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(54) EVAPORATOR AND REFRIGERATION CYCLE DEVICE EQUIPPED WITH SAME

(57) There is provided an evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator improving frost proof performance and heat exchange performance. If the opening side of a cutout is present on the windward side of an airflow, a difference between an air temperature and an evaporator surface temperature is large, which improves heat exchange performance but easily causes frost. Conversely, if the opening side of the cutout is present on the leeward side, frost proof performance is improved but heat exchange performance is degraded. In particular, since a non-azeotropic refrigerant mixture is used as a refrigerant, the refrigerant temperature tends to decrease on the inlet side of the evaporator due to a temperature gradient, and frost is easily generated. However, since a first heat exchange section (23a) in which the opening side of the cutout is positioned on the leeward side in the airflow direction is formed, it is possible to improve frost proof performance by providing the first heat exchange section (23a) at least on the inlet side of the evaporator.

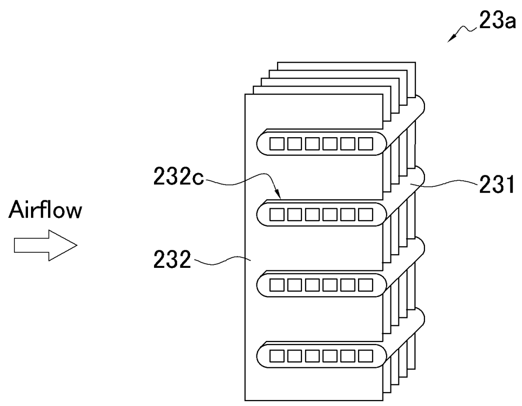


FIG. 5A

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed.

BACKGROUND ART

[0002] As an evaporator of a refrigeration cycle apparatus, there is an evaporator in a form in which a plurality of heat transfer tubes are unevenly distributed more on either one of the windward side and the leeward side of the center of a heat transfer fin. For example, the evaporator described in PTL 1 (WO2017/183180) is a stack-type heat exchanger in which elongated holes each having a longitudinal diameter extending in the width direction of a fin are provided at a predetermined interval in a direction orthogonal to the width direction and the thickness direction of the fin and in which a flat pipe is inserted into each of the elongated holes.

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0003] In an evaporator such as that described above, disposing the center of the entirety of a flat pipe group in the width direction on the air windward side of the center of a fin in the width direction increases a difference between an air temperature and a heat-exchanger surface temperature, which improves heat exchange performance but easily causes frost. Conversely, disposing the center of the entirety of the flat pipe group in the width direction on the leeward side of the center of the fin in the width direction tends to improve frost proof performance (capacity of suppressing frost) but degrades heat exchange performance.

[0004] In particular, since the composition of a non-azeotropic refrigerant mixture is different between a liquid phase and a gas phase, the refrigerant temperature at an inlet is lower than that at an outlet in an evaporator. Thus, when flat pipes are unevenly distributed more on the windward side, frost is easily generated.

[0005] In PTL 1, a distance between the flat pipes and a windward-side edge of the fin is considered from the point of view of drainage of condensed water and melted water but is not considered from the point of view of frost proof performance (capacity of suppressing frost) and/or heat exchange performance in a case where a refrigerant that flows in the evaporator is specified as a non-azeotropic refrigerant mixture.

[0006] Therefore, there is a task of providing, as an evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, an evaporator that improves frost proof performance and/or heat exchange performance.

SOLUTION TO PROBLEM

[0007] An evaporator according to a first aspect is an evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator including a plurality of fins and a plurality of heat transfer tubes. The plurality of fins are arranged at a predetermined interval in a plate thickness direction. The plurality of heat transfer tubes extend through the plurality of fins in the plate thickness direction. In the evaporator, a first heat exchange section is formed. In the first heat exchange section, when the plurality of heat transfer tubes are viewed as a heat-transfer-tube group in the plate thickness direction of the fins, a distribution center of the heat-transfer-tube group in an airflow direction is positioned on the leeward side of the center of the fins in the airflow direction.

[0008] In this evaporator, since an enclosed refrigerant is a non-azeotropic refrigerant mixture, a refrigerant temperature at an evaporator inlet is low compared with at an outlet, which easily causes frost. However, for example, when the first heat exchange section is provided on the refrigerant inlet side, the distribution center of the heat-transfer-tube group is positioned on the leeward side of the center of the fins in the airflow direction. Thus, frost is not easily generated compared with when the distribution center of the heat-transfer-tube group is positioned on the windward side of the center of the fins.

[0009] An evaporator according to a second aspect is the evaporator according to the first aspect in which a second heat exchange section is further formed. In the second heat exchange section, the distribution center of the heat-transfer-tube group is positioned on the windward side of the center of the fins in the airflow direction.

[0010] In this evaporator, the temperature of the non-azeotropic refrigerant mixture increases from the inlet toward the outlet of the evaporator. It is thus preferable on the outlet side to put high priority on heat exchange performance rather than frost proof performance and to position the distribution center of the heat-transfer-tube group on the windward side of the center of the fins in the airflow direction.

[0011] Therefore, by forming, in addition to the first heat exchange section according to the first aspect, the second heat exchange section in which the distribution center of the heat-transfer-tube group is positioned on the windward side of the center of the fins in the airflow direction, it is possible to, for example, dispose the first heat exchange section on the evaporator inlet side and the second heat exchange section on the evaporator outlet side. Thus, it is possible to try a combination of the heat exchange sections suitable for a refrigerant temperature in the evaporator.

[0012] An evaporator according to a third aspect is the evaporator according to the second aspect in which a third heat exchange section is further formed. In the third heat exchange section, the distribution center of the heat-transfer-tube group substantially coincides with the center of the fins in the airflow direction.

[0013] In this evaporator, for example, it is possible to dispose the first heat exchange section on the evaporator inlet side, the second heat exchange section on the evaporator outlet side, and the third heat exchange section between the first heat exchange section and the second heat exchange section. Thus, it is possible to try a combination of the heat exchange sections suitable for a refrigerant temperature in the evaporator.

[0014] An evaporator according to a fourth aspect is the evaporator according to the second aspect in which the first heat exchange section and the second heat exchange section are integral with each other.

[0015] An evaporator according to a fifth aspect is the evaporator according to the third aspect in which the first heat exchange section is integral with at least either one of the second heat exchange section and the third heat exchange section.

[0016] An evaporator according to a sixth aspect is an evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator including a plurality of fins and a plurality of heat transfer tubes. The plurality of fins are arranged at a predetermined interval in a plate thickness direction. The plurality of heat transfer tubes extend through the plurality of fins in the plate thickness direction. In the evaporator, a first heat exchange section and a second heat exchange section are formed. In the first heat exchange section, a distance from a windward-side end of the heat transfer tube positioned on the most windward side in an airflow direction to a windward-side end of the fins is a first dimension. In the second heat exchange section, a distance from a windward-side end of the heat transfer tube positioned on the most windward side in the airflow direction to a windward-side end of the fins is a second dimension smaller than the first dimension.

[0017] In this evaporator, the temperature of the non-azeotropic refrigerant mixture increases from the inlet toward the outlet of the evaporator. It is thus preferable to put a high priority on frost proof performance on the inlet side and put a high priority on heat exchange performance on the outlet side.

[0018] For example, it is possible to dispose the first heat exchange section on the evaporator inlet side and the second heat exchange section on the evaporator outlet side. Thus, it is possible to try a combination suitable for a refrigerant temperature in the evaporator.

[0019] An evaporator according to a seventh aspect is the evaporator according to the sixth aspect in which a third heat exchange section is further formed. In the third heat exchange section, a distance from a windward-side end of the heat transfer tube positioned on the most windward side in the airflow direction to a windward-side end of the fins and a distance from a leeward-side end of the heat transfer tube positioned on the most leeward side in the airflow direction to a leeward-side end of the fins are equal to each other.

[0020] In this evaporator, for example, it is possible to dispose the first heat exchange section on the evaporator inlet side, the second heat exchange section on the evaporator outlet side, and the third heat exchange section between the first heat exchange section and the second heat exchange section. Thus, it is possible to try a combination of the heat exchange sections suitable for a refrigerant temperature in the evaporator.

[0021] An evaporator according to an eighth aspect is the evaporator according to the sixth aspect in which the first heat exchange section and the second heat exchange section are integral with each other.

[0022] An evaporator according to a ninth aspect is the evaporator according to the seventh aspect in which the first heat exchange section is integral with at least either one of the second heat exchange section and the third heat exchange section.

[0023] An evaporator according to a tenth aspect is an evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator including a plurality of fins and a plurality of heat transfer tubes. The plurality of fins are arranged at a predetermined interval in a plate thickness direction. The plurality of heat transfer tubes extend through the plurality of fins in the plate thickness direction. The fins have a plurality of cutouts. The plurality of cutouts are arranged in a direction orthogonal to both an airflow direction and the plate thickness direction. The heat transfer tubes are flat multi-hole pipes inserted into the cutouts. In the evaporator, a first heat exchange section is formed. In the first heat exchange section, the opening side of the cutouts is positioned on the leeward side in the airflow direction.

[0024] In this evaporator, if the opening side of a cutout is present on the windward side of an airflow, a difference between an air temperature and an evaporator surface temperature is large, which improves heat exchange performance but easily causes frost. Conversely, if the opening side of the cutout is present on the leeward side, frost proof performance is improved but heat exchange performance is degraded. In particular, since a non-azeotropic refrigerant mixture is used as a refrigerant, the refrigerant temperature tends to decrease on the inlet side of the evaporator due to a temperature gradient, and frost is easily generated.

[0025] However, since the first heat exchange section in which the opening side of the cutout is positioned on the leeward side in the airflow direction is formed, it is possible to improve frost proof performance by providing the first heat exchange section at least on the inlet side of the evaporator.

[0026] An evaporator according to an eleventh aspect is the evaporator according to the tenth aspect in which a second heat exchange section is further formed. In the second heat exchange section, the opening side of the cutouts is positioned on the windward side in the airflow direction.

[0027] In this evaporator, for example, it is possible to dispose the first heat exchange section on the evaporator inlet side and the second heat exchange section on the evaporator outlet side. Thus, it is possible to try a combination suitable for a refrigerant temperature in the evaporator.

[0028] An evaporator according to a twelfth aspect is the evaporator according to the eleventh aspect in which the first heat exchange section and the second heat exchange section are integral with each other.

[0029] A refrigeration cycle apparatus according to a thirteenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes any of a HFC refrigerant, a HFO refrigerant, CF3I, and a natural refrigerant.

[0030] A refrigeration cycle apparatus according to a fourteenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes any of R32, R1132(E), R1234yf, R1234ze, CF3I, and CO2.

[0031] A refrigeration cycle apparatus according to a fifteenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes at least R1132(E), R32, and R1234yf.

[0032] A refrigeration cycle apparatus according to a sixteenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes at least R1132(E), R1123, and R1234yf.

[0033] A refrigeration cycle apparatus according to a seventeenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes at least R1132(E) and R1234yf.

[0034] A refrigeration cycle apparatus according to an eighteenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes at least R32, R1234yf, and at least one of R1132a and R1114.

[0035] A refrigeration cycle apparatus according to a nineteenth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes at least R32, CO2, R125, R134a, and R1234yf.

[0036] A refrigeration cycle apparatus according to a twentieth aspect is a refrigeration cycle apparatus including the evaporator according to any one of the first to twelfth aspects. The non-azeotropic refrigerant mixture includes at least R1132(Z) and R1234yf.

BRIEF DESCRIPTION OF DRAWINGS

[0037]

Fig. 1 is a schematic diagram of an air conditioning apparatus as a refrigeration apparatus according to one embodiment of the present disclosure.

Fig. 2 is a schematic front view of an indoor heat exchanger.

Fig. 3 is an external perspective view of an outdoor heat exchanger.

Fig. 4 is a P-H diagram of a non-azeotropic refrigerant mixture.

Fig. 5A is a perspective view of a first heat exchange section of an outdoor heat exchanger according to a first embodiment.

Fig. 5B is a perspective view of a second heat exchange section of the outdoor heat exchanger according to the first embodiment.

Fig. 6A is a schematic perspective view of an outdoor heat exchanger that uses both the first heat exchange section and the second heat exchange section.

Fig. 6B is a schematic perspective view of a different outdoor heat exchanger that uses both the first heat exchange section and the second heat exchange section.

Fig. 7A is a perspective view of a first heat exchange section of an outdoor heat exchanger according to a second embodiment.

Fig. 7B is a perspective view of a second heat exchange section of the outdoor heat exchanger according to the second embodiment.

Fig. 7C is a perspective view of a third heat exchange section of an outdoor heat exchanger according to a modification of the second embodiment.

Fig. 8A is a perspective view of a first heat exchange section of an outdoor heat exchanger according to a third embodiment.

Fig. 8B is a perspective view of a second heat exchange section of the outdoor heat exchanger according to the third embodiment.

Fig. 8C is a perspective view of a third heat exchange section of an outdoor heat exchanger according to a modification of the third embodiment.

DESCRIPTION OF EMBODIMENTS

<First Embodiment

(1) Configuration of Air Conditioning Apparatus 1

[0038] Fig. 1 is a schematic diagram of an air conditioning apparatus 1 according to one embodiment of the present disclosure. In Fig. 1, the air conditioning apparatus 1 is a refrigeration apparatus that performs cooling operation and heating operation by a vapor compression refrigeration cycle.

[0039] A refrigerant circuit 10 of the air conditioning apparatus 1 is constituted by an outdoor unit 2 and an indoor unit 4 that are connected to each other via a liquid-refrigerant connection pipe 5 and a gas-refrigerant connection pipe 6.

[0040] A refrigerant enclosed in the refrigerant circuit

10 is a non-azeotropic refrigerant mixture. The non-azeotropic refrigerant mixture includes any of a HFC refrigerant, a HFO refrigerant, CF3I, and a natural refrigerant.

(1-1) Indoor Unit 4

[0041] The indoor unit 4 is installed indoors and constitutes part of the refrigerant circuit 10. The indoor unit 4 includes an indoor heat exchanger 41, an indoor fan 42, and an indoor-side control unit 44.

(1-1-1) Indoor Heat Exchanger 41

[0042] The indoor heat exchanger 41 functions as an evaporator for the refrigerant during cooling operation and cools indoor air. In addition, the indoor heat exchanger 41 functions as a radiator for the refrigerant during heating operation and heats indoor air. The refrigerant inlet side of the indoor heat exchanger 41 during cooling operation is connected to the liquid-refrigerant connection pipe 5, and the refrigerant outlet side thereof is connected to the gas-refrigerant connection pipe 6.

[0043] Fig. 2 is a front view of the indoor heat exchanger 41. In Fig. 2, the indoor heat exchanger 41 is a cross-fin-type heat exchanger. The indoor heat exchanger has a heat transfer fin 412 and a heat transfer tube 411.

[0044] The heat transfer fin 412 is a thin aluminum flat plate. The heat transfer fin 412 has a plurality of through holes. The heat transfer tube 411 has a straight tube 411a inserted into the through holes of the heat transfer fin 412, and U-shaped tubes 411b and 411c that couple end portions of mutually adjacent straight tubes 411a to each other.

[0045] The straight tube 411a is in close contact with the heat transfer fin 412 by being subjected to tube expansion processing after inserted into the through holes of the heat transfer fin 412. The straight tube 411a and the first U-shaped tube 411b are formed integrally with each other. The second U-shaped tube 411c is coupled to an end portion of the straight tube 411a by welding, brazing, or the like after the straight tube 411a is inserted into the through holes of the heat transfer fin 412 and subjected to tube expansion processing.

(1-1-2) Indoor Fan 42

[0046] The indoor fan 42 takes indoor air into the indoor unit 4, causes the indoor air to exchange heat with the refrigerant in the indoor heat exchanger 41, and then supplies the air to the inside of a room. As the indoor fan 42, a centrifugal fan, a multi-blade fan, or the like is employed. The indoor fan 42 is driven by an indoor fan motor 43.

(1-1-3) Indoor-Side Control Unit 44

[0047] The indoor-side control unit 44 controls operation of each portion that constitutes the indoor unit 4. The indoor-side control unit 44 has a microcomputer and a memory that are for controlling the indoor unit 4.

[0048] The indoor-side control unit 44 transmits and receives a control signal and the like to and from a remote controller (not illustrated). In addition, the indoor-side control unit 44 transmits and receives a control signal and the like to and from an outdoor-side control unit 38 of the outdoor unit 2 via a transmission line 8a.

(1-2) Outdoor Unit 2

[0049] The outdoor unit 2 is installed outdoors and constitutes part of the refrigerant circuit 10. The outdoor unit 2 includes a compressor 21, a four-way switching valve 22, an outdoor heat exchanger 23, an expansion valve 26, a liquid-side shutoff valve 27, and a gas-side shutoff valve 28.

(1-2-1) Compressor 21

[0050] The compressor 21 is a device that compresses a low-pressure refrigerant of the refrigeration cycle. The compressor 21 drives and rotates a positive-displacement compression element (not illustrated) of a rotary type, a scroll type, or the like by a compressor motor 21a.

[0051] A suction pipe 31 is connected to the suction side of the compressor 21, and a discharge pipe 32 is connected to the discharge side thereof. The suction pipe 31 is a refrigerant pipe that connects the suction side of the compressor 21 and the four-way switching valve 22 to each other. The discharge pipe 32 is a refrigerant pipe that connects the discharge side of the compressor 21 and the four-way switching valve 22 to each other.

[0052] An accumulator 29 is connected to the suction pipe 31. The accumulator 29 separates a flowed-in refrigerant into a liquid refrigerant and a gas refrigerant and causes only the gas refrigerant to flow to the suction side of the compressor 21.

(1-2-2) Four-Way Switching Valve 22

[0053] The four-way switching valve 22 switches the direction of the flow of the refrigerant in the refrigerant circuit 10. During cooling operation, the four-way switching valve 22 causes the outdoor heat exchanger 23 to function as a radiator for the refrigerant and causes the indoor heat exchanger 41 to function as an evaporator for the refrigerant.

[0054] During cooling operation, the four-way switching valve 22 connects the discharge pipe 32 of the compressor 21 and a first gas refrigerant pipe 33 of the outdoor heat exchanger 23 to each other and connects the suction pipe 31 of the compressor 21 and a second gas refrigerant pipe 34 to each other (refer to the solid lines of the four-way switching valve 22 in Fig. 1).

[0055] During heating operation, the four-way switching valve 22 is switched to a heating cycle state in which the outdoor heat exchanger 23 functions as an evaporator for the refrigerant and in which the indoor heat exchanger 41 functions as a radiator for the refrigerant.

[0056] During heating operation, the four-way switching valve 22 connects the discharge pipe 32 of the compressor 21 and the second gas refrigerant pipe 34 to each other and connects the suction pipe 31 of the compressor 21 and the first gas refrigerant pipe 33 of the outdoor heat exchanger 23 to each other (refer to the broken lines of the four-way switching valve 22 in Fig. 1).

[0057] Here, the first gas refrigerant pipe 33 is a refrigerant pipe that connects the four-way switching valve 22 and the refrigerant inlet of the outdoor heat exchanger 23 during cooling operation to each other. The second gas refrigerant pipe 34 is a refrigerant pipe that connects the four-way switching valve 22 and the gas-side shutoff valve 28 to each other.

(1-2-3) Outdoor Heat Exchanger 23

[0058] The outdoor heat exchanger 23 functions as a radiator for the refrigerant during cooling operation. In addition, the outdoor heat exchanger 23 functions as an evaporator for the refrigerant during heating operation. One end of a liquid refrigerant pipe 35 is connected to the refrigerant outlet of the outdoor heat exchanger 23 during cooling operation. The other end of the liquid refrigerant pipe 35 is connected to the expansion valve 26.

[0059] The outdoor heat exchanger 23 will be described in detail in the section "(3) Detailed Structure of Outdoor Heat Exchanger 23".

(1-2-4) Expansion Valve 26

[0060] The expansion valve 26 is an electric expansion valve. During cooling operation, the expansion valve 26 decompresses a high-pressure refrigerant that is sent from the outdoor heat exchanger 23 to a low pressure. During heating operation, the expansion valve 26 decompresses a high-pressure refrigerant that is sent from the indoor heat exchanger 41 to a low pressure.

(1-2-5) Liquid-Side Shutoff Valve 27 and Gas-Side Shutoff Valve 28

[0061] The liquid-side shutoff valve 27 is connected to the liquid-refrigerant connection pipe 5. The gas-side shutoff valve 28 is connected the gas-refrigerant connection pipe 6. The liquid-side shutoff valve 27 is positioned downstream the expansion valve 26 in a refrigerant circulation direction during cooling operation. The gas-side shutoff valve 28 is positioned upstream the four-way switching valve 22 in a refrigerant circulation direction during cooling operation.

(1-2-6) Outdoor Fan

[0062] The outdoor unit 2 includes an outdoor fan 36. The outdoor fan 36 takes outdoor air into the outdoor unit 2, causes the outdoor air to exchange heat with the refrigerant in the outdoor heat exchanger 23, and then discharges the air to the outside. As the outdoor fan 36, a propeller fan or the like is employed. The outdoor fan 36 is driven by an outdoor-fan motor 37.

(1-2-7) Outdoor-Side Control Unit 38

[0063] The outdoor-side control unit 38 controls operation of each portion that constitutes the outdoor unit 2. The outdoor-side control unit 38 has a microcomputer and a memory that are for controlling the outdoor unit 2.

[0064] The outdoor-side control unit 38 transmits and receives a control signal and the like to and from the indoor-side control unit 44 of the indoor unit 4 via the transmission line 8a.

(1-3) Refrigerant Connection Pipes 5 and 6

[0065] The connection pipes 5 and 6 are refrigerant pipes that are constructed at a local site during installation of the air conditioning apparatus 1 in an installation location at a building or the like. As each of the connection pipes 5 and 6, a pipe having an appropriate length and an appropriate diameter is employed in accordance with installation conditions such as an installation location, a combination of the outdoor unit 2 and the indoor unit 4, and the like.

(2) Basic Operation of Air Conditioning Apparatus

[0066] Next, a basic operation of the air conditioning apparatus 1 will be described with reference to Fig. 1. The air conditioning apparatus 1 is capable of performing cooling operation and heating operation as basic operation.

(2-1) Cooling Operation

[0067] During cooling operation, the four-way switching valve 22 is switched to a cooling cycle state (the state indicated by the solid lines in Fig. 1). In the refrigerant circuit 10, a low-pressure gas refrigerant of the refrigeration cycle is sucked by the compressor 21 and discharged after compressed.

[0068] The high-pressure gas refrigerant discharged from the compressor 21 is sent to the outdoor heat exchanger 23 via the four-way switching valve 22.

[0069] In the outdoor heat exchanger 23 that functions as a radiator, the high-pressure gas refrigerant sent to the outdoor heat exchanger 23 radiates heat by exchanging heat with outdoor air supplied from the outdoor fan 36, and becomes a high-pressure liquid refrigerant. The high-pressure liquid refrigerant is sent to the expansion valve 26.

[0070] The high-pressure liquid refrigerant sent to the expansion valve 26 is decompressed to a low pressure of the refrigeration cycle by the expansion valve 26 and becomes a low-pressure gas-liquid two-phase refrigerant. The low-pressure gas-liquid two-phase refrigerant decompressed in the expansion valve 26 is sent to the indoor heat exchanger 41 via the liquid-side shutoff valve 27 and the liquid-refrigerant connection pipe 5.

[0071] The low-pressure gas-liquid two-phase refrigerant sent to the indoor heat exchanger 41 evaporates in the indoor heat exchanger 41 by exchanging heat with indoor air supplied from the indoor fan 42. Consequently, the indoor air is cooled. Then, the cooled air is supplied to the inside of a room, thereby cooling the inside of the room.

[0072] The low-pressure gas refrigerant that has evaporated in the indoor heat exchanger 41 is sucked again by the compressor 21 via the gas-refrigerant connection pipe 6, the gas-side shutoff valve 28, and the four-way switching valve 22.

(2-2) Heating Operation

[0073] During heating operation, the four-way switching valve 22 is switched to the heating cycle state (the state indicated by the broken lines in Fig. 1). In the refrigerant circuit 10, a low-pressure gas refrigerant of the refrigeration cycle is sucked by the compressor 21 and discharged after compressed.

[0074] The high-pressure gas refrigerant discharged from the compressor 21 is sent to the indoor heat exchanger 41 via the four-way switching valve 22, the gas-side shutoff valve 28, and the gas-refrigerant connection pipe 6.

[0075] The high-pressure gas refrigerant sent to the indoor heat exchanger 41 radiates heat in the indoor heat exchanger 41 by exchanging heat with indoor air supplied from the indoor fan 42, and becomes a high-pressure liquid refrigerant. Consequently, the indoor air is heated. Then, the heated air is supplied to the inside of a room, thereby heating the inside of the room.

[0076] The high-pressure liquid refrigerant that has radiated heat in the indoor heat exchanger 41 is sent to the expansion valve 26 via the liquid-refrigerant connection pipe 5 and the liquid-side shutoff valve 27.

[0077] The high-pressure liquid refrigerant sent to the expansion valve 26 is decompressed to a low pressure of the refrigeration cycle by the expansion valve 26 and becomes a low-pressure gas-liquid two-phase refrigerant. The low-pressure gas-liquid two-phase refrigerant decompressed in the expansion valve 26 is sent to the outdoor heat exchanger 23.

[0078] The low-pressure gas-liquid two-phase refrigerant sent to the outdoor heat exchanger 23 evaporates in the outdoor heat exchanger 23 by exchanging heat with outdoor air supplied from the outdoor fan 36, and becomes a low-pressure gas refrigerant.

[0079] The low-pressure refrigerant that has evaporated in the outdoor heat exchanger 23 is sucked again by the compressor 21 through the four-way switching valve 22.

(3) Detailed Description of Outdoor Heat Exchanger 23

(3-1) Structure

[0080] Fig. 3 is an external perspective view of the outdoor heat exchanger 23. In Fig. 3, the outdoor heat exchanger 23 is a stack-type heat exchanger. The outdoor heat exchanger 23 includes a plurality of flat pipes 231 and a plurality of heat transfer fins 232.

(3-1-1) Flat Pipes 231

[0081] Each flat pipe 231 is a multi-hole pipe. The flat pipe 231 is formed of aluminum or an aluminum alloy and has a flat portion 231a that serves as a heat transfer surface, and a plurality of internal flow paths 231b in which the refrigerant flows.

[0082] The flat pipes 231 are arrayed in a plurality of stages to be stacked with a gap (ventilation space) therebetween in a state in which respective flat portions 231a are directed upward/downward.

(3-1-2) Heat Transfer Fins 232

[0083] Each heat transfer fin 232 is a fin made of aluminum or an aluminum alloy. The heat transfer fin 232 is disposed in a ventilation space between the flat pipes 231 that are vertically adjacent to each other and is in contact with the flat portions 231a of the flat pipes 231.

[0084] The heat transfer fin 232 has cutouts 232c (refer to Fig. 5A and Fig. 5B) into which the flat pipes 231 are inserted. After the flat pipes 231 are inserted into the cutouts 232c of the heat transfer fins 232, the heat transfer fins 232 and the flat portions 231a of the flat pipes 231 are joined to each other by brazing or the like.

(3-1-3) Headers 233a and 233b

[0085] The headers 233a and 233b are coupled to both ends of the flat pipes 231 arrayed in the plurality of stages in the up-down direction. The headers 233a and 233b have a function of supporting the flat pipes 231, a function of guiding the refrigerant to the internal flow paths of the flat pipes 231, and a function of gathering the refrigerant that has flowed out from the internal flow paths.

[0086] When the outdoor heat exchanger 23 functions as an evaporator for the refrigerant, the refrigerant flows into the first header 233a. The refrigerant that has flowed into the first header 233a is distributed to the internal flow paths of the flat pipes 231 of the stages substantially evenly and flows toward the second header 233b. The refrigerant that flows in the internal flow paths of the flat pipes 231 of the stages absorbs heat via the heat transfer fins 232 from an air flow that flows in the ventilation spaces. The refrigerant that has flowed in the internal flow paths of the flat pipes 231 of the stages gathers at the second header 233b and flows out from the second header 233b.

[0087] When the outdoor heat exchanger 23 functions as a radiator for the refrigerant, the refrigerant flows into the second header 233b. The refrigerant that has flowed into the second header 233b is distributed to the internal flow paths of the flat pipes 231 of the stages substantially evenly and flows toward the first header 233a. The refrigerant that flows in the internal flow paths of the flat pipes 231 of the stages radiates heat via the heat transfer fins 232 into an air flow that flows in the ventilation spaces. The refrigerant that has flowed in the internal flow paths of the flat pipes 231 of the stages gathers at the first header 233a and flows out from the first header 233a.

(3-2) Suppression of Frost

[0088] Fig. 4 is a P-H diagram of a non-azeotropic refrigerant mixture. In Fig. 4, the refrigerant temperature increases toward the evaporator outlet. Since the composition of the non-azeotropic refrigerant mixture is different between a liquid phase and a gas phase, a "temperature gradient" in which an evaporation start temperature and an evaporation end temperature in the evaporator are different is present. Due to the temperature gradient, the temperature at the inlet easily decreases in the evaporator, which easily causes frost during heating operation.

[0089] Fig. 5A is a perspective view of a first heat exchange section 23a of the outdoor heat exchanger 23 according to the first embodiment. In Fig. 5A, the opening side of the cutouts 232c is positioned on the leeward side in the airflow direction in the first heat exchange section 23a.

[0090] Fig. 5B is a perspective view of a second heat exchange section 23b of the outdoor heat exchanger 23 according to the first embodiment. In Fig. 5B, the opening side of the cutouts 232c is positioned on the windward side in the airflow direction.

[0091] Since the openings of the cutouts 232c are positioned on the windward side in the airflow direction in the second heat exchange section 23b illustrated in Fig. 5B, a difference between an air temperature and a heat-exchanger surface temperature is large, and thus has a feature of improving heat exchange performance but easily causing frost.

[0092] Meanwhile, since the openings of the cutouts 232c are positioned on the leeward side in the airflow direction in the first heat exchange section 23a illustrated in Fig. 5A, a difference between an air temperature and a heat-exchanger surface temperature is small compared with the second heat exchange section 23b. Frost is thus suppressed.

[0093] Therefore, in the present embodiment, the first heat exchange section 23a is formed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator.

(3-3) Improvement of Heat Exchange Performance

[0094] As described above, compared with the second heat exchange section 23b, a difference between an air temperature and a heat-exchanger surface temperature is small in the first heat exchange section 23a. The heat exchange performance is thus degraded. Therefore, constituting the entirety of the outdoor heat exchanger 23 by the first heat exchange section 23a is not preferable for performance.

[0095] Thus, in the present embodiment, both the first heat exchange section 23a and the second heat exchange section 23b are used to improve heat exchange performance while suppressing frost.

[0096] Fig. 6A is a schematic perspective view of the outdoor heat exchanger 23 that uses both the first heat exchange section 23a and the second heat exchange section 23b. Fig. 6B is a schematic perspective view of a different outdoor heat exchanger 23' that uses both a first heat exchange section 23a' and a second heat exchange section 23b'.

[0097] In Fig. 6A, when the outdoor heat exchanger 23 functions as an evaporator for the refrigerant, the refrigerant that has flowed into the first header 233a is distributed to the internal flow paths 231b of the flat pipes 231 of the stages substantially evenly and flows toward the second header 233b. The temperature of the non-azeotropic refrigerant mixture at the evaporator inlet easily decreases, which easily causes frost. Therefore, a certain section from the first header 233a toward the second header 233b is constituted by the first heat exchange section 23a to suppress frost.

[0098] Meanwhile, the temperature of the non-azeotropic refrigerant mixture increases toward the evaporator outlet. Thus, to improve heat exchange performance, a part between the first heat exchange section 23a and the second header 233b is constituted by the second heat exchange section 23b.

[0099] It is possible by thus disposing the first heat exchange section 23a on the evaporator inlet side and the second heat exchange section 23b on the evaporator outlet side to improve heat exchange performance while suppressing frost.

[0100] In Fig. 6B, when the outdoor heat exchanger 23' functions as an evaporator for the refrigerant, the refrigerant that has flowed into the lower stage of the first header 233a' is distributed to internal flow paths 231b' of the flat pipes 231 of the stages of the lower stage substantially evenly and flows toward the second header 233b'.

[0101] The refrigerant that has reached the lower stage of the second header 233b' gathers temporarily and flows into the upper stage of the second header 233b' via a curved pipe 234. Thereafter, the refrigerant is distributed to the internal flow paths 231b of the flat pipes 231 of the stages of the upper stage substantially evenly and flows toward the second header 233b'.

[0102] The temperature of the non-azeotropic refrigerant mixture at the evaporator inlet easily decreases, which easily causes frost. Therefore, a section from the lower stage of the first header 233a' toward the lower stage of the second header 233b' is constituted by the first heat exchange section 23a' to suppress frost.

[0103] Meanwhile, the temperature of the non-azeotropic refrigerant mixture increases toward the evaporator outlet. Thus, to improve heat exchange performance, a section from the upper stage of the first header 233b' toward the upper stage of the first header 233a' is constituted by the second heat exchange section 23b'.

[0104] It is possible by thus disposing the first heat exchange section 23a' on the evaporator inlet side and the second heat exchange section 23b' on the evaporator outlet side to improve heat exchange performance while suppressing frost.

(4) Features

(4-1)

[0105] In the first heat exchange section 23a of the outdoor heat exchanger 23, the opening side of the cutouts 232c of the heat transfer fins 232 is positioned on the leeward side in the airflow direction. By disposing the first heat exchange section 23a on the side of the inlet for the non-azeotropic refrigerant mixture, it is possible to improve frost proof performance (capacity of suppressing frost) when the outdoor heat exchanger 23 functions as an evaporator.

(4-2)

[0106] In addition, by disposing the first heat exchange section 23a on the side of the inlet for the non-azeotropic refrigerant mixture and disposing the second heat exchange section 23b, in which the openings of the cutouts 232c are positioned on the windward side in the airflow direction, on the side of the outlet, it is possible to improve heat exchange performance while suppressing frost.

(4-3)

[0107] The first heat exchange section 23a and the second heat exchange section 23b are integral with each other.

(5) Modification

[0108] With the first heat exchange section 23a being disposed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator and the second heat exchange section 23b being disposed on the outlet side, a third heat exchange section 23c may be disposed between the first heat exchange section 23a and the second heat exchange section 23b.

[0109] In the third heat exchange section 23c, the distribution center of the flat pipes 231 in the width direction coincides with the center of the heat transfer fins 232 in the airflow direction.

[0110] The technical significance of this modification is that it is possible to try a combination of the heat exchange sections suitable for a refrigerant temperature in the outdoor heat exchanger 23 that functions as an evaporator. As a result, it is possible to improve heat exchange performance while suppressing frost.

[0111] The first heat exchange section 23a may be integral with at least either one of the second heat exchange section 23b and the third heat exchange section 23c.

<Second Embodiment

[0112] In the first embodiment, a stack-type heat exchanger in which the flat pipes 231 are inserted into the cutouts 232c provided in the heat transfer fins 232 is employed as the outdoor heat exchanger 23.

[0113] In the second embodiment, a stack-type heat exchanger in which flat pipes extend through elongated holes provided in heat transfer fins is employed as the outdoor heat exchanger 23.

(1) Suppression of Frost

[0114] Fig. 7A is a perspective view of a first heat exchange section 123a of the outdoor heat exchanger 23 according to the second embodiment. In the first heat exchange section 123a in Fig. 7A, a distance from the windward-side end of a flat pipe 231M positioned on the most windward side in the airflow direction to the windward-side end of a heat transfer fin 232M is a first dimension D1.

[0115] Fig. 7B is a perspective view of a second heat exchange section 123b of the outdoor heat exchanger 23 according to the second embodiment. In the second heat exchange section 123b in Fig. 7B, a distance from the windward-side end of the flat pipe 231M positioned on the most windward side in the airflow direction to the windward-side end of the heat transfer fin 232M is a second dimension D2 smaller than the first dimension D1.

[0116] Since the distance (second dimension D2) from the windward-side end of the flat pipe 231M positioned on the most windward side in the airflow direction to the windward-side end of the heat transfer fin 232M in the second heat exchange section 123b illustrated in Fig. 7B is smaller than the distance (first dimension D1) in the first heat exchange section 123a, a difference between an air temperature and a heat-exchanger surface temperature is large. The second heat exchange section 123b thus has a feature of improving heat exchange performance but easily causing frost.

[0117] Meanwhile, since the distance from the windward-side end of the flat pipe 231M positioned on the most windward side in the airflow direction to the windward-side end of the heat transfer fin 232M in the first heat exchange section 123a illustrated in Fig. 7A is larger than the distance (second dimension D2) in the second heat exchange section 123b, a difference between an air temperature and a heat-exchanger surface temperature is small, compared with the second heat exchange section 123b, which suppresses frost.

[0118] Therefore, in the second embodiment, the first heat exchange section 123a is formed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator.

(2) Improvement of Heat Exchange Performance

[0119] As described above, compared with the second heat exchange section 123b, a difference between an air temperature and a heat-exchanger surface temperature is small in the first heat exchange section 123a. The heat exchange performance is thus degraded. Therefore, constituting the entirety of the outdoor heat exchanger 23 by the first heat exchange section 123a is not preferable for performance.

[0120] Thus, in the second embodiment, both the first heat exchange section 123a and the second heat exchange section 123b are used, as in the first embodiment, to improve heat exchange performance while suppressing frost. Fig. 6A and Fig. 6B are also applied to the second embodiment by replacing the first heat exchange section 23a of the first embodiment with the "first heat exchange section 123a" and replacing the second heat exchange section 23b of the first embodiment with the "second heat exchange section 123b".

[0121] In Fig. 6A, when the outdoor heat exchanger 23 functions as an evaporator for the refrigerant, the refrigerant that has flowed into the first header 233a is distributed to the internal flow paths of the flat pipes of the stages substantially evenly and flows toward the second header 233b. The temperature of the non-azeotropic refrigerant mixture at the evaporator inlet easily decreases, which easily causes frost. Therefore, a certain section from the first header 233a toward the second header 233b is constituted by the first heat exchange section 123a to suppress frost.

[0122] Meanwhile, the temperature of the non-azeotropic refrigerant mixture increases toward the evaporator outlet. Thus, to improve heat exchange performance, a part between the first heat exchange section 123a and the second header 233b is constituted by the second heat exchange section 123b.

[0123] It is possible by thus disposing the first heat exchange section 123a on the evaporator inlet side and the second heat exchange section 123b on the evaporator outlet side to improve heat exchange performance while suppressing frost.

(3) Features of Second Embodiment

(3-1)

[0124] The temperature of the non-azeotropic refrigerant mixture increases from the inlet toward the outlet of the evaporator. It is thus preferable to put a high priority on frost proof performance (capacity of suppressing frost) on the inlet side and put a high priority on heat exchange performance on the outlet side.

[0125] Therefore, it is possible to try a combination suitable for a refrigerant temperature in the evaporator, the combination being such that the first heat exchange section 123a is disposed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator and the second heat exchange section 123b is disposed on the outlet side.

(3-2)

[0126] The first heat exchange section 123a and the second heat exchange section 123b are integral with each other.

(4) Modification

[0127] With the first heat exchange section 123a being disposed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator and the second heat exchange section 123b being disposed on the outlet side, a third heat exchange section may be disposed between the first heat exchange section 123a and the second heat exchange section 123b.

[0128] Fig. 7C is a perspective view of a third heat exchange section 123c of the outdoor heat exchanger 23 according to a modification of the second embodiment. In the third heat exchange section 123c in Fig. 7C, a distance D3 from the windward-side end of the flat pipe 231M positioned on the most windward side in the airflow direction to the windward-side end of the heat transfer fin 232M and a distance from the leeward-side end of the flat pipe 231M positioned on the most leeward side in the airflow direction to the leeward-side end of the heat transfer fin 232M are equal to each other.

[0129] The technical significance of this modification is that it is possible to try a combination of the heat exchange sections suitable for a refrigerant temperature in the outdoor heat exchanger 23 that functions as an evaporator. As a result, it is possible to improve heat exchange performance while suppressing frost.

[0130] The first heat exchange section 123a may be integral with at least either one of the second heat exchange section 123b and the third heat exchange section 123c.

<Third Embodiment

[0131] In the first embodiment and the second embodiment, a stack-type heat exchanger is employed as the outdoor heat exchanger 23. In a third embodiment, a cross-fin-type heat exchanger is employed as the outdoor heat exchanger 23.

(1) Suppression of Frost

[0132] Fig. 8A is a perspective view of a first heat exchange section 223a of the outdoor heat exchanger 23 according to the third embodiment. In the first heat exchange section 223a in Fig. 8A, when a plurality of heat transfer tubes 231N are viewed as a heat-transfer-tube group in the plate thickness direction of a heat transfer fin 232N, the distribution center of the heat-transfer-tube group in the airflow direction is positioned on the leeward side of the center of the heat transfer fin 232N in the airflow direction.

[0133] Fig. 8B is a perspective view of a second heat exchange section 223b of the outdoor heat exchanger 23 according to the third embodiment. In the second heat exchange section 223b in Fig. 8B, the distribution center of the heat-transfer-tube group in the airflow direction is positioned on the windward side of the center of the heat transfer fin 232N in the airflow direction.

[0134] Since the distribution center of the heat-transfer-tube group is positioned on the windward side of the center of the heat transfer fin 232N in the airflow direction, a distance from the windward-side end of the heat transfer tube 231N positioned on the most windward side in the airflow direction to the windward-side end of the heat transfer fin 232N is smaller in the second heat exchange section 223b illustrated in Fig. 8B than the distance in the first heat exchange section 223a. As a result, a difference between an air temperature and a heat-exchanger surface temperature is large. The second heat exchange section 223b thus has a feature of improving heat exchange performance but easily causing frost.

[0135] Meanwhile, since the distribution center of the heat-transfer-tube group in the airflow direction is positioned on the leeward side of the center of the heat transfer fin 232N in the airflow direction, a distance from the windward-side end of the heat transfer tube 231N positioned on the most windward side in the airflow direction to the windward-side end of the heat transfer fin 232N is larger in the first heat exchange section 223a illustrated in Fig. 8A than the distance in the second heat exchange section 223b. As a result, compared with the second heat exchange section 223b, a difference between an air temperature and a heat-exchanger surface temperature is small, which suppresses frost.

[0136] Therefore, in the third embodiment, the first heat exchange section 223a is formed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator.

(2) Improvement of Heat Exchange Performance

[0137] As described above, compared with the second heat exchange section 223b, a difference between an air temperature and a heat-exchanger surface temperature is small in the first heat exchange section 223a. The heat exchange performance is thus degraded. Therefore, constituting the entirety of the outdoor heat exchanger 23 by the first heat exchange section 223a is not preferable for performance.

[0138] Thus, in the third embodiment, both the first heat exchange section 223a and the second heat exchange section 223b are used, as in the first embodiment and the second embodiment, to improve heat exchange performance while suppressing frost. Fig. 6A and Fig. 6B are also applied to the third embodiment by replacing the first heat exchange section 23a of the first embodiment with the "first heat exchange section 223a" and replacing the second heat exchange section 23b of the first embodiment with the "second heat exchange section 223b".

[0139] In Fig. 6A, when the outdoor heat exchanger 23 functions as an evaporator for the refrigerant, the refrigerant that has flowed into the first header 233a is distributed to the heat transfer tubes of the stages substantially evenly and flows toward the second header 233b. The temperature of the non-azeotropic refrigerant mixture at the evaporator inlet easily decreases, which easily causes frost. Therefore, a certain section from the first header 233a toward the second header 233b is constituted by the first heat exchange section 223a to suppress frost.

[0140] Meanwhile, the temperature of the non-azeotropic refrigerant mixture increases toward the evaporator outlet. Thus, to improve heat exchange performance, a part between the first heat exchange section 223a and the second header 233b is constituted by the second heat exchange section 223b.

[0141] It is possible by thus disposing the first heat exchange section 223a on the evaporator inlet side and the second heat exchange section 223b on the evaporator outlet side to improve heat exchange performance while suppressing frost.

(3) Features of Third Embodiment

(3-1)

[0142] The temperature of the non-azeotropic refrigerant mixture increases from the inlet toward the outlet of the evaporator. It is thus preferable to put a high priority on frost proof performance (capacity of suppressing frost) on the inlet side and put a high priority on heat exchange performance on the outlet side.

[0143] Therefore, it is possible to try a combination suitable for a refrigerant temperature in the evaporator, the combination being such that the first heat exchange section 223a is disposed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator and the second heat exchange section 223b is disposed on the outlet side.

(3-2)

[0144] The first heat exchange section 223a and the second heat exchange section 223b are integral with each other.

(4) Modification

[0145] With the first heat exchange section 23a being disposed on the inlet side of the outdoor heat exchanger 23 that functions as an evaporator and the second heat exchange section 23b being disposed on the outlet side, a third heat exchange section may be disposed between the first heat exchange section 223a and the second heat exchange section 223b.

[0146] Fig. 8C is a perspective view of a third heat exchange section 223c of the outdoor heat exchanger 23 according to a modification of the third embodiment. In the third heat exchange section 223c in Fig. 8C, the distribution center of the heat-transfer-tube group in the airflow direction coincides with the center of the fin in the airflow direction.

[0147] The technical significance of this modification is that it is possible to try a combination of the heat exchange sections suitable for a refrigerant temperature in the outdoor heat exchanger 23 that functions as an evaporator. As a result, it is possible to improve heat exchange performance while suppressing frost.

[0148] The first heat exchange section 223a may be integral with at least either one of the second heat exchange section 223b and the third heat exchange section 223c.

<Others>

[0149] In each of the embodiments described above, the non-azeotropic refrigerant mixture is described to include any of a HFC refrigerant, a HFO refrigerant, CF3I, and a natural refrigerant. More specifically, a non-azeotropic refrigerant mixture corresponding to any of (A) to (G) below is desirable.

(A) A non-azeotropic refrigerant mixture that includes any of R32, R1132(E), R1234yf, R1234ze, CF3I, and CO2
(B) A non-azeotropic refrigerant mixture that includes at least R1132(E), R32, and R1234yf
(C) A non-azeotropic refrigerant mixture that includes at least R1132(E), R1123, and R1234yf
(D) A non-azeotropic refrigerant mixture that includes at least R1132(E) and R1234yf
(E) A non-azeotropic refrigerant mixture that includes at least R32, R1234yf, and at least one of R1132a and R1114
(F) A non-azeotropic refrigerant mixture that includes at least R32, CO2, R125, R134a, and R1234yf
(G) A non-azeotropic refrigerant mixture that includes at least R1132(Z) and R1234yf

[0150] Embodiments of the present disclosure have been described above; however, it should be understood that various changes in the forms and details are possible without departing from the gist and the scope of the present disclosure described in the claims.

INDUSTRIAL APPLICABILITY

[0151] The present disclosure is widely applicable to a refrigeration apparatus capable of performing cooling operation and heating operation.

REFERENCE SIGNS LIST

[0152]

1 air conditioning apparatus (refrigeration apparatus)
23 outdoor heat exchanger (evaporator)
23a first heat exchange section
23b second heat exchange section
23c third heat exchange section
123a first heat exchange section
123b second heat exchange section
123c third heat exchange section
223a first heat exchange section
223b second heat exchange section
223c third heat exchange section
231 flat pipe (heat transfer tube)
231M flat pipe (heat transfer tube)
231N heat transfer tube
232 heat transfer fin
232c cutout
232M heat transfer fin
232N heat transfer fin

CITATION LIST

PATENT LITERATURE

[0153] PTL 1
WO2017/183180

Claims

1. An evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator comprising:

a plurality of fins (232) that are arranged at a predetermined interval in a plate thickness direction; and
a plurality of heat transfer tubes (231) that extend through the plurality of fins in the plate thickness direction,
wherein a first heat exchange section (23a) in which, when the plurality of heat transfer tubes are viewed as a heat-transfer-tube group in the plate thickness direction of the fins, a distribution center of the heat-transfer-tube group in an airflow direction is positioned on a leeward side of

a center of the fins in the airflow direction is formed.

2. The evaporator according to claim 1, wherein a second heat exchange section (23b) in which the distribution center of the heat-transfer-tube group is positioned on a windward side of the center of the fins in the airflow direction is further formed.

3. The evaporator according to claim 2, wherein a third heat exchange section in which the distribution center of the heat-transfer-tube group coincides with the center of the fins in the airflow direction is further formed.

4. The evaporator according to claim 2, wherein the first heat exchange section and the second heat exchange section are integral with each other.

5. The evaporator according to claim 3, wherein the first heat exchange section is integral with at least either one of the second heat exchange section and the third heat exchange section.

6. An evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator comprising:

a plurality of fins (232) that are arranged at a predetermined interval in a plate thickness direction; and
a plurality of heat transfer tubes (231) that extend through the plurality of fins in the plate thickness direction,
wherein a first heat exchange section (23a) in which a distance from a windward-side end of the heat transfer tube positioned on a most windward side in an airflow direction to a windward-side end of the fins is a first dimension, and
a second heat exchange section (23b) in which a distance from a windward-side end of the heat transfer tube positioned on a most windward side in an airflow direction to a windward-side end of the fins is a second dimension smaller than the first dimension
are formed.

7. The evaporator according to claim 6,

wherein a third heat exchange section in which

a distance from a windward-side end of the heat transfer tube positioned on a most windward side in an airflow direction to a windward-side end of the fins, and
a distance from a leeward-side end of the heat transfer tube positioned on a most leeward side in an airflow direction to a leeward-side end of the fins

are equal to each other is further formed.

8. The evaporator according to claim 6, wherein the first heat exchange section and the second heat exchange section are integral with each other.

9. The evaporator according to claim 7, wherein the first heat exchange section is integral with at least either one of the second heat exchange section and the third heat exchange section.

10. An evaporator of a refrigeration cycle apparatus in which a non-azeotropic refrigerant mixture is enclosed, the evaporator comprising:

a plurality of fins (232) that are arranged at a predetermined interval in a plate thickness direction; and
a plurality of heat transfer tubes (231) that extend through the plurality of fins in the plate thickness direction,
wherein the fins have a plurality of cutouts (232c) that are arranged in a direction orthogonal to both an airflow direction and the plate thickness direction,
the heat transfer tubes are flat multi-hole pipes inserted into the cutouts, and
a first heat exchange section (23a) in which an opening side of the cutouts is positioned on a leeward side in the airflow direction is formed.

11. The evaporator according to claim 10, wherein a second heat exchange section (23b) in which the opening side of the cutouts is positioned on a windward side in the airflow direction is further formed.

12. The evaporator according to claim 11, wherein the first heat exchange section and the second heat exchange section are integral with each other.

13. A refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes any of a HFC refrigerant, a HFO refrigerant, CF3I, and a natural refrigerant.

14. A refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1

to 12,
wherein the non-azeotropic refrigerant mixture includes any of R32, R1132(E), R1234yf, R1234ze, CF3I, and CO2.

15. A refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes at least R1132(E), R32, and R1234yf.

16. A refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes at least R1132(E), R1123, and R1234yf.

17. A refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes at least R1132(E) and R1234yf.

18. A refrigeration cycle apparatus comprising:

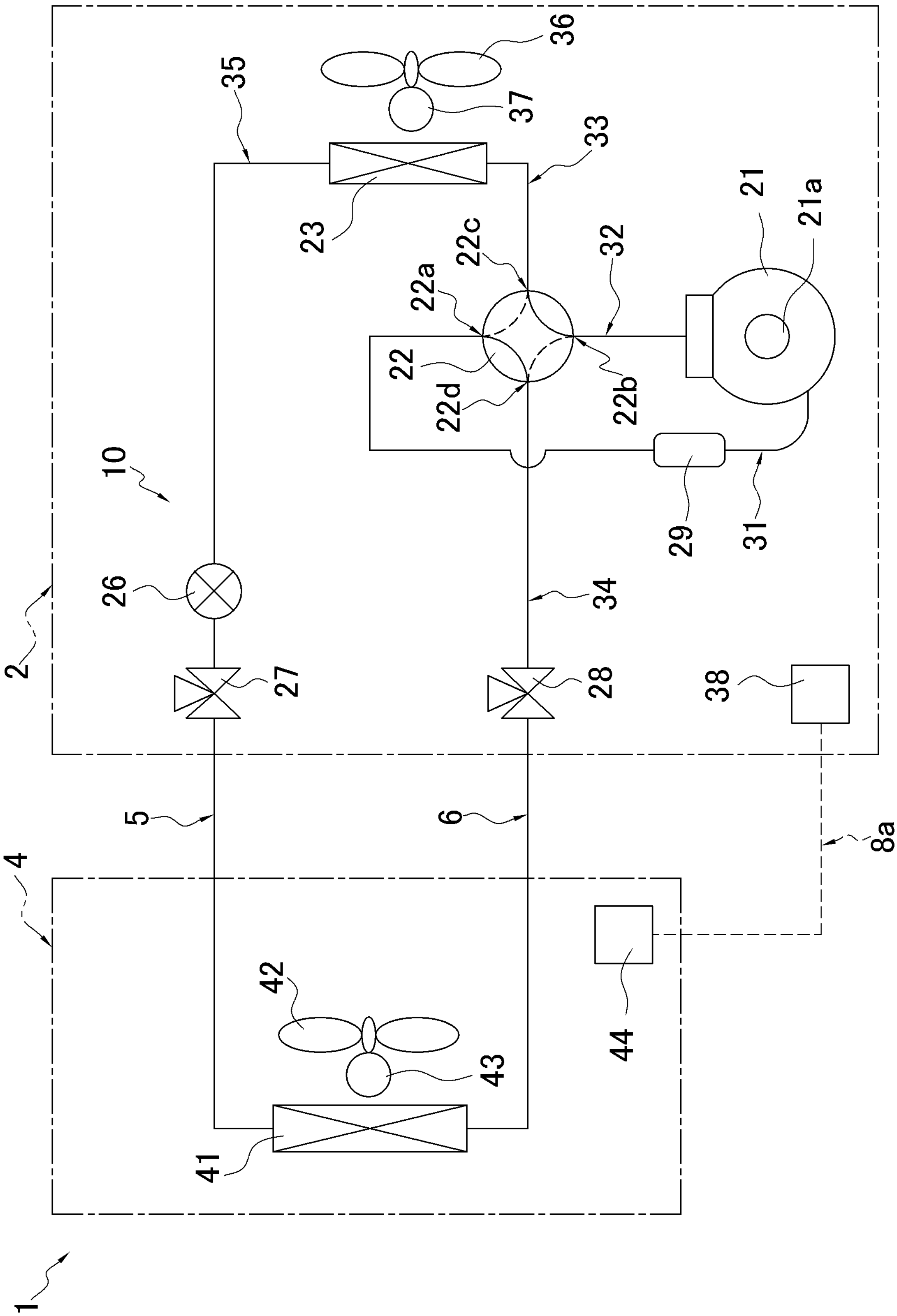
the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes at least R32, R1234yf, and at least one of R1132a and R1114.

19. A refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes at least R32, CO2, R125, R134a, and R1234yf.

20. The refrigeration cycle apparatus comprising:

the evaporator according to any one of claims 1 to 12,
wherein the non-azeotropic refrigerant mixture includes at least R1132(Z) and R1234yf.


36
35
37
33
23
21
21a
22c
32
22a
22
22b
22d
10
29
31
26
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4
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44
43
41
1

FIG. 1

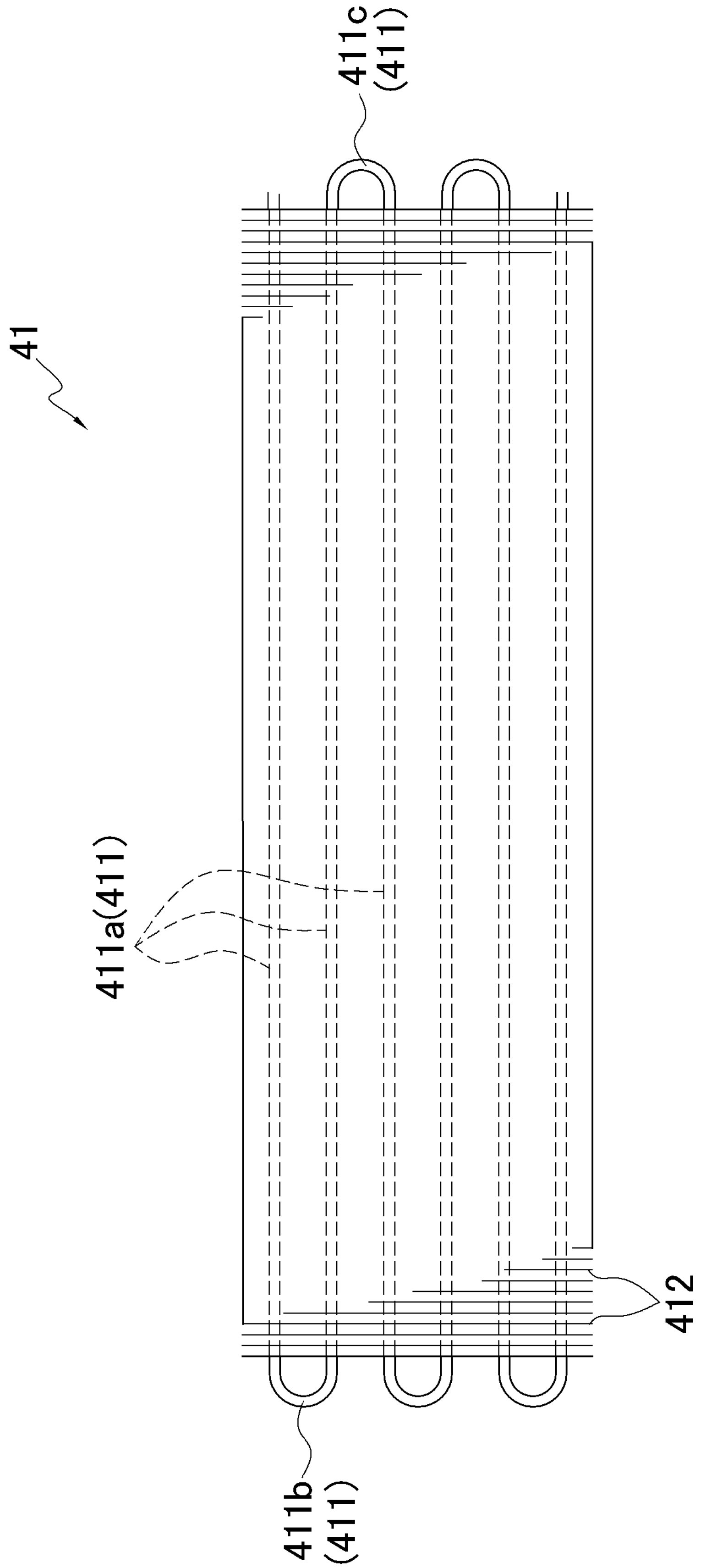

FIG. 2

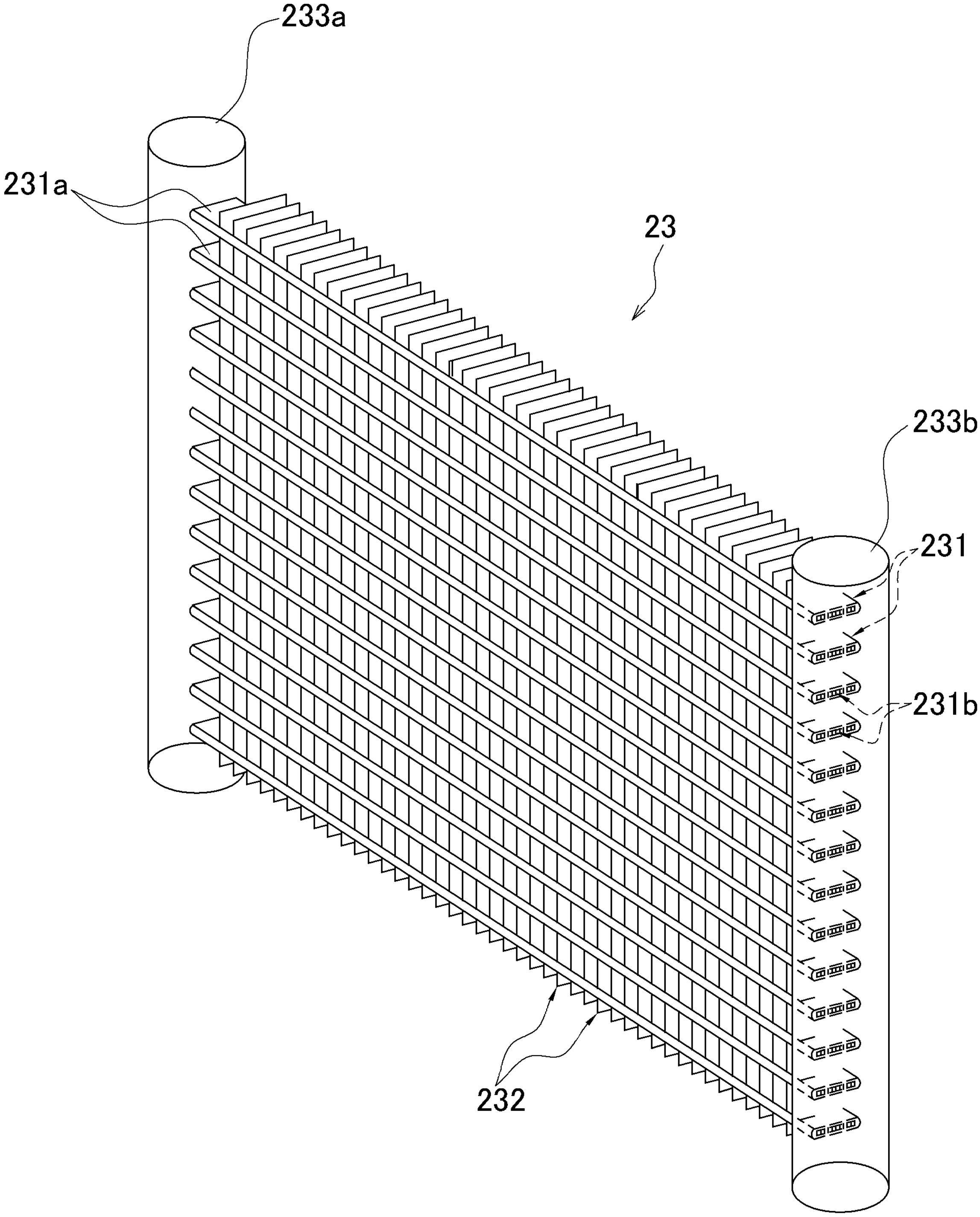

FIG. 3

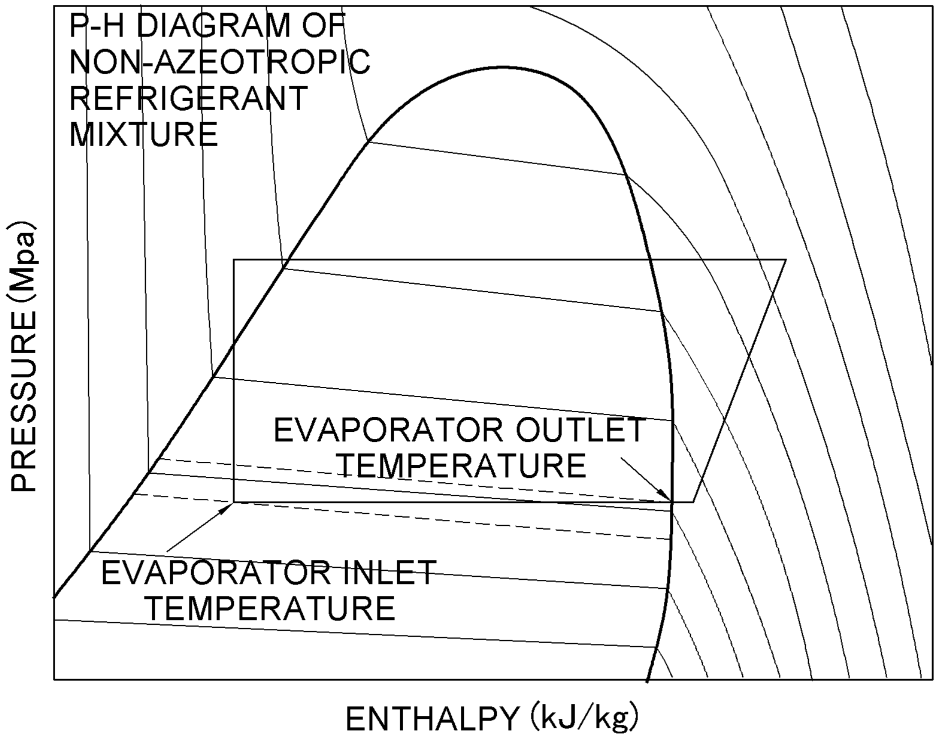
P-H DIAGRAM OF
NON-AZEOTROPIC
REFRIGERANT
MIXTURE
PRESSURE (Mpa)
EVAPORATOR OUTLET
TEMPERATURE
EVAPORATOR INLET
TEMPERATURE
ENTHALPY (kJ/kg)

FIG. 4

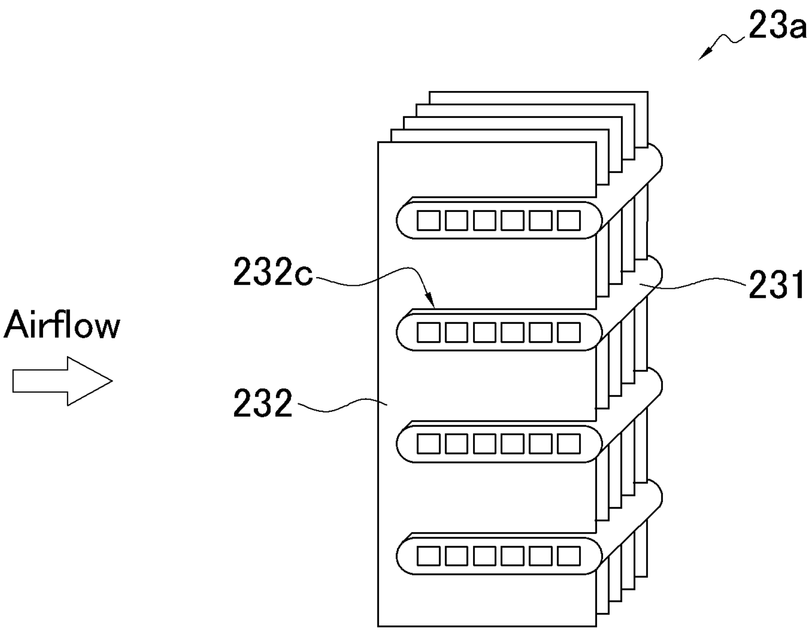
23a
232c
231
Airflow
232

FIG. 5A

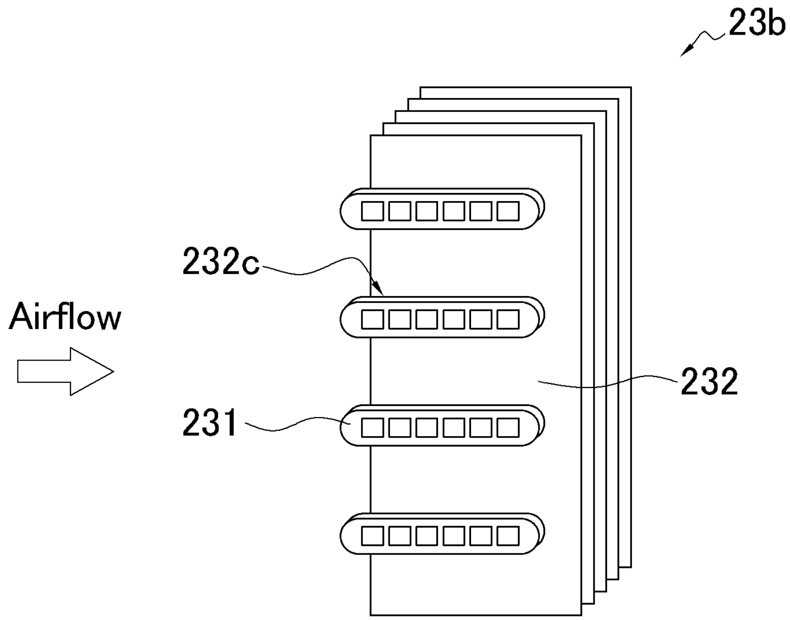

FIG. 5B

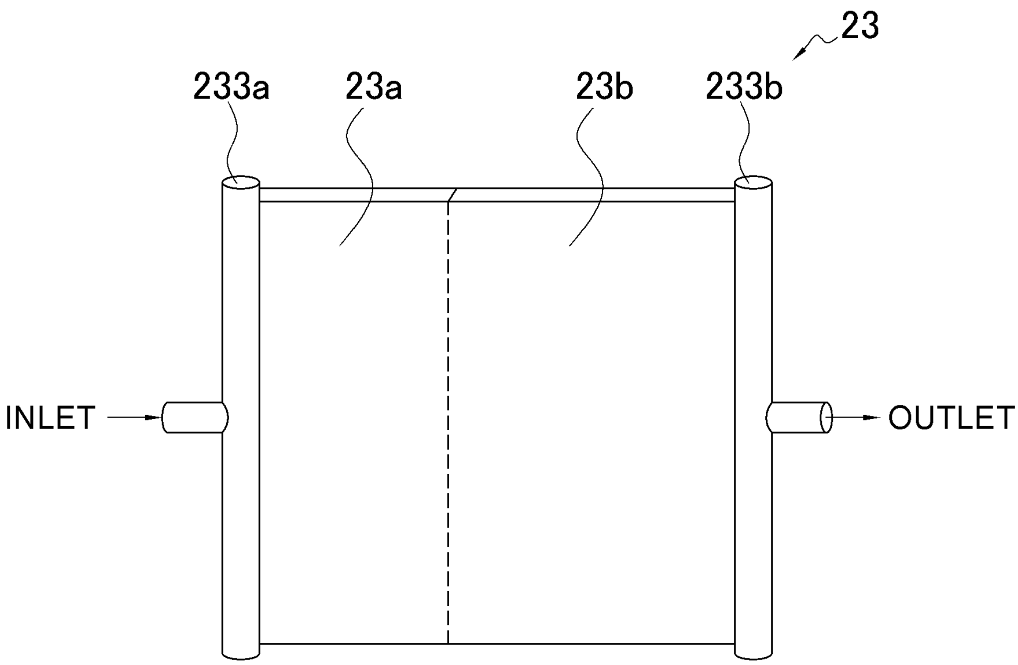

FIG. 6A

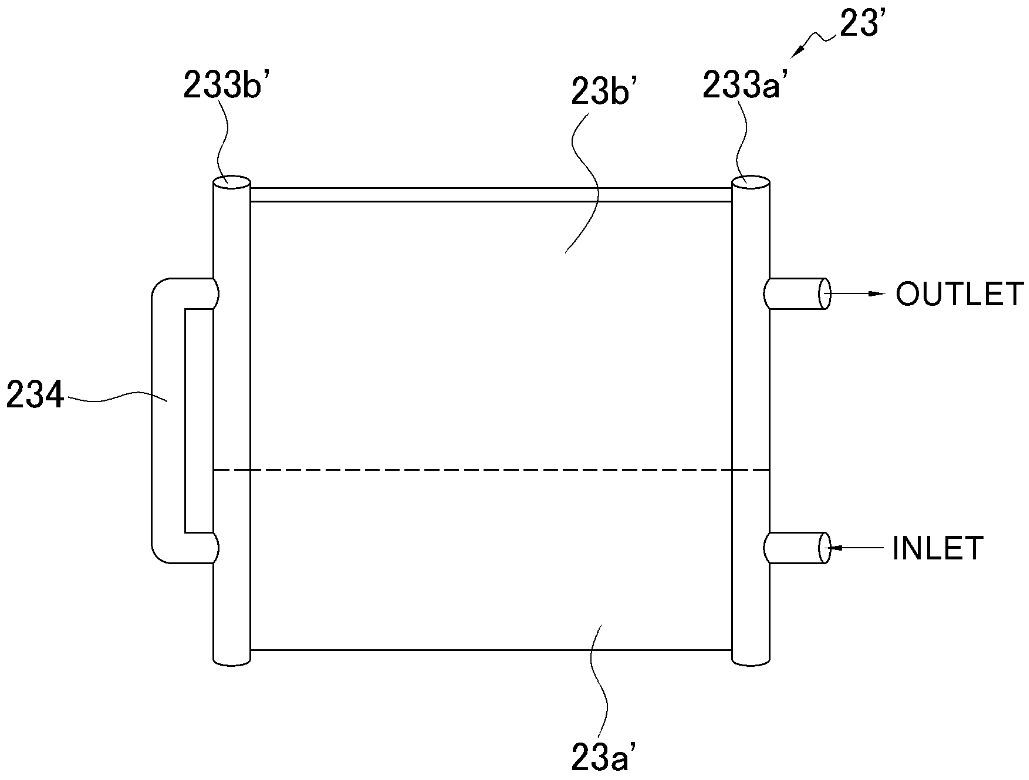
23'
233b'
23b'
233a'
OUTLET
234
INLET
23a'

FIG. 6B

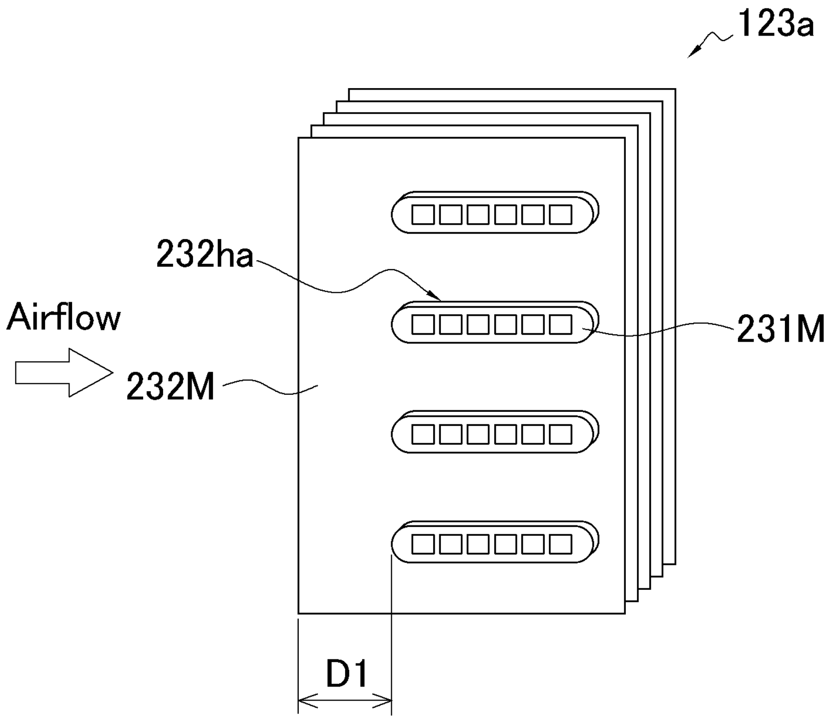
123a
232ha
Airflow
231M
232M
D1

FIG. 7A

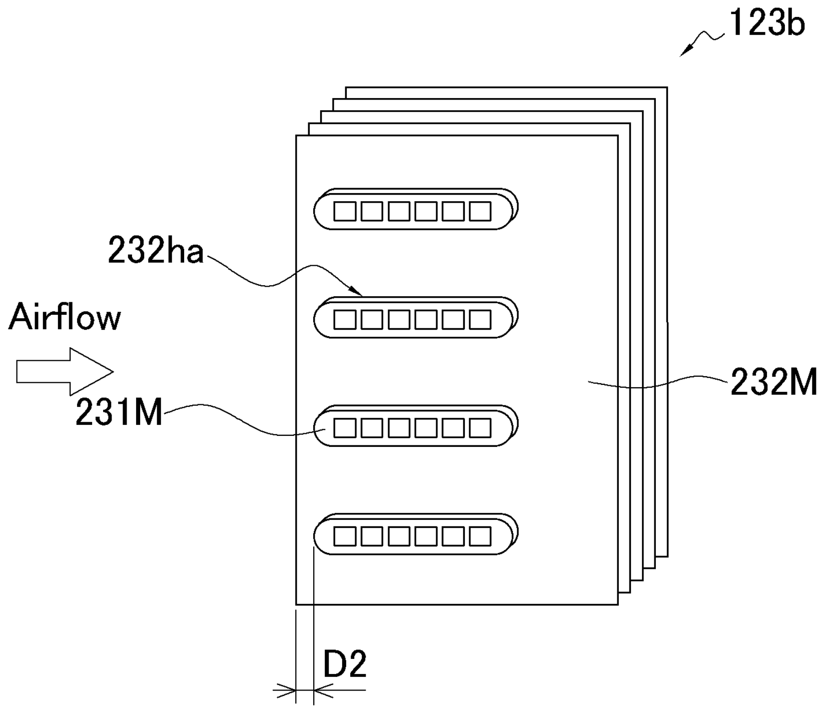
123b
232ha
Airflow
231M
232M
D2

FIG. 7B

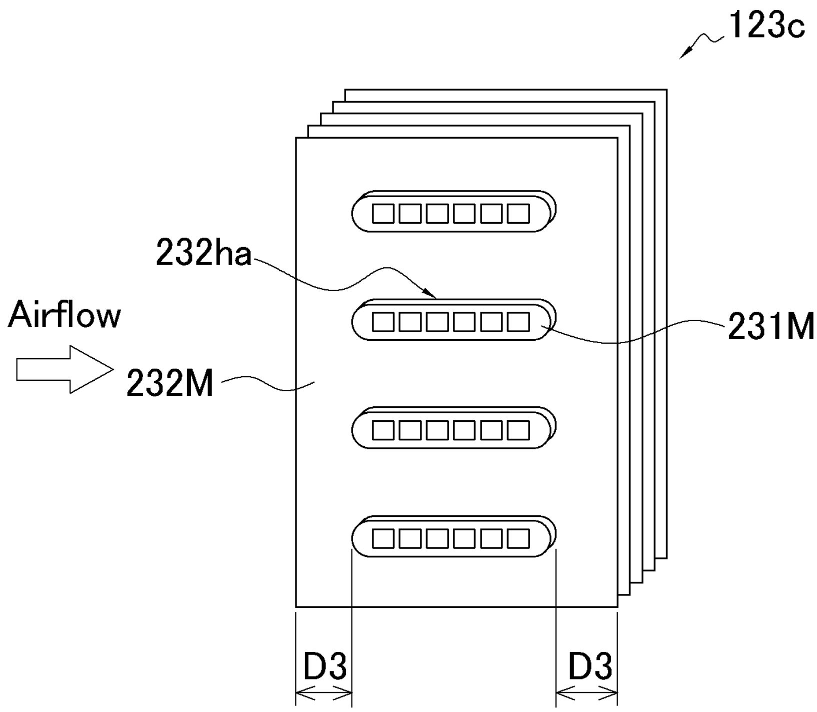
123c
232ha
Airflow
232M
231M
D3
D3

FIG. 7C

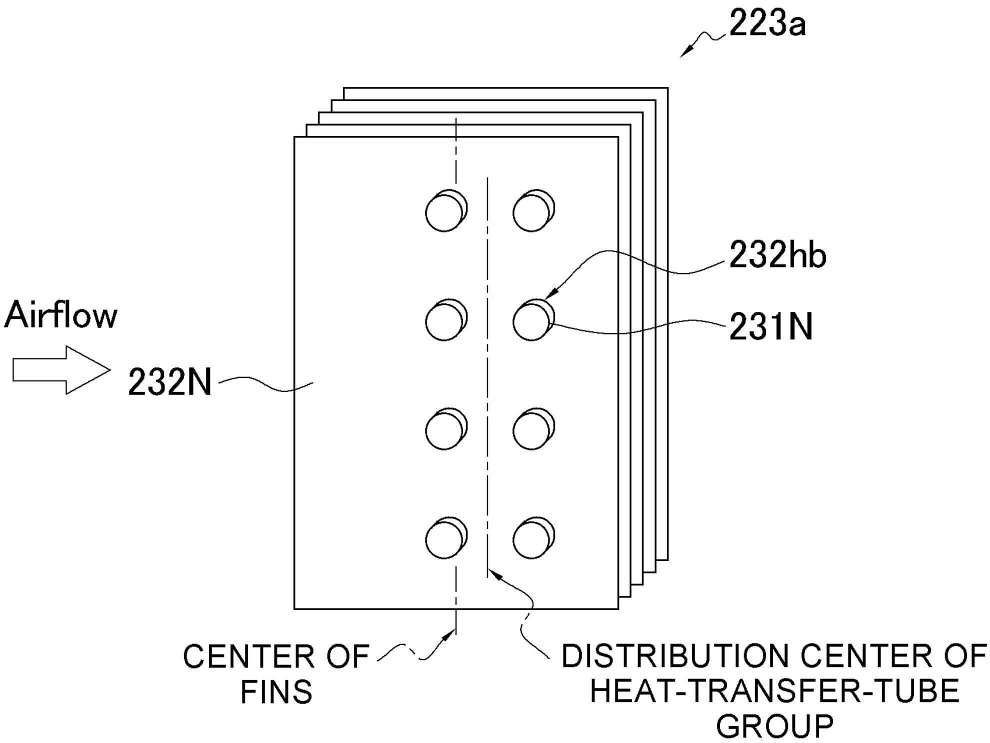
223a
232hb
Airflow
231N
232N
CENTER OF
FINS
DISTRIBUTION CENTER OF
HEAT-TRANSFER-TUBE
GROUP

FIG. 8A

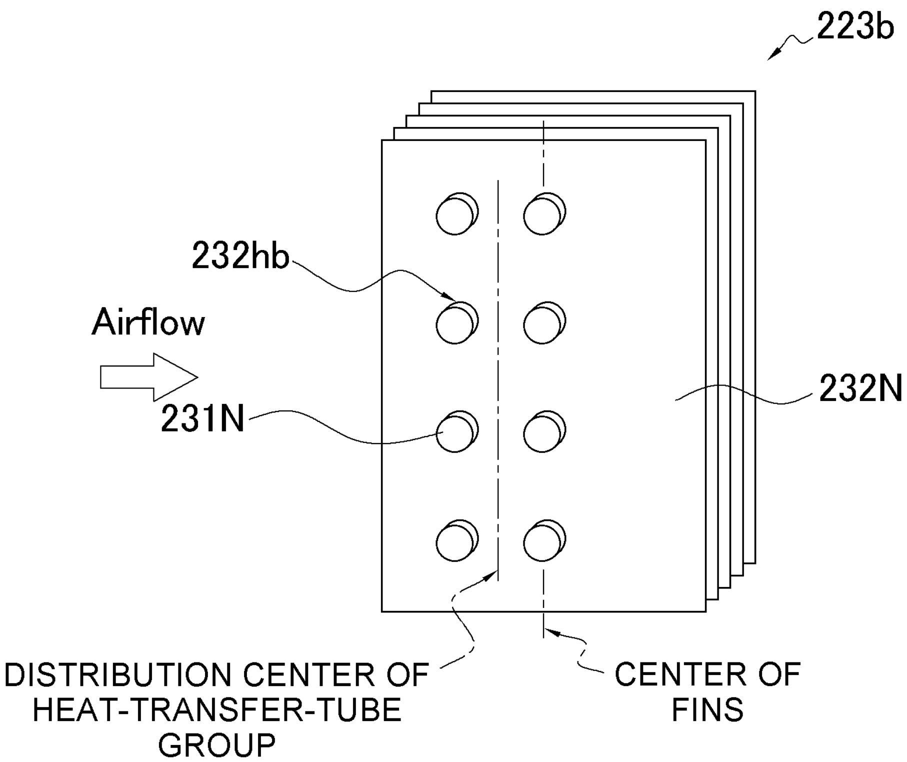
223b
232hb
Airflow
231N
232N
DISTRIBUTION CENTER OF
HEAT-TRANSFER-TUBE
GROUP
CENTER OF
FINS

FIG. 8B

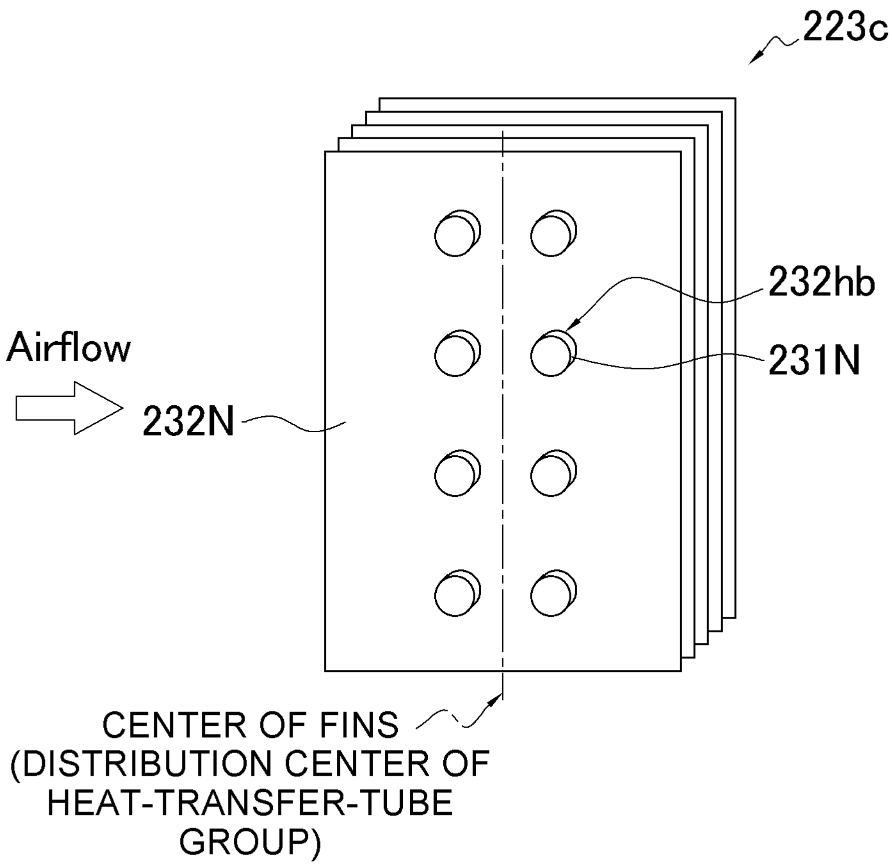
223c
232hb
Airflow
231N
232N
CENTER OF FINS
(DISTRIBUTION CENTER OF
HEAT-TRANSFER-TUBE
GROUP)

FIG. 8C

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2020/036920

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F25B39/02(2006.01)i, F28D5/00(2006.01)i, F28F1/32(2006.01)i, F25B1/00(2006.01)i
FI: F25B39/02H, F25B1/00396B, F28F1/32W, F28D5/00, F28F1/32V

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F25B39/02, F28D5/00, F28F1/32, F25B1/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2001-165586 A (MITSUBISHI ELECTRIC CORPORATION) 22 June 2001 (2001-06-22), paragraphs [0031], [0032], [0093]-[0095], fig. 1	1-3,6-7, 13-14, 18 4-5, 8-12, 15-17, 19-20
Y	JP 2004-218945 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 05 August 2004 (2004-08-05), paragraph [0054], fig. 3	4-5, 8-12, 15-17, 19-20
Y	JP 2019-89084 A (MITSUBISHI ELECTRIC CORPORATION) 13 June 2019 (2019-06-13), paragraph [0011], fig. 2	10-12, 15-17, 19-20
Y	WO 2015/136981 A1 (MITSUBISHI ELECTRIC CORPORATION) 17 September 2015 (2015-09-17), paragraph [0025]	15-17, 19-20

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 October 2020	24 November 2020

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/036920

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2015-216728 A (SIAM COMPRESSOR INDUSTRY CO., LTD.) 03 December 2015 (2015-12-03), paragraph [0020]	16-17, 19-20
Y	JP 2019-104814 A (DAIKIN INDUSTRIES, LTD.) 27 June 2019 (2019-06-27), paragraph [0030]	19

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/036920

JP 2001-165586 A	22 June 2001	(Family: none)
JP 2004-218945 A	05 August 2004	(Family: none)
JP 2019-89084 A	13 June 2019	(Family: none)
WO 2015/136981 A1	17 September 2015	(Family: none)
JP 2015-216728 A	03 December 2015	US 2017/0018982 A1 paragraph [0037]
JP 2019-104814 A	27 June 2019	(Family: none)

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2017183180 A **[0002] [0153]**