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(54) **REFRIGERATION DEVICE**

(57) An air conditioning device (1) in which, during a cooling operation, refrigerant flows sequentially through a compressor (21), an outdoor heat exchanger (23), an expansion mechanism (24), and an indoor heat exchanger (41), and during a heating operation, refrigerant flows sequentially through the compressor (21), the indoor heat exchanger (41), the expansion mechanism (24), and the outdoor heat exchanger (23). The air conditioning device (1) uses R32 as a refrigerant, the capacity of the outdoor heat exchanger (23) is less than or equal to the capacity of the indoor heat exchanger (41), and a refrigerant storage tank (25) configured to store refrigerant is provided between the outdoor heat exchanger (23) and the expansion mechanism (24).

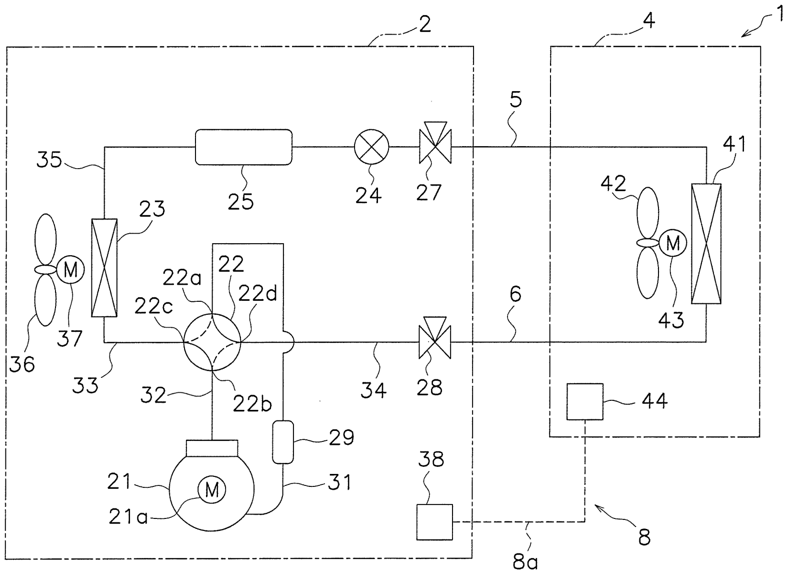

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration device, and in particular relates to a refrigeration device that uses R32 as a refrigerant and is configured to enable a cooling operation and a heating operation.

BACKGROUND ART

[0002] As disclosed in Patent Literature 1 (Japanese Patent Application Laid-Open No. 2001-194015), a conventional refrigeration device such as an air conditioning device that is enabled for air cooling and air heating operations includes a configuration that uses R32 as a refrigerant. During an air cooling operation (cooling operation), the refrigerant in this type of refrigeration device is configured to flow sequentially through a gas-liquid separator (refrigerant storage tank), a compressor, an outdoor heat exchanger, an expansion valve (expansion mechanism), and an indoor heat exchanger. Furthermore, during an air heating operation (heating operation), the refrigerant flows sequentially through the refrigerant storage tank, the compressor, the indoor heat exchanger, the expansion mechanism, and the outdoor heat exchanger. An optimal refrigerant amount of this refrigerating device during the cooling operation differs from an optimal refrigerant amount during the heating operation. Consequently, a capacity of the outdoor heat exchanger that is configured to function as a radiator during the cooling operation is different from a capacity of the indoor heat exchanger that is configured to function as a radiator during the heating operation. Normally, since the capacity of the outdoor heat exchanger is greater than the capacity of the indoor heat exchanger, the refrigerant that cannot be contained in the indoor heat exchanger during the heating operation is temporarily stored in a refrigerant storage tank connected to an intake side of the compressor.

SUMMARY OF THE INVENTION

[0003] However, since R32 is used as the refrigerant in the above refrigeration device, under a low temperature condition, a solubility of a refrigerating machine oil that is filled together with the refrigerant to lubricate the compressor exhibits a tendency to become extremely low. As a result, when operating during a low pressure refrigeration cycle, a large fall in the solubility of the refrigerating machine oil caused by a fall in the refrigerant temperature results in a two layer separation of the refrigerating machine oil and the refrigerant R32 in the refrigerant storage tank, that is at the low pressure during the refrigeration cycle, and thereby inhibits the return of the refrigerating machine oil to the compressor.

[0004] Furthermore, when a high-performance radiator such as that disclosed in Patent Literature 2 (Japanese Patent Application Laid-Open No. 6-143991) is used as the outdoor heat exchanger in relation to the above refrigeration device, the capacity of the outdoor heat exchanger will be less than or equal to the capacity of the indoor heat exchanger. Consequently, in that situation, during the air cooling operation, the refrigerant is produced that cannot be contained in the outdoor heat exchanger (excess refrigerant), and the amount thereof exceeds the amount that can be stored in the refrigerant storage tank.

[0005] Thus, in the refrigeration device configured to enable the cooling operation and the heating operation and that uses R32 as the refrigerant, a problem related to an oil return to the compressor is caused by the connection of the refrigerant storage tank to the intake side of the compressor, and when the capacity of the outdoor heat exchanger is less than or equal to the capacity of the indoor heat exchanger, there is also a problem of the excess refrigerant.

[0006] The problem of the present invention is to configure the refrigeration device, in which the capacity of the outdoor heat exchanger is less than or equal to the capacity of the indoor heat exchanger in the refrigeration device configured to enable the cooling operation and the heating operation and which uses R32 as the refrigerant, to enable the refrigerating machine oil to return to the compressor and enable the containment of the excess refrigerant produced during the cooling operation.

[0007] A refrigeration device according to a first aspect of the present invention is a refrigeration device in which, during a cooling operation, a refrigerant flows sequentially through a compressor, an outdoor heat exchanger, an expansion mechanism, and an indoor heat exchanger, and during a heating operation, the refrigerant flows sequentially through the compressor, the indoor heat exchanger, the expansion mechanism, and the outdoor heat exchanger. Furthermore, in this refrigeration device, the refrigerant that is used is R32, a capacity of the outdoor heat exchanger is less than or equal to a capacity of the indoor heat exchanger, and a refrigerant storage tank that is configured to store the refrigerant is provided between the outdoor heat exchanger and the expansion mechanism. A refrigeration device according to a second aspect of the present invention is the refrigeration device according to the first aspect of the present invention in which the refrigerant storage tank is configured with a high pressure in a refrigeration cycle during the cooling operation, and a low pressure in a refrigeration cycle during the heating operation.

[0008] Since a problem related to an oil return to the compressor may arise as a result of use of R32 as the refrigerant in this refrigeration device, the provision of the refrigerant storage tank between the outdoor heat exchanger and the expansion mechanism facilitates the return of a refrigerating machine oil to the compressor when compared with a configuration in which the refrigerant storage tank is provided on the intake side of the compressor. Moreover, in light of the fact that an excess refrigerant may be produced in this refrigeration device during the cooling operation since the capacity of the outdoor heat exchanger is less than or equal to the capacity of the indoor heat exchanger, damage to a refrigerant control can be prevented since the excess refrigerant can be contained in the refrigerant storage tank.

[0009] In this manner, this refrigeration device is configured to enable the return of the refrigerating machine oil to the compressor and to enable the excess refrigerant to be stored during the cooling operation notwithstanding the fact that R32 is used as the refrigerant and that the capacity of the outdoor heat exchanger is less than or equal to the capacity of the indoor heat exchanger.

[0010] A refrigeration device according to a third aspect of the present invention is the refrigeration device according to the first aspect and the second aspect of the present invention in which the outdoor heat exchanger is a heat exchanger that uses a flat tube as a heat transfer tube. Furthermore, a refrigeration device according to a fourth aspect of the present invention is the refrigeration device according to the third aspect of the present invention in which the outdoor heat exchanger is a heat exchanger that includes a plurality of the flat tubes that are disposed at intervals in a plurality of stacking arrangements, and fins that are sandwiched by the adjacent flat tubes. A refrigeration device according to a fifth aspect of the present invention is the refrigeration device according to the third aspect of the present invention in which the outdoor heat exchanger is a heat exchanger that includes a plurality of the flat tubes that are disposed at intervals in a plurality of stacking arrangements, and fins that are configured with notches to accommodate insertion of the flat tubes.

[0011] This refrigeration device is configured to use a flat tube as a heat transfer tube to reduce the refrigerant amount in the refrigeration device since the capacity of the outdoor heat exchanger is less than or equal to the capacity of the indoor heat exchanger. Although the excess refrigerant is produced in this refrigeration device during the cooling operation, damage to the refrigerant control is prevented since the excess refrigerant is contained in the refrigerant storage tank.

[0012] A refrigeration device according to a sixth aspect of the present invention is the refrigeration device according to the first aspect or the second aspect of the present invention in which the outdoor heat exchanger and the indoor heat exchanger are a cross-fin type heat exchanger, a heat transfer tube diameter in the outdoor heat exchanger is smaller than a heat transfer tube diameter in the indoor heat exchanger.

[0013] In this refrigeration device, in the same manner as the refrigeration device according to the first aspect or the second aspect, the refrigerant amount in the refrigeration device is reduced since the capacity of the outdoor heat exchanger is less than or equal to the capacity of the indoor heat exchanger. Although the excess refrigerant is produced in this refrigeration device during the cooling operation, damage to the refrigerant control is prevented since the excess refrigerant is contained in the refrigerant storage tank.

[0014] A refrigeration device according to a seventh aspect of the present invention is the refrigeration device according to any one of the first aspect to the sixth aspect of the present invention in which a bypass pipe is further provided to guide gas components in the refrigerant, that is stored in the refrigerant storage tank, into the compressor or an intake pipe of the compressor.

[0015] This refrigeration device is configured to separate the refrigerant into liquid and gas in the refrigerant storage tank before the intake port of the outdoor heat exchanger during the heating operation, that is to say, when the outdoor heat exchanger is functioning as an evaporator, and then to guide the gas components into the bypass pipe. As a result, the gas components that do not participate in evaporation are inhibited from flowing into the outdoor heat exchanger, and therefore, to that extent, the flow rate of refrigerant that flows into the outdoor heat exchanger can be reduced, and a pressure drop in relation to the refrigerant (that is to say, depressurization loss) in the outdoor heat exchanger can be inhibited.

[0016] A refrigeration device according to an eighth aspect of the present invention is the refrigeration device according to the seventh aspect of the present invention in which the bypass pipe has a flow rate regulating mechanism.

[0017] When an operation frequency of the compressor is high, the refrigerant that is in a gas-liquid two-phase state returns from the refrigerant storage tank through the bypass pipe to the compressor or the intake pipe of the compressor, and therefore there is a risk of intake into the compressor.

[0018] However, since the bypass pipe in this refrigeration device is configured with the flow rate regulating mechanism, the liquid components of the refrigerant that is the gas-liquid two-phase state is depressurized and evaporates.

[0019] In this manner, the refrigeration device is configured to prevent return of the liquid components to the compressor or the intake pipe of the compressor.

[0020] Furthermore the refrigerant in this refrigeration device firstly passes through the flow rate regulating mechanism during the heating operation, is evaporated in the outdoor heat exchanger, and then joins flow with the refrigerant towards the compressor or the intake pipe of the compressor. At this time, when the flow rate regulating mechanism is an electrically operated expansion valve, the refrigerant state immediately prior to intake into the compressor is regulated to a more optimal condition by controlling the valve aperture. Moreover, since the flow rate of the refrigerant returning to the compressor can be varied by controlling the valve aperture of the flow rate regulating mechanism, a circulation flow rate of the refrigerant, that is to say, the flow rate of the refrigerant flowing in the indoor heat exchanger, can be controlled in response to a refrigerating load on the indoor heat exchanger side.

[0021] A refrigeration device according to a ninth aspect of the present invention is the refrigeration device according to any one of the first aspect to the eighth aspect of the present invention in which the refrigerant storage tank is a gas-liquid separator.

[0022] The refrigerant storage tank in this refrigeration device is configured as a gas-liquid separator to have both a function of storing the liquid components and a function of separating the liquid components and the gas components.

[0023] In this manner, since there is no requirement in this refrigeration device to provide a device configured with the refrigerant storage function separately to a device configured with the gas-liquid separating function, the device configuration can be simplified.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG. 1 is a schematic view of an air conditioning apparatus as an example of a refrigeration device according to a first aspect of the present invention.
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 graph showing ratio of outdoor heat exchanger capacity to indoor heat exchanger capacity, according to capability.
FIG. 5 is a schematic view of an air conditioning apparatus as an example of a refrigeration device according to a first modified example.
FIG. 6 is a schematic sectional view of a refrigerant storage tank according to a second modified example.
FIG. 7 is an external perspective view of an outdoor heat exchanger according to a third modified example.
FIG. 8 is a vertical sectional view of an outdoor heat exchanger according to the third modified example.

DESCRIPTION OF EMBODIMENTS

[0025] The embodiments and modified examples of a refrigeration device according to the present invention will be described below with reference to the figures. The specific configuration of the refrigeration device according to the present invention is not limited to the embodiments and the modified examples below, and changes are possible within a scope that does not depart from the concept of the invention.

(1) Configuration of Air conditioning Apparatus

[0026] FIG. 1 is a schematic view of an air conditioning apparatus 1 as an example of a refrigeration device according to a first aspect of the present invention.

[0027] The air conditioning apparatus 1 is a refrigeration device configured for an air cooling operation, as a cooling operation, and an air heating operation, as a heating operation, through performance of a vapor-compression refrigeration cycle. The air conditioning apparatus 1 is principally configured by connection of an outdoor unit 2 with an indoor unit 4. The outdoor unit 2 and the indoor unit 4 are connected through a liquid refrigerant communication pipe 5 and a gas refrigerant communication pipe 6. That is to say, the outdoor unit 2 and the indoor unit 4 of a vapor-compression refrigerant circuit 10 of the air conditioning apparatus 1 are connected by the refrigerant communication pipes 5 and 6. The refrigerant circuit 10 is filled with R32 that is a type of HFC refrigerant. The refrigerant circuit 10 is also filled with refrigerating machine oil for lubricating a compressor 21 (described below) in addition to the refrigerant. In this context, the refrigerating machine oil includes use of an ether-based synthetic oil that exhibits some compatibility with R32, a mineral oil that does not exhibit compatibility to R32, an alkylbenzene-based synthetic oil, or the like.

<Indoor Unit>

[0028] The indoor unit 4 is disposed indoors, and configures a portion of the refrigerant circuit 10. The indoor unit 4 is principally configured by an indoor heat exchanger 41.

[0029] The indoor heat exchanger 41 cools indoor air by functioning as an evaporator for refrigerant during an air cooling operation, and heats indoor air by functioning as a refrigerant radiator during an air heating operation. The liquid side of the indoor heat exchanger 41 is connected to the liquid refrigerant communication pipe 5 and the gas side of the indoor heat exchanger 41 is connected to the gas refrigerant communication pipe 6.

[0030] As illustrated in FIG. 2, the indoor heat exchanger 41 is a cross-fin type heat exchanger, and principally comprises heat transfer fins 411 and heat transfer tubes 412. FIG. 2 is a schematic front view of the indoor heat exchanger 41. The heat transfer fin 411 is a thin aluminum plate, and a plurality of through holes are provided in the heat transfer fin 411. The heat transfer tube 412 includes a straight tube 412a configured to be inserted into a through hole of the heat transfer fins 411, and U-shaped tubes 412b, 412c configured to connect end portions of adjacent straight tubes 412a. The straight tubes 412a are bonded to the heat transfer fins 411 by tube expansion processing after insertion into the through holes of the heat transfer fins 411. The straight tubes 412a and the first U-shaped tubes 412b are integrally formed, and the second U-shaped tube 412c is connected to the end portion of the straight tube 412a by welding or soldering after the insertion of the straight tubes 412a into the through holes of the heat transfer fins 411 and the tube expansion processing into the through holes of the heat transfer fins 411.

[0031] The indoor unit 4 has an indoor fan 42 that intakes indoor air into the indoor unit 4, causes heat exchange with refrigerant in the indoor heat exchanger 41, and then supplies air into the room as supply air. A multiblade fan or a centrifugal fan driven by an indoor fan motor 43, or the like, can be used as the indoor fan 42.

[0032] The indoor unit 4 has an indoor control unit 44 that controls the operation of the respective units that configure the indoor unit 4. The indoor control unit 44 includes a microprocessor, a memory, or the like to perform control of the indoor unit 4, exchanges control signals or the like with a remote controller (not illustrated), and exchanges control signals or the like through a transmission wire 8a with the outdoor unit 2.

<Outdoor Unit>

[0033] The outdoor unit 2 is installed in an outdoor position, and configures a portion of the refrigerant circuit 10. The outdoor unit 2 principally includes a compressor 21, a switching mechanism 22, an outdoor heat exchanger 23, an expansion mechanism 24, a refrigerant storage tank 25, a liquid-side shutoff valve 27, and a gas-side shutoff valve 28.

[0034] The compressor 21 is a device that compresses the refrigerant that has a low pressure in the refrigeration cycle to a high pressure. The compressor 21 has a sealed structure configured to use a compressor motor 21 a controlled by an inverter to rotate and drive the positive-displacement compressor elements (not illustrated) such as a rotary type or scroll type, or the like. The compressor 21 has an intake pipe 31 connected on the intake side, and discharge pipe 32 connected on the discharge side. The intake pipe 31 is a refrigerant pipe that connects a first port 22a of the switching mechanism 22 with the intake side of the compressor 21. The intake pipe 31 includes an accumulator 29. The discharge pipe 32 is a refrigerant pipe that connects a second port 22b of the switching mechanism 22 with the discharge side of the compressor 21.

[0035] The switching mechanism 22 is a mechanism for switching the direction of flow of the refrigerant in the refrigerant circuit 10. During an air cooling operation, the switching mechanism 22 switches between a function of causing the outdoor heat exchanger 23 to function as a radiator for refrigerant compressed in the compressor 21, and causing the indoor heat exchanger 41 to function as an evaporator for refrigerant after radiation in the outdoor heat exchanger 23. That is to say, during an air cooling operation, the switching mechanism 22 switches to connect the second port 22b and the third port 22c and to connect the first port 22a and the fourth port 22d. In this manner, the discharge side of the compressor 21 (designated herein as the discharge pipe 32) and the gas side of the outdoor heat exchanger 23 (designated herein as the first gas refrigerant pipe 33) are connected (reference is made to the solid line of the switching mechanism 22 in FIG. 1). In addition, the intake side of the compressor 21 (designated herein as the intake pipe 31) and the gas refrigerant communication pipe 6 side (designated herein as the second gas refrigerant pipe 34) are connected (reference is made to the solid line of the switching mechanism 22 in FIG. 1). Furthermore, during an air heating operation, the switching mechanism 22 switches between a function of causing the outdoor heat exchanger 23 to function as an evaporator for refrigerant after radiation in the indoor heat exchanger 41, and causing the indoor heat exchanger 41 to function as a radiator for refrigerant compressed in the compressor 21. That is to say, during an air heating operation, the switching mechanism 22 switches to connect the second port 22b and the fourth port 22d and to connect the first port 22a and the third port 22c. In this manner, the discharge side of the compressor 21 (designated herein as the discharge pipe 32) and the gas refrigerant communication pipe 6 side (designated herein as the second gas refrigerant pipe 34) are connected (reference is made to the broken line of the switching mechanism 22 in FIG. 1). In addition, the intake side of the compressor 21 (designated herein as the intake pipe 31) and the gas side of the outdoor heat exchanger 23 (designated herein as the first gas refrigerant pipe 33) are connected (reference is made to the broken line of the switching mechanism 22 in FIG. 1). The first gas refrigerant pipe 33 is a refrigerant pipe that connects the third port 22c of the switching mechanism 22 with the gas side of the outdoor heat exchanger 23. The second gas refrigerant pipe 34 is a refrigerant pipe that connects the fourth port 22d of the switching mechanism 22 with the gas refrigerant communication pipe 6 side. The switching mechanism 22 as used herein is a four-way switching valve.

[0036] The outdoor heat exchanger 23 is a heat exchanger that is configured to function as a radiator for refrigerant that uses outdoor air as a cooling source during an air cooling operation and to function as an evaporator for refrigerant that uses outdoor air as a heating source during an air heating operation. The liquid side of the outdoor heat exchanger 23 is connected to the liquid refrigerant pipe 35, and the gas side is connected to the first gas refrigerant pipe 33. The liquid refrigerant pipe 35 is a refrigerant pipe that connects the liquid side of the outdoor heat exchanger 23 with a liquid refrigerant communication pipe 5 side.

[0037] As illustrated in FIG. 3, the outdoor heat exchanger 23 is a heat exchanger configured to use flat tubes as heat transfer tubes. More specifically, the outdoor heat exchanger 23 is a stacked heat exchanger, and principally comprises flat tubes 231, waveform fins 232, and headers 233a, 233b. In this context, FIG. 3 is an external perspective view of the outdoor heat exchanger 23. The flat tube 231 is formed from aluminum or an aluminum alloy, and comprises a plane section 231a forming a heat transfer surface and a plurality of internal flow passages (not illustrated) configured to allow flow of refrigerant. The flat tubes 231 are arranged at a plurality of levels to be stacked with gaps (ventilation spaces) therebetween in a configuration in which the plane sections 231a are oriented vertically. The waveform fin 232 is an aluminum or aluminum alloy fin bent into a waveform. The waveform fin 232 is disposed in the ventilation space to be sandwiched by the vertically adjacent flat tubes 231, and valley portions and peak portions are configured to make contact with the plane sections 231 a of the flat tubes 231. The valley portions and peak portions are bonded with the plane sections 231a by soldering or the like. The headers 233a, 233b are connected to both ends of the flat tubes 231 that are disposed in a plurality of vertically oriented levels. The header 233a, 233b has a function of supporting the flat tubes 231, a function of guiding refrigerant into the internal flow passages of the flat tubes 231, and a function of collecting refrigerant that is discharged from the internal flow passages. When the outdoor heat exchanger 23 functions as a radiator for refrigerant, refrigerant that flows in from a first exit / entrance 234 of the first header 233a is distributed evenly into each internal flow passages of the uppermost level of flat tubes 231, and flows towards the second header 233b. The refrigerant that reaches the second header 233b is distributed evenly into each internal flow passages of the second level of flat tubes 231, and flows towards the first header 233a. Thereafter, the refrigerant in the odd-numbered flat tubes 231 flows towards the second header 233b, and the refrigerant in the even-numbered flat tubes 231 flows towards the first header 233a. The refrigerant in the lowermost and even-numbered flat tubes 231 flows towards the first header 233a, collects in the first header 233a, and flows out from a second exit / entrance 235 of the first header 233a. When the outdoor heat exchanger 23 functions as an evaporator for refrigerant, refrigerant that flows in from the exit / entrance 235 of the first header 233a, and in an opposite direction to the direction during a function as a radiator for refrigerant, after flowing through the flat tubes 231 and the headers 233a, 233b, the refrigerant flows from the first exit / entrance 234 of the first header 233a. Then, when the outdoor heat exchanger 23 functions as a radiator for refrigerant, refrigerant that flows in the flat tubes 231 radiates heat into the air flow that flows in the ventilation space through the waveform fins 232. When the outdoor heat exchanger 23 functions as an evaporator for refrigerant, refrigerant that flows in the flat tubes 231 absorbs heat from the air flow that flows in the ventilation space through the waveform fins 232. Since the outdoor heat exchanger 23 is configured as a stacked heat exchanger as described above, the capacity of the outdoor heat exchanger 23 is smaller than the capacity of the indoor heat exchanger 41. This point will be described below with reference to the example of a package air conditioning apparatus illustrated in FIG. 4. FIG. 4 is a graph showing the ratio of outdoor heat exchanger capacity to indoor heat exchanger capacity, according to capability. In Figure 4, ◊ denotes a normal type of package air conditioning apparatus (cross-fin type outdoor heat exchanger), ♦ denotes a small diameter type of outdoor heat exchanger of a package type air conditioning apparatus (stacked outdoor heat exchanger), ∆ denotes a normal type of room air conditioning apparatus (cross-fin type outdoor heat exchanger), and ▲ denotes a small diameter type of outdoor heat exchanger of room air conditioning apparatus (stacked outdoor heat exchanger). As shown in FIG. 4, the ratio of outdoor heat exchanger capacity to indoor heat exchanger capacity is less than 1.0 when only the outdoor heat exchanger is replaced with a stacked heat exchanger having a similar heat exchange performance in contrast to a combination in which the outdoor heat exchanger and the indoor heat exchanger are both cross-fin type heat exchangers. This means that the capacity of the stacked heat exchanger is not only less than the capacity of the cross-fin type outdoor heat exchanger, but is also less than the capacity of the cross-fin type indoor heat exchanger 41 connected thereto. Therefore, excess refrigerant is produced in the air conditioning apparatus 1 during an air cooling operation. In the air conditioning apparatus 1, the excess refrigerant is accommodated in the refrigerant storage tank 25. In FIG. 4, when the ratio of outdoor heat exchanger capacity to indoor heat exchanger capacity is 0.3 to 0.9, it is preferable to use the refrigerant storage tank 25 for accommodating the excess refrigerant, but even in cases in which the ratio of outdoor heat exchanger capacity to indoor heat exchanger capacity is 1.0, stable refrigerant control is made possible by using the refrigerant storage tank 25.

[0038] The expansion mechanism 24 is a device configured to depressurize the high-pressure refrigerant in the refrigeration cycle during temporary storage in the refrigerant storage tank 25 to a low pressure in the refrigeration cycle during an air cooling operation. The expansion mechanism 24 is a device configured to depressurize the high-pressure refrigerant in the refrigeration cycle that has radiated in the indoor heat exchanger 41 to a low pressure in the refrigeration cycle during an air heating operation. The expansion mechanism 24 is provided in portion nearer to the liquid-side shutoff valve 27 of the liquid refrigerant pipe 35. As used herein, the expansion mechanism 24 is configured as an electrically operated expansion valve.

[0039] The refrigerant storage tank 25 is disposed between the outdoor heat exchanger 23 and the expansion mechanism 24. The refrigerant storage tank 25 is a container that exhibits a high pressure in the refrigeration cycle during an air cooling operation, and can store high-pressure refrigerant in the refrigeration cycle after radiation in the outdoor heat exchanger 23. In addition, the refrigerant storage tank 25 is a container that exhibits a low pressure in the refrigeration cycle during an air heating operation, and can store low-pressure refrigerant in the refrigeration cycle after depressurization in the expansion mechanism 24. For example, in cases in which the liquid refrigerant quantity that can be contained in the indoor heat exchanger 41 during an air heating operation when the indoor heat exchanger 41 functions as a refrigerant radiator is 1100 cc, and the liquid refrigerant quantity that can be contained in the outdoor heat exchanger 23 during an air cooling operation when the outdoor heat exchanger 23 functions as a refrigerant radiator is 800 cc, the excess 300 cc of liquid refrigerant that cannot be contained in the outdoor heat exchanger 23 during an air cooling operation is temporarily contained in the refrigerant storage tank 25.

[0040] The liquid-side shutoff valve 27 and the gas-side shutoff valve 28 are valves provided to a connecting port with the device and distribution pipe to the outside (more specifically, the liquid refrigerant communication pipe 5 and a gas refrigerant communication pipe 6). A liquid-side shutoff valve 27 is provided on the end portion of the liquid refrigerant pipe 35. A gas-side shutoff valve 28 is provided on the end portion of the second gas refrigerant pipe 34.

[0041] The outdoor unit 2 includes an outdoor fan 36 that intakes outdoor air into the outdoor unit 2, causes heat exchange with the refrigerant in the outdoor heat exchanger 23, and then discharges the air to the outside. A propeller fan driven by an outdoor fan motor 37, or the like, can be used as the outdoor fan 36.

[0042] The outdoor unit 2 includes an outdoor control unit 38 that controls the operation of the respective units that configure the outdoor unit 2. The outdoor control unit 38 includes a microprocessor, a memory, or the like that performs control of the outdoor unit 2, and exchanges control signals or the like through the transmission wire 8a with the indoor control unit 43 of the indoor unit 4. That is to say, a control unit 8 is configured to perform overall operation control of the air conditioning apparatus 1 by the indoor control unit 44, the outdoor control unit 38 and the transmission wire 8a that connects the control units 38, 44.

[0043] The control unit 8 is enabled to control the operation of the respective types of the device and valves 21a, 22, 24, 37, 43, and the like, based on the detection values of the respective sensors or the various types of operational settings.

<Refrigerant Communication Pipe>

[0044] When the air conditioning apparatus 1 is installed in an installation place such as a building and the like, the refrigerant communication pipes 5, 6 are attached to the installation site, and may have a configuration of a variety of lengths and diameters depending on the installation condition, such as an installation site or a combination of the outdoor unit and the indoor unit.

[0045] As described above, the outdoor unit 2, the indoor unit 4 and the refrigerant communication pipes 5, 6 are connected to configure a refrigerant circuit 10 for the air conditioning apparatus 1. During an air cooling operation that is a cooling operation, the refrigerant circuit 10 is configured to perform a refrigeration cycle by causing refrigerant to flow sequentially through the compressor 21, the outdoor heat exchanger 23, the refrigerant storage tank 25, the expansion mechanism 24, and the indoor heat exchanger 41. During an air heating operation that is a heating operation, the refrigerant circuit 10 is configured to perform a refrigeration cycle by causing refrigerant to flow sequentially through the compressor 21, the indoor heat exchanger 41, the expansion mechanism 24, the refrigerant storage tank 25, and the outdoor heat exchanger 23. The air conditioning apparatus 1 is configured to enable each type of operation such as an air cooling operation and an air heating operation by the control unit 8 that is configured from an indoor control unit 44 and an outdoor control unit 38.

(2) Operation of Air conditioning Apparatus

[0046] The air conditioning apparatus 1 as described above is enabled to perform an air cooling operation and an air heating operation. The operation during an air cooling operation and an air heating operation of the air conditioning apparatus will be described below.

<Air Heating Operation>

[0047] During an air heating operation, the switching mechanism 22 switches to the configuration illustrated by the broken line in FIG. 1, that is to say, causes communication between the second port 22b and the fourth port 22d, and communication between the first port 22a and the third port 22c.

[0048] The low pressure refrigerant in the refrigeration cycle in the refrigerant circuit 10 is taken up by the compressor 21 and discharged after compression to a high pressure in the refrigeration cycle.

[0049] The high pressure refrigerant discharged from the compressor 21 is conveyed through the switching mechanism 22, the gas-side shutoff valve 28 and the gas refrigerant communication pipe 6 to the indoor heat exchanger 41.

[0050] The high pressure refrigerant conveyed to the indoor heat exchanger 41 radiates heat by performing heat exchange with the indoor air in the indoor heat exchanger 41. In this manner, the indoor air is heated. In this context, since the capacity of the indoor heat exchanger 41 is larger than the capacity of the outdoor heat exchanger 23, during an air heating operation, almost all the liquid refrigerant is contained in the indoor heat exchanger 41.

[0051] The high pressure refrigerant that radiates heat in the indoor heat exchanger 41 is conveyed through the liquid refrigerant communication pipe 5 and the liquid-side shutoff valve 27 to the expansion mechanism 24.

[0052] The refrigerant that is conveyed to the expansion mechanism 24 is depressurized to a low pressure in the refrigeration cycle by the expansion mechanism 24, and then is conveyed to the refrigerant storage tank 25 and stored in the refrigerant storage tank 25. Then the refrigerant in the refrigerant storage tank 25 is conveyed to the outdoor heat exchanger 23.

[0053] The low pressure refrigerant conveyed to the outdoor heat exchanger 23 undergoes evaporation by performing heat exchange with the outdoor air supplied by the outdoor fan 36 in the outdoor heat exchanger 23.

[0054] The low pressure refrigerant evaporated in the outdoor heat exchanger 23 is taken up through the switching mechanism 22 again into the compressor 21.

<Air Cooling Operation>

[0055] During air cooling operation, the switching mechanism 22 switches to the configuration illustrated by the solid line in FIG. 1, that is to say, causes communication between the second port 22b and the third port 22c, and communication between the first port 22a and the fourth port 22d.

[0056] The low pressure refrigerant in the refrigeration cycle in the refrigerant circuit 10 is taken up by the compressor 21 and discharged after compression to a high pressure in the refrigeration cycle.

[0057] The high pressure refrigerant discharged from the compressor 21 is conveyed through the switching mechanism 22 to the outdoor heat exchanger 23.

[0058] The high pressure refrigerant conveyed to the outdoor heat exchanger 23 radiates heat by performing heat exchange with the outdoor air in the outdoor heat exchanger 23.

[0059] The high pressure refrigerant that radiates heat in the outdoor heat exchanger 23 is conveyed to the refrigerant storage tank 25. Since the capacity of the outdoor heat exchanger 23 is less than or equal to the capacity of the indoor heat exchanger 41, the outdoor heat exchanger 23 cannot contain all the liquid refrigerant during the air cooling operation. Consequently, the liquid refrigerant that cannot be contained by the outdoor heat exchanger 23 is stored in the refrigerant storage tank 25, and the refrigerant storage tank 25 is filled with high pressure liquid refrigerant during the refrigeration cycle. The liquid refrigerant in the refrigerant storage tank 25 is depressurized to a low pressure in the refrigeration cycle by the expansion mechanism 24, and then is conveyed through the liquid-side shutoff valve 27 and the liquid refrigerant communication pipe 5 to the indoor heat exchanger 41.

[0060] The low pressure refrigerant conveyed to the indoor heat exchanger 41 undergoes evaporation by perfoming heat exchange with the indoor air in the indoor heat exchanger 41. In this manner, the indoor air is cooled.

[0061] The low pressure refrigerant evaporated in the indoor heat exchanger 41 is taken up through the gas refrigerant communication pipe 6, the gas-side shutoff valve 28 and the switching mechanism 22 again into the compressor 21.

(3) Characteristics of Air conditioning Apparatus

[0062] The air conditioning apparatus 1 according to the present embodiment has the following characteristics.

[0063] The air conditioning apparatus 1 as described above uses R32 as a refrigerant. As a result, a problem related to oil return to the compressor 21 must be considered. Furthermore, as described above, in the air conditioning apparatus 1, the indoor heat exchanger 41 is configured as a cross-fin type heat exchanger, the outdoor heat exchanger 23 is configured as a stacked heat exchanger uses the flat tubes 231 as heat transfer tubes, and the capacity of the outdoor heat exchanger 23 is less than or equal to 100% of the capacity of the indoor heat exchanger 41. Consequently, excess refrigerant is produced during an air cooling operation, and therefore there is a risk of damage to refrigerant control.

[0064] In this respect, the air conditioning apparatus 1 as described above is provided with the refrigerant storage tank 25 between the outdoor heat exchanger 23 and the expansion mechanism 24. The refrigerant storage tank 25 exhibits a high pressure in the refrigeration cycle during air cooling operation and a low pressure in the refrigeration cycle during air heating operation.

[0065] As a result, in the air conditioning apparatus 1, return of refrigerating machine oil to the compressor 21 is facilitated in comparison to a configuration in which the refrigerant storage tank is provided on the intake side of the compressor 21, and the problem of oil return to the compressor 21 is solved. Moreover, the air conditioning apparatus 1 prevents damage to refrigerant control since excess refrigerant produced during an air cooling operation is contained in the refrigerant storage tank 25 since the capacity of the outdoor heat exchanger 23 is less than or equal to the capacity of the indoor heat exchanger 41.

[0066] In this manner, notwithstanding the fact that the air conditioning apparatus 1 uses R32 as a refrigerant and that the capacity of the outdoor heat exchanger 23 is less than or equal to the capacity of the indoor heat exchanger 41, excess refrigerant produced during an air cooling operation can be contained and refrigerating machine oil can return to the compressor 21.

(4) Modified Example 1

[0067] In the above embodiment (reference is made to FIG. 1), as illustrated in FIG. 5, a bypass pipe 30 may further be provided to guide the gas component of the refrigerant that is stored in the refrigerant storage tank 25 into the compressor 21 or the intake pipe 31 of the compressor 21.

[0068] More specifically, for example, refrigerant immediately prior to entering the refrigerant storage tank 25 during an air heating operation contains a gas component that was produced when passing through the expansion mechanism 24. As result, after the refrigerant enters into the refrigerant storage tank 25, the liquid component and the gas component become separated, the liquid refrigerant is stored in a lower portion and the gas component is stored in an upper portion. Then the gas refrigerant that is separated in the refrigerant storage tank 25 flows through the bypass pipe 30 to the intake pipe 31 of the compressor 21. The liquid refrigerant that is separated in the refrigerant storage tank 25 is depressurized in the expansion mechanism 24, and flows into the outdoor heat exchanger 23. The bypass pipe 30 is provided to connect the upper portion of the refrigerant storage tank 25 and an intermediate section of the intake pipe 31. A flow rate regulating mechanism 30a is provided at an intermediate section of the bypass pipe 30. In this context, an electrically operation expansion valve is used as the flow rate regulating mechanism 30a. The outlet of the bypass pipe 30 is not connected to an intermediate section of the intake pipe 31, and may be directly connected with the compressor 21. The flow rate regulating mechanism 30a is controlled by a control unit 8 in the same manner as the other devices and valves 21 a, 22, 24, 37, 43, or the like. More specifically, during an air heating operation, the flow rate regulating mechanism 30a is controlled to an open configuration, and during an air cooling operation, the flow rate regulating mechanism 30a is controlled to a closed configuration.

[0069] In this manner, during an air heating operation, high pressure refrigerant that is conveyed to the expansion mechanism 24 after radiating heat in the indoor heat exchanger 41 is depressurized to a low pressure in the refrigeration cycle by the expansion mechanism 24, and thereafter is conveyed to the refrigerant storage tank 25. The refrigerant immediately prior to entering into the refrigerant storage tank 25, contains a gas component that was produced during depressurization in the expansion mechanism 24. However, after entering the refrigerant storage tank 25, the liquid component and gas component are separated, the liquid refrigerant is stored in the lower portion in the refrigeration cycle and the low pressure gas refrigerant is stored in an upper portion in the refrigeration cycle. At this time, as described above, since the flow rate regulating mechanism 30a of the bypass pipe 30 is controlled to an open configuration, the gas refrigerant in the refrigerant storage tank 25 flows through the bypass pipe 30 towards the intake pipe 31 of the compressor 21. The liquid refrigerant in the refrigerant storage tank 25 is conveyed to the outdoor heat exchanger 23. The low pressure refrigerant conveyed to the outdoor heat exchanger 23 evaporates as a result of heat exchange with the outdoor air supplied by the outdoor fan 36 in the outdoor heat exchanger 23. At this time, the flow rate of refrigerant that flows into the outdoor heat exchanger 23 is reduced by the gas-liquid separation operation in the refrigerant storage tank 25 and by the operation in which gas refrigerant resulting from gas-liquid separation is taken up through the bypass pipe 30 into the compressor 21. Consequently, the flow rate of refrigerant flowing in the outdoor heat exchanger 23 is reduced, and it is possible to reduce the pressure drop to that extent. Therefore the depressurization loss in the refrigeration cycle can be reduced.

[0070] On the other hand, during an air cooling operation, as described above, since the flow rate regulating mechanism 30a of the bypass pipe 30 is controlled to a closed configuration, the liquid refrigerant stored in the refrigerant storage tank 25 does not flow into the bypass pipe 30. The liquid refrigerant in the refrigerant storage tank 25 is depressurized to a low pressure in the refrigeration cycle by the expansion mechanism 24, and then is conveyed through the liquid-side shutoff valve 27 and the liquid refrigerant communication pipe 5 to the indoor heat exchanger 41.

[0071] As described above, since the air conditioning apparatus 1 according to the present modified example is provided with a bypass pipe 30 to guide the gas component of the refrigerant that is stored in the refrigerant storage tank 25 into the compressor 21 or the intake pipe 31 of the compressor 21, in addition to the effect of the above embodiment, the following effect is also imparted.

(A)

[0072] In the air conditioning apparatus 1, refrigerant that is depressurized in the expansion mechanism 24 during an air heating operation is separated into a liquid component and a gas component in the refrigerant storage tank 25, and thereafter the gas component flows into the bypass pipe 30.

[0073] In this manner, the gas component that does not participate in evaporation in the air conditioning apparatus 1 during an air heating operation does not flow into the outdoor heat exchanger 23 that functions as a refrigerant evaporator, and to that extent, the flow rate of refrigerant that flows through the outdoor heat exchanger 23 that functions as a refrigerant evaporator can be reduced, and therefore the depressurization loss in the refrigeration cycle can be reduced.

(B)

[0074] When the operation frequency of the compressor 21 is high, refrigerant that is a gas-liquid two-phase state returns from the refrigerant storage tank 25 through the bypass pipe 30 to the compressor 21 or the intake pipe 31 of the compressor 21, and therefore there is a risk of intake into the compressor 21.

[0075] However, since the bypass pipe 30 in this air conditioning apparatus 1 is configured with a flow rate regulating mechanism 30a, the liquid component of the refrigerant that is a gas-liquid two-phase state is depressurized and evaporates.

[0076] In this manner, the air conditioning apparatus 1 can prevent the liquid component from returning to the compressor 21 or the intake pipe 31 of the compressor 21.

(C)

[0077] The refrigerant that passes through the flow rate regulating mechanism 30a in this air conditioning apparatus 1 during an air heating operation evaporates in the indoor heat exchanger 41 or the outdoor heat exchanger 23, and then joins flow with refrigerant towards the compressor 21 or the intake pipe 31 of the compressor 21. At this time, when the flow rate regulating mechanism 30a is configured as an electrically operated expansion valve, the state of the refrigerant immediately prior to intake into the compressor 21 is regulated to a more optimal condition by controlling the valve aperture. Moreover, since the flow rate of refrigerant returning to the compressor 21 can be varied by controlling the valve aperture of the flow rate regulating mechanism 30a, the circulation flow rate of refrigerant, that is to say, the flow rate of refrigerant flowing in the indoor heat exchanger 41, can be controlled in response to the refrigerating load on the indoor heat exchanger 41 side.

(5) Modified Example 2

[0078] In the above modified example 1, although a container to store the refrigerant is adopted as the configuration of the refrigerant storage tank 25, there is not limitation in that regard, and for example, as illustrated in FIG. 6, a cyclone-type gas-liquid separator may be adopted.

[0079] The refrigerant storage tank 25 according to the modified example primarily includes a cylindrical container 251, a first connection pipe 252, a second connection pipe 253 and a third connection pipe 254.

[0080] The first connection pipe 252 is connected in a tangential direction relative to the peripheral side wall of the cylindrical container 251, and is connected with the expansion mechanism 24 and the inner portion of the cylindrical container 251. The second connection pipe 253 is connected with the bottom wall of the cylindrical container 251, and is connected with the outdoor heat exchanger 23 and the inner portion of the cylindrical container 251. The third connection pipe 254 is connected with the upper wall of the cylindrical container 251, and is connected with the bypass pipe 30 and the inner portion of the cylindrical container 251.

[0081] As a result of this configuration, during an air heating operation, the low pressure refrigerant in the refrigeration cycle that flows through the first connection pipe 252 into the cylindrical container 251 describes a vortex flow along the inner peripheral surface 251a of the peripheral side wall of the cylindrical container 251, and at that time, the liquid refrigerant attaches to the inner peripheral surface 251a to thereby enable efficient separation of the liquid refrigerant and the gas refrigerant.

[0082] The liquid refrigerant falls as a result of gravity, and is stored in a lower section and flows out through the second connection pipe 253 from the cylindrical container 251. On the other hand, the gas refrigerant rises while revolving and is stored in an upper section to thereby flow out through the third connection pipe 254 from the cylindrical container 251.

[0083] As described above, in the present modified example, since a cyclone-type gas-liquid separator is adopted as the refrigerant storage tank 25, efficient liquid-gas separation is enabled. Furthermore, there is no requirement for provision of both a refrigerant storage container and a gas-liquid separator due to provision of both a refrigerant storage function to store liquid refrigerant and a function of separating the liquid component and the gas component in the refrigerant storage tank 25 that comprises a gas-liquid separator, and therefore, the apparatus configuration can be simplified.

(6) Modified Example 3

[0084] In the above embodiment and modified examples 1 and 2, an example was described of a stacked heat exchanger that includes a plurality of the flat tubes 231 and waveform fins 232 as an example of an outdoor heat exchanger 23 that uses the flat tubes 231 as heat transfer tubes. In this outdoor heat exchanger 23, the plurality of the flat tubes 231 are arranged at intervals in a stacked configuration with the waveform fins 232 sandwiched by adjacent flat tubes 231.

[0085] However, the outdoor heat exchanger 23 is not limited to the above embodiment and modified examples 1 and 2, and for example, as illustrated in FIG. 7 and FIG. 8, a stacked heat exchanger may be configured to include a plurality of the flat tubes 231 that are arranged with intervals in a stacked configuration and fins 236 configured with notches 236a to accommodate insertion of the flat tubes 231.

[0086] The same effect as the above embodiment and modified examples 1 and 2 is imparted by this configuration.

(7) Modified Example 4

[0087] In the above embodiment and modified examples 1 and 2, an example was described of a stacked heat exchanger that includes a plurality of the flat tubes 231 and waveform fins 232 as an example of an outdoor heat exchanger 23 that uses the flat tubes 231 as heat transfer tubes. In this outdoor heat exchanger 23, the plurality of the flat tubes 231 are arranged at intervals in a stacked configuration with the waveform fins 232 sandwiched by adjacent flat tubes 231.

[0088] However, the outdoor heat exchanger 23 is not limited to the above embodiment and modified examples 1 and 2, and for example, a configuration is possible in which the flat tube is configured in a serpentine shape, and the fins are sandwiched between adjacent surfaces of the flat tube.

[0089] The same effect as the above embodiment and modified examples 1 and 2 is imparted by this configuration.

(8) Modified Example 5

[0090] In the above embodiment and modified examples 1 to 4, an example was described of a stacked heat exchanger in which the outdoor heat exchanger 23 includes a plurality of the flat tubes 231 and the waveform fins 232 or the fins 236 with the notches 236a. However there is no limitation in this regard, and for example, when the refrigeration device is configured to cool the outdoor heat exchanger 23 using water during an air cooling operation, a cross-fin type of heat exchanger including both an outdoor heat exchanger 23 and an indoor heat exchanger 41 may be configured so that the heat transfer tube diameter of the outdoor heat exchanger 23 is smaller than the heat transfer tube diameter of the indoor heat exchanger 41.

[0091] The same effect as the above embodiment and modified examples 1 to 4 is imparted by this configuration.

INDUSTRIAL APPLICABILITY

[0092] The present invention relates to a refrigeration device that uses R32 as a refrigerant and is configured to enable both a cooling operation and a heating operation to thereby be of wide applicability.

REFERENCE SIGNS LIST

[0093]

1	AIR CONDITIONING APPARATUS (REFRIGERATION DEVICE)
21	COMPRESSOR
23	OUTDOOR HEAT EXCHANGER
24	EXPANSION MECHANISM
25	REFRIGERANT STORAGE TANK
30	BYPASS PIPE
30a	FLOW RATE REGULATION MECHANISM
41	INDOOR HEAT EXCHANGER

CITATION LIST

PATENT LITERATURE

PATENT LITERATURE 1

[0094] Japanese Patent Application Laid-Open No. 2001-194015

PATENT LITERATURE 2

[0095] Japanese Patent Application Laid-Open No. 6-143991

Claims

1. A refrigeration device (1) in which, during a cooling operation, a refrigerant flows sequentially through a compressor (21), an outdoor heat exchanger (23), an expansion mechanism (24), and an indoor heat exchanger (41), and during a heating operation, the refrigerant flows sequentially through the compressor, the indoor heat exchanger, the expansion mechanism, and the outdoor heat exchanger, the refrigeration device using R32 as the refrigerant, a capacity of the outdoor heat exchanger is less than or equal to a capacity of the indoor heat exchanger, and a refrigerant storage tank (25) configured to store the refrigerant is provided between the outdoor heat exchanger and the expansion mechanism.

2. A refrigeration device (1) according to claim 1, wherein the refrigerant storage tank (25) is configured with a high pressure in a refrigeration cycle during the cooling operation, and a low pressure in a refrigeration cycle during the heating operation.

3. A refrigeration device (1) according to claim 1 or claim 2, wherein the outdoor heat exchanger (23) is a heat exchanger that uses a flat tube as a heat transfer tube.

4. A refrigeration device (1) according to claim 3, wherein the outdoor heat exchanger (23) is a heat exchanger that includes a plurality of the flat tubes that are disposed at intervals in a plurality of stacking arrangements, and fins that are sandwiched by the adjacent flat tubes.

5. A refrigeration device (1) according to claim 3, wherein the outdoor heat exchanger (23) is a heat exchanger that includes a plurality of the flat tubes that are disposed at intervals in a plurality of stacking arrangements, and fins that are configured with notches to accommodate insertion of the flat tubes.

6. A refrigeration device (1) according to claim 1 or claim 2, wherein the outdoor heat exchanger (23) and the indoor heat exchanger (41) are a cross-fin type heat exchanger, and a heat transfer tube diameter in the outdoor heat exchanger is smaller than a heat transfer tube diameter in the indoor heat exchanger.

7. A refrigeration device (1) according to any one of claim 1 to claim 6, wherein a bypass pipe (30) is further provided to guide gas components in the refrigerant, that is stored in the refrigerant storage tank (25), into the compressor (21) or a refrigerant pipe on an intake side of the compressor.

8. A refrigeration device (1) according to claim 7,

wherein the bypass pipe (30) has a flow rate regulating mechanism (30a).

9. A refrigeration device (1) according to any one of claim 1 to claim 8, wherein the refrigerant storage tank (25) is a gas-liquid separator.

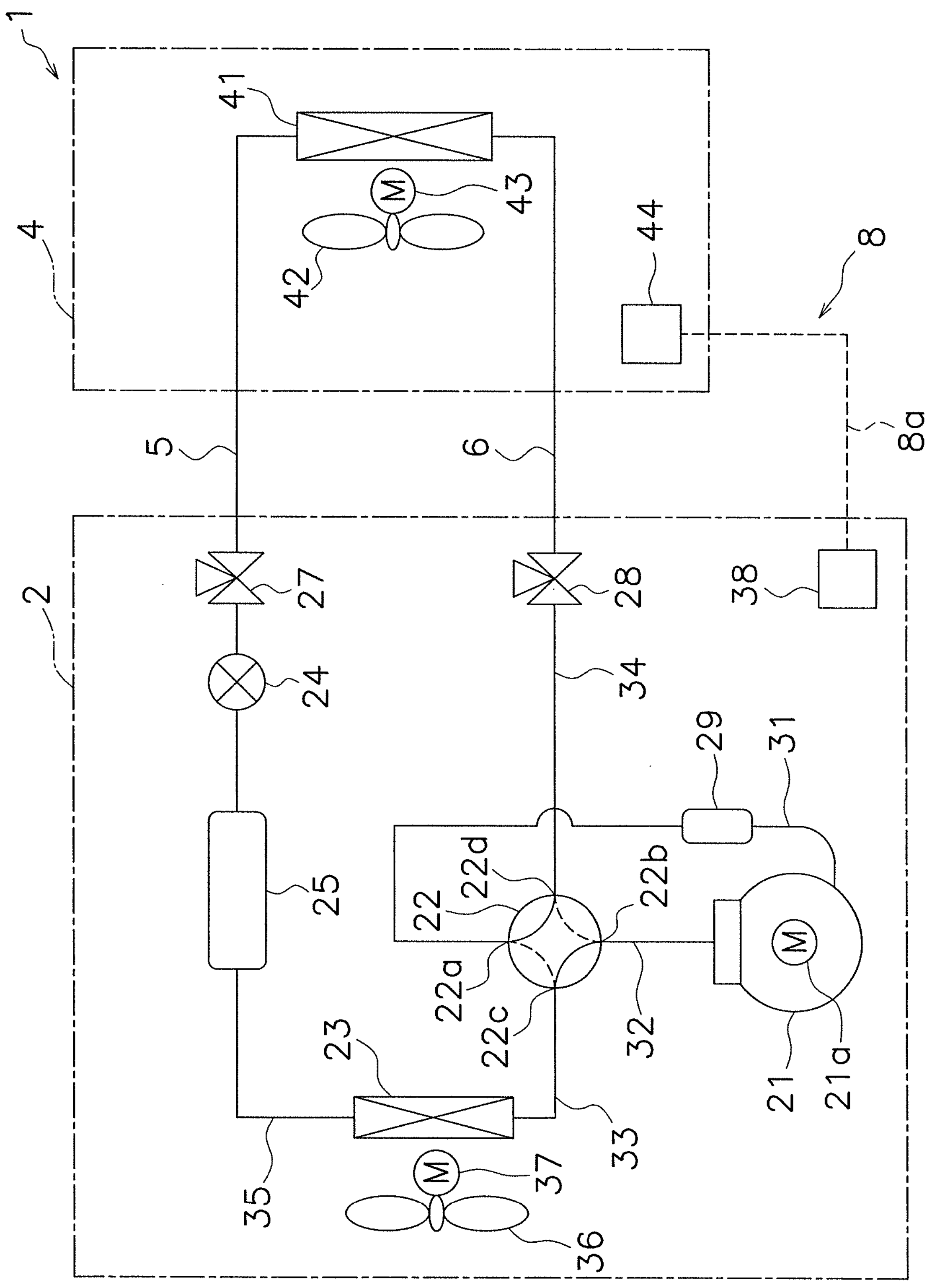
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FIG. 1

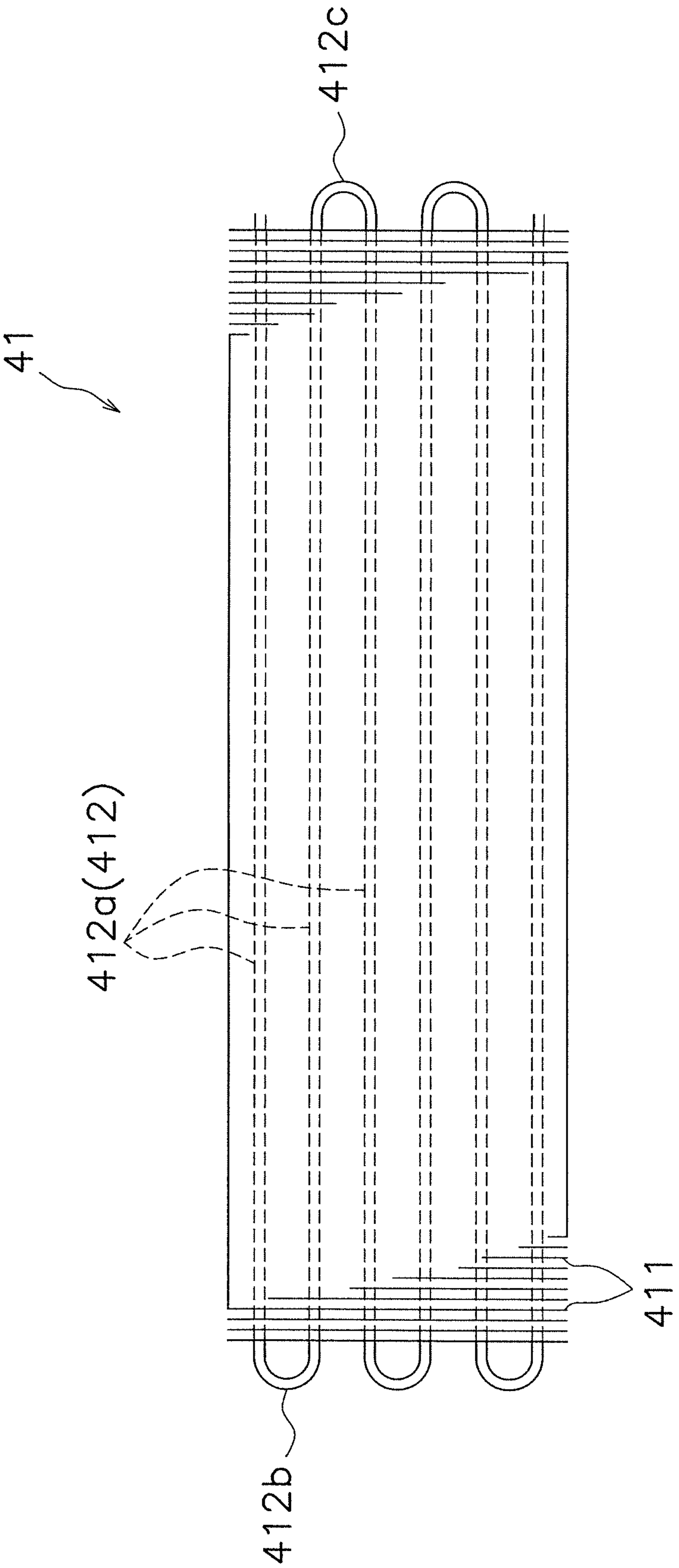


FIG. 2

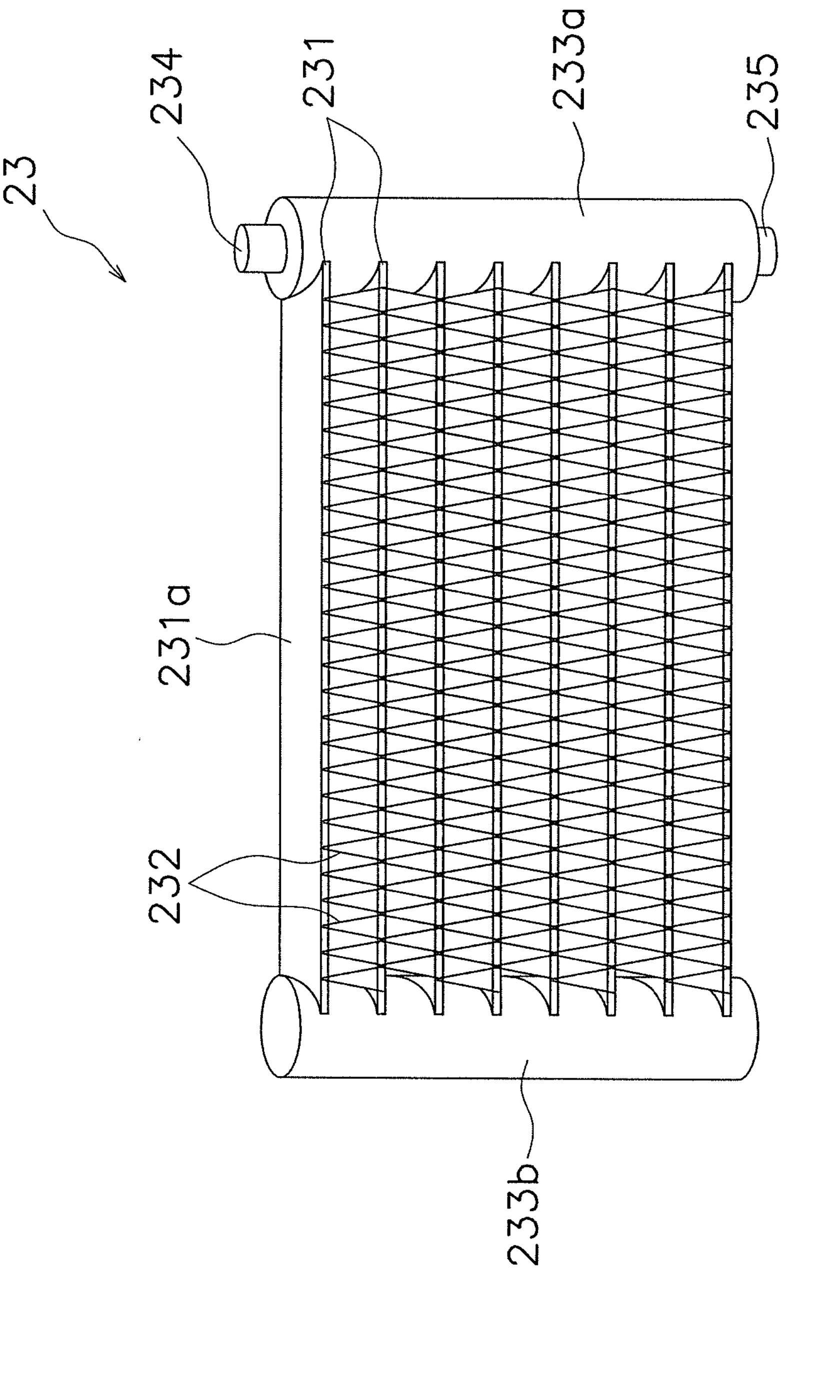
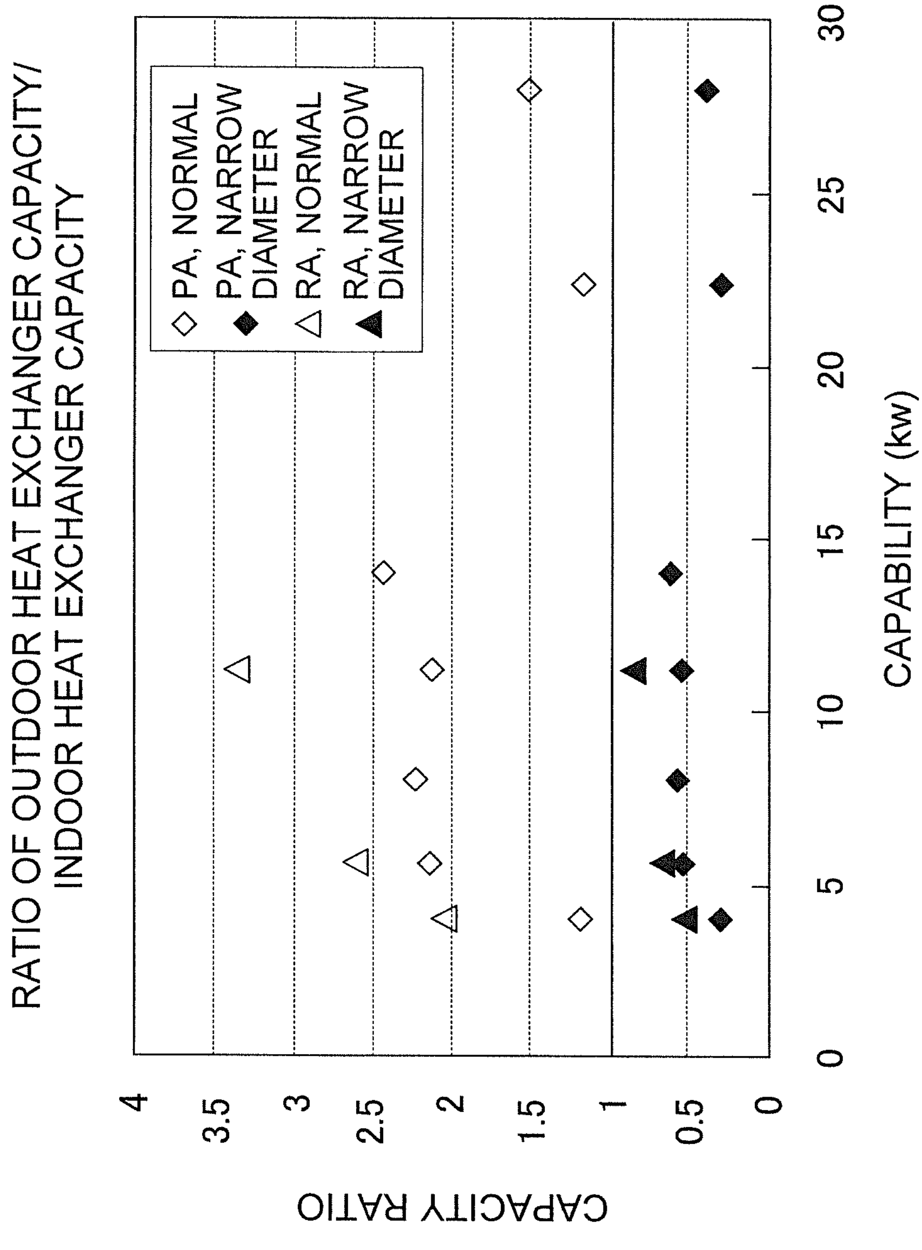


FIG. 3


RATIO OF OUTDOOR HEAT EXCHANGER CAPACITY/
INDOOR HEAT EXCHANGER CAPACITY
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PA, NARROW DIAMETER
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RA, NARROW DIAMETER
CAPACITY RATIO
4
3.5
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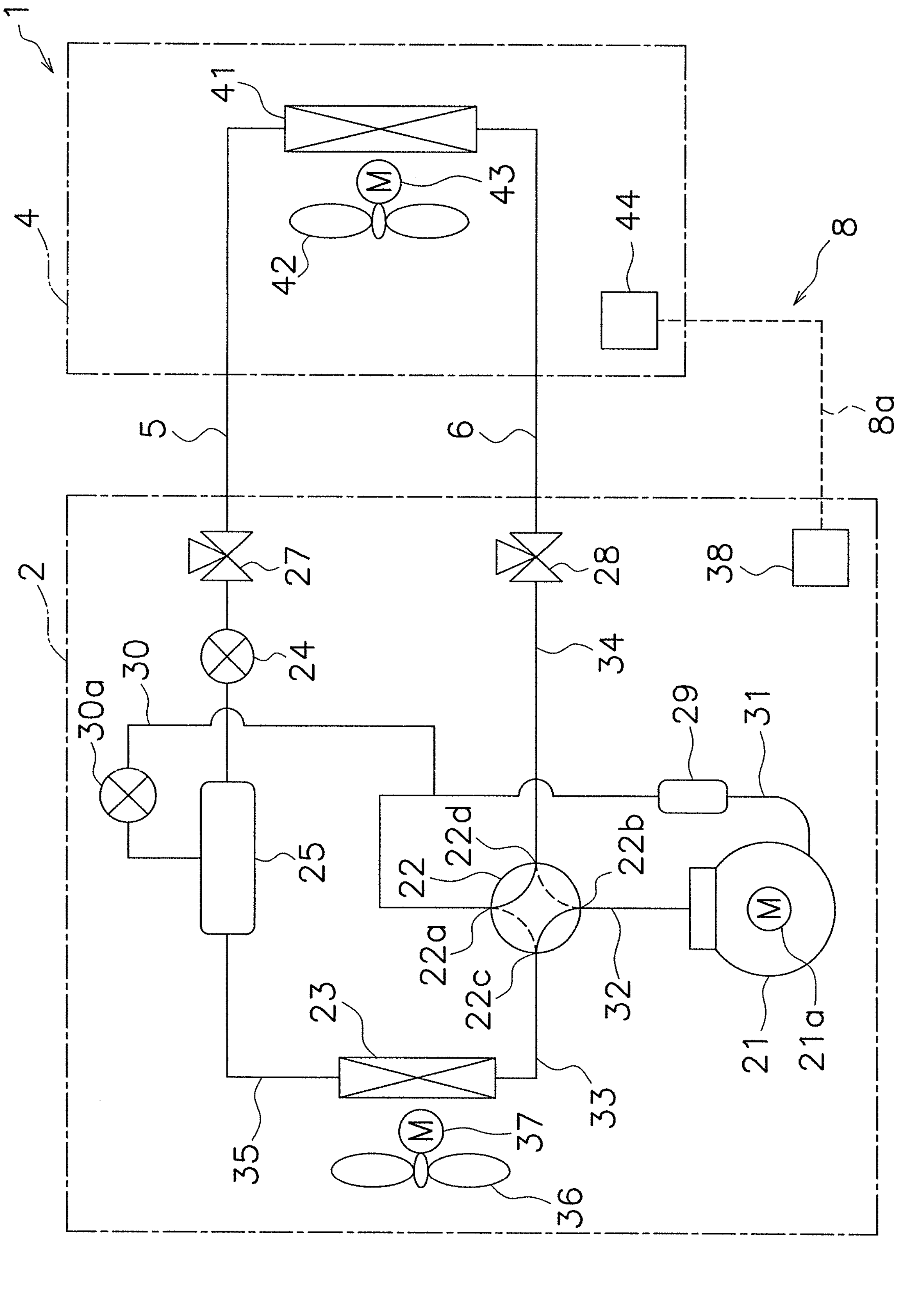
CAPABILITY (kw)

FIG. 4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22c
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21a
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FIG. 5

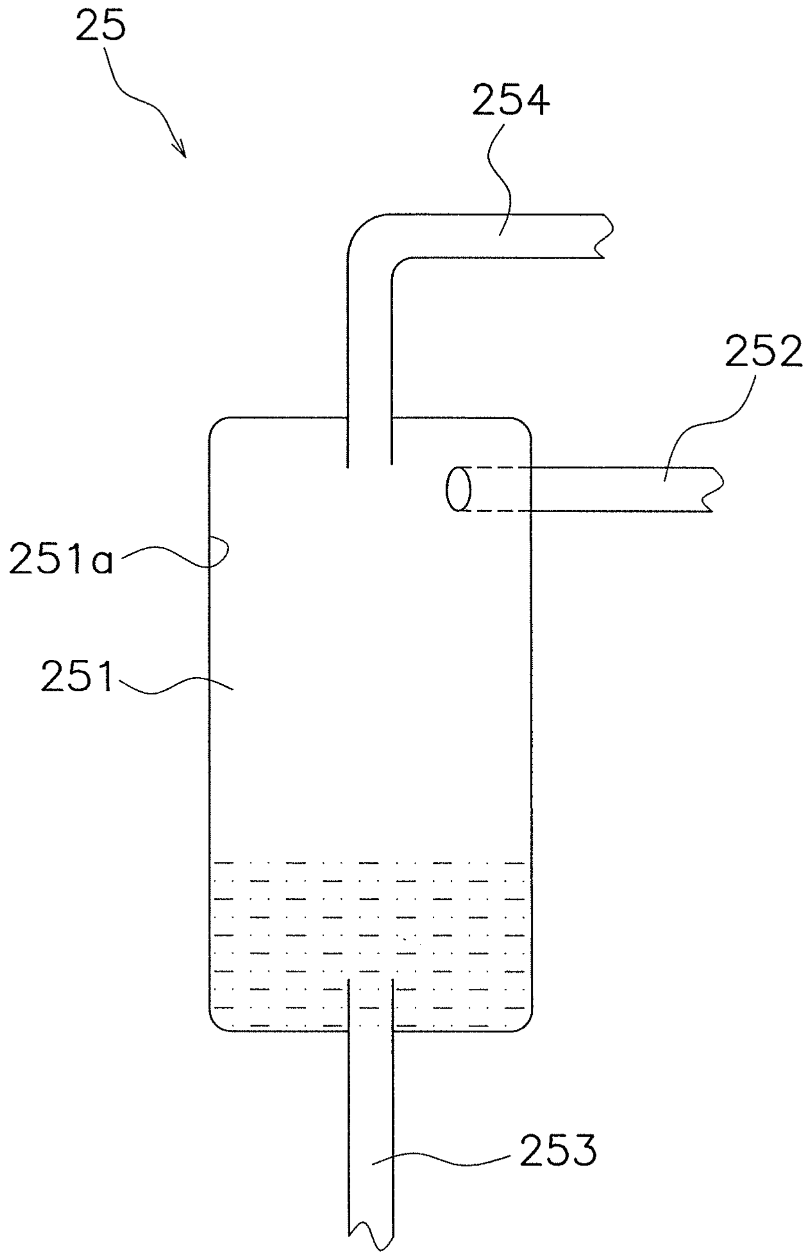

FIG. 6

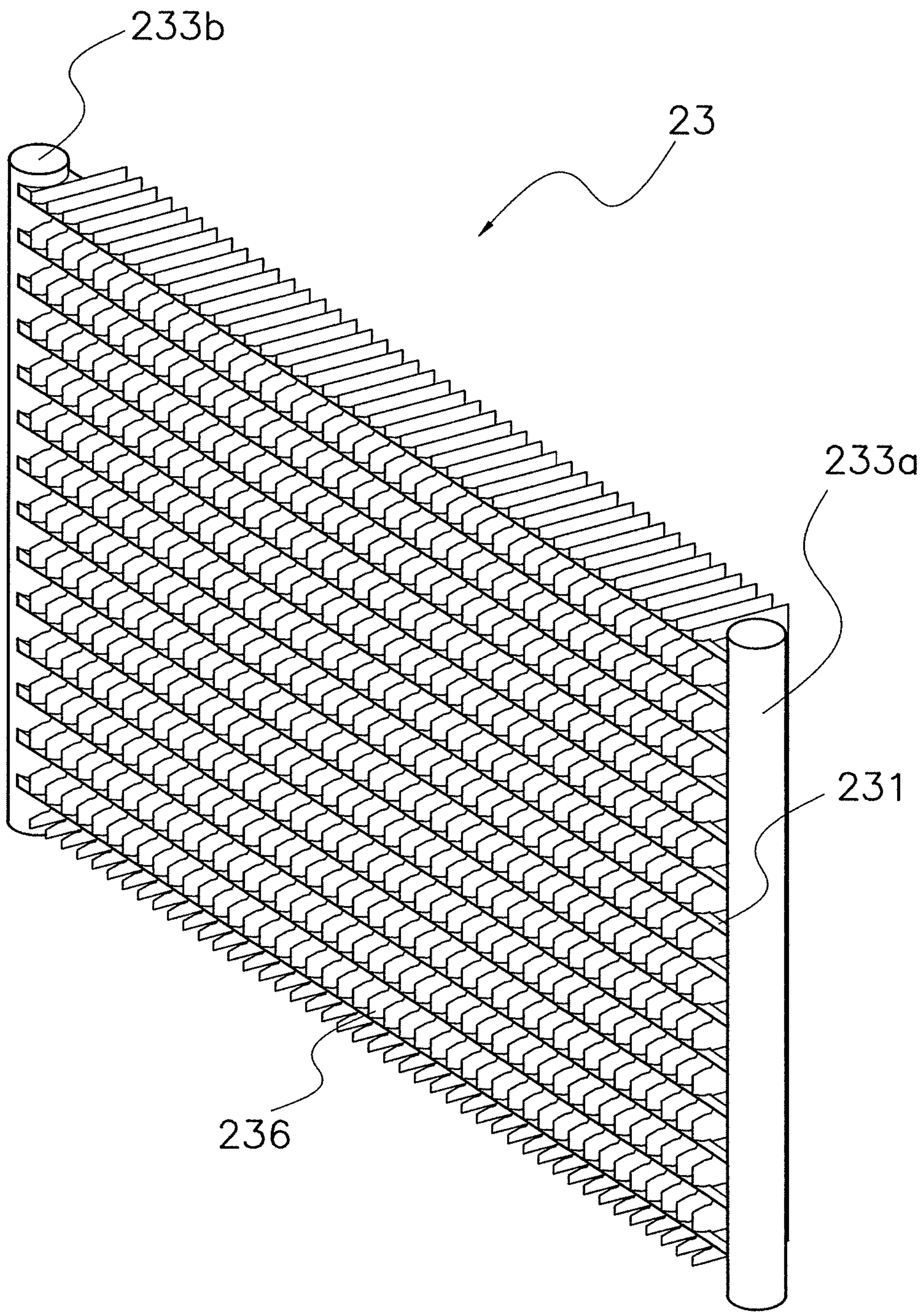

FIG. 7

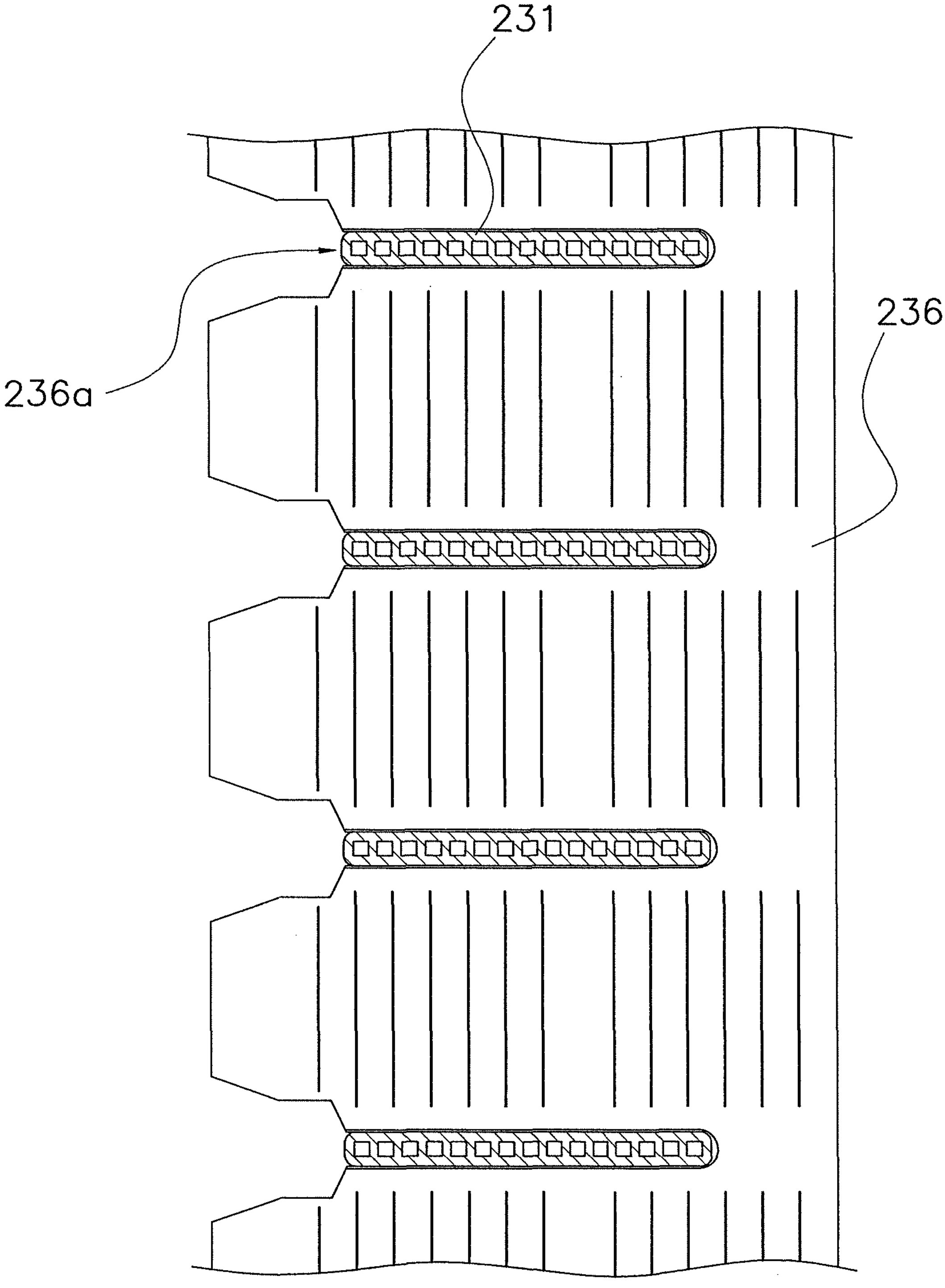

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/058687

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F25B39/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/00, F25B39/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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.
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Y	JP 2007-85730 A (Mitsubishi Electric Corp.), 05 April 2007 (05.04.2007), paragraphs [0035], [0036]; fig. 1 (Family: none)	1-9
Y	JP 6-18063 A (Hitachi, Ltd.), 25 January 1994 (25.01.1994), claim 1; fig. 1 to 3 (Family: none)	3-5

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

* Special categories of cited documents:
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 June, 2013 (04.06.13)	11 June, 2013 (11.06.13)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/058687

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 7-91873 A (Hitachi, Ltd.), 07 April 1995 (07.04.1995), paragraphs [0019] to [0021]; fig. 2 (Family: none)	5
Y	JP 2001-263859 A (Hitachi, Ltd.), 26 September 2001 (26.09.2001), paragraphs [0047], [0049], [0068]; fig. 1, 2, 8 (Family: none)	6-9

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REFERENCES CITED IN THE DESCRIPTION

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- JP 6143991 A **[0004] [0095]**