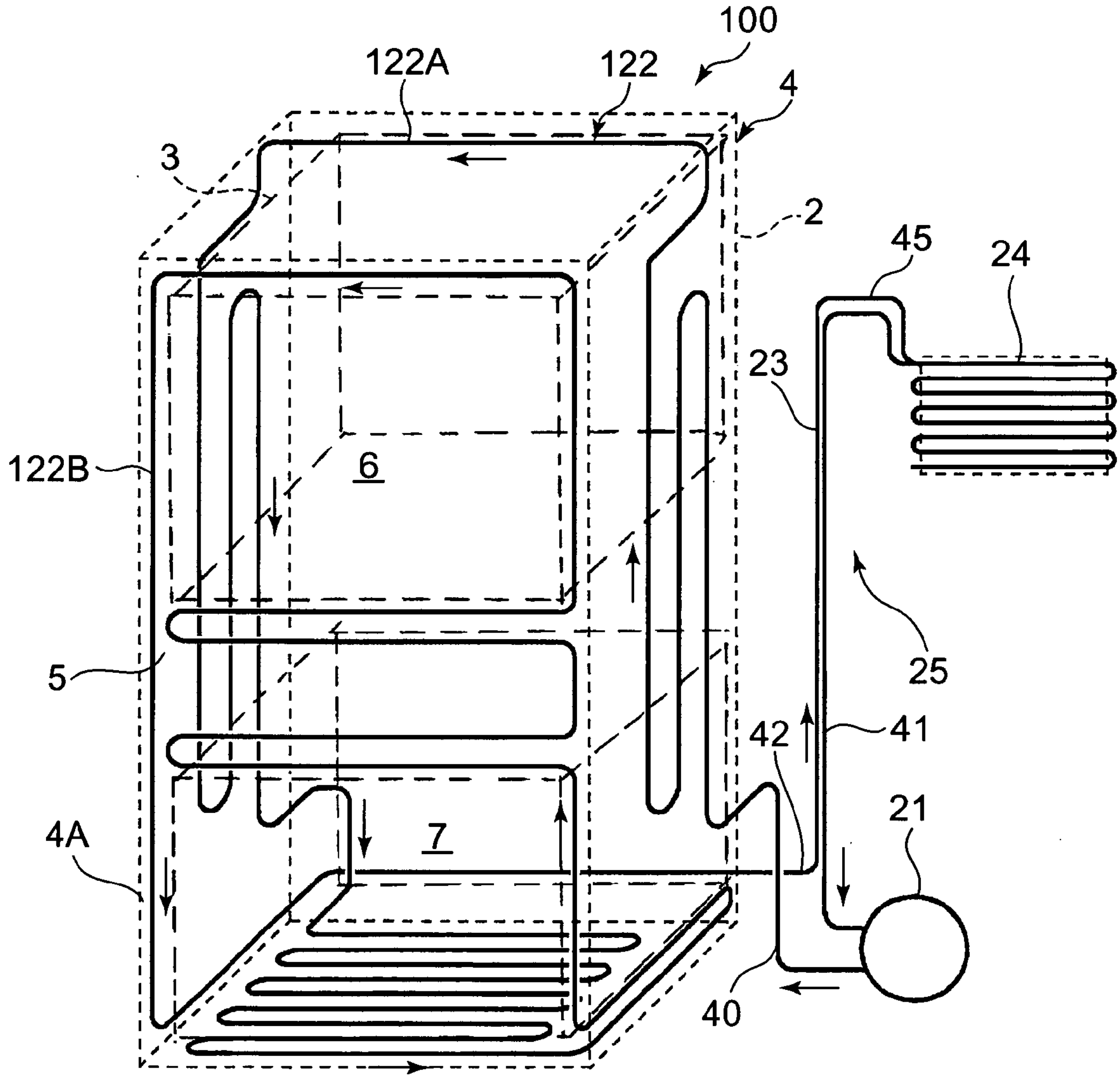
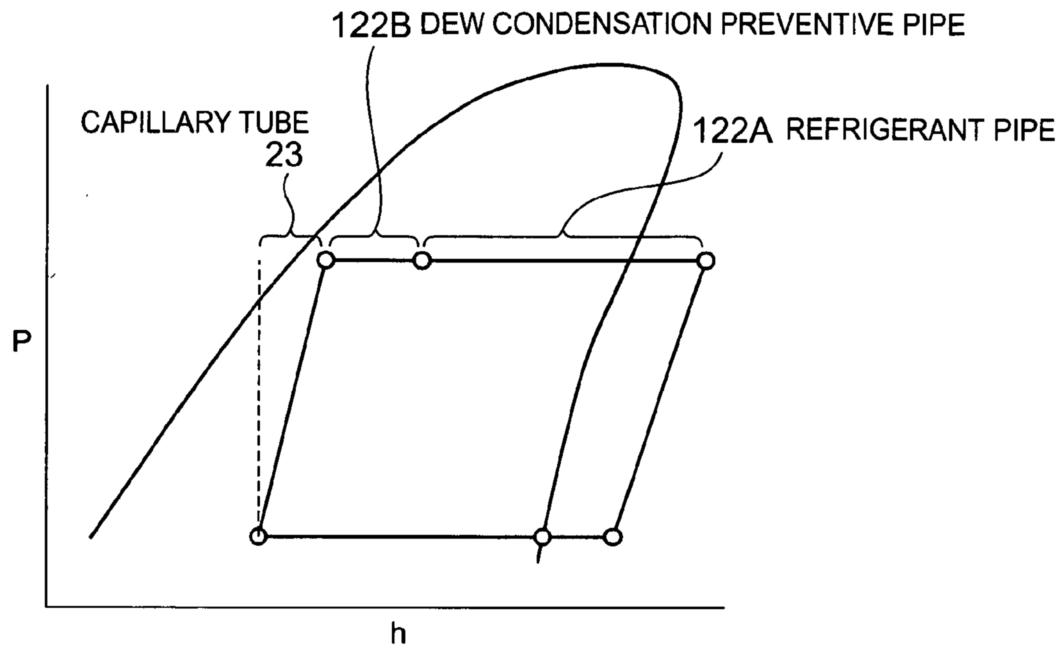


FIG. 9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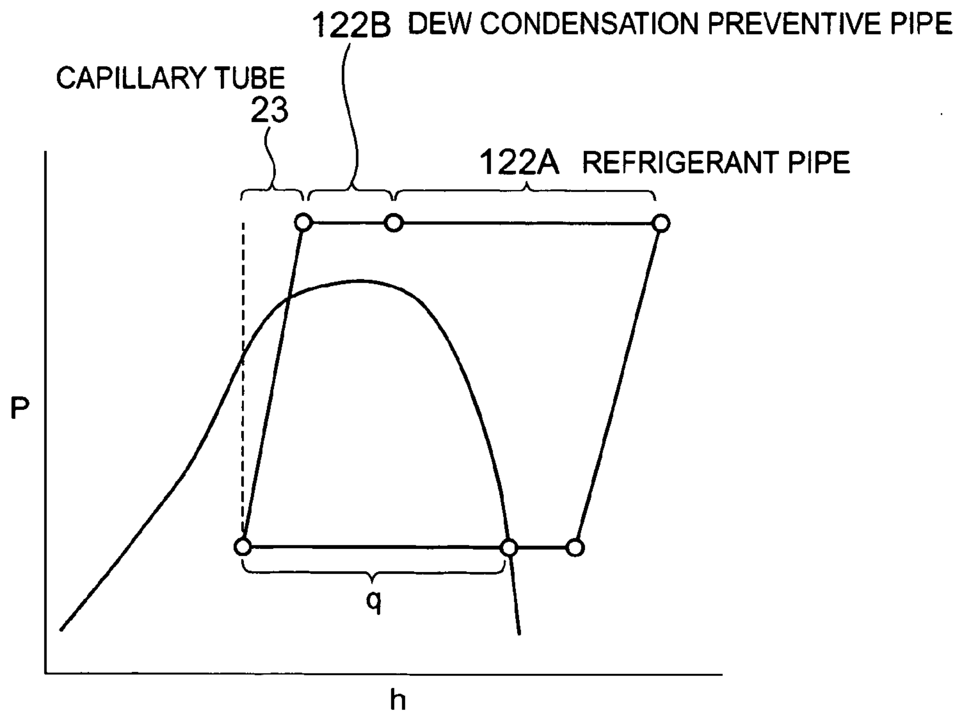
CAPILLARY TUBE
23
122A REFRIGERANT PIPE
P
h

FIG. 10


122B DEW CONDENSATION PREVENTIVE PIPE
CAPILLARY TUBE
23
122A REFRIGERANT PIPE
P
q
h

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- JP 7239178 A **[0005]**
- JP 10197122 A **[0005]**