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(54) **REFRIGERATION DEVICE**

KÜHLVORRICHTUNG

DISPOSITIF DE RÉFRIGÉRATION

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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration apparatus, and particularly relates to a refrigeration apparatus capable of performing a cooling operation and a heating operation.

BACKGROUND ART

[0002] In conventional refrigeration apparatuses such as air-conditioning apparatuses capable of air-cooling and air-warming operations, there is a difference between the optimal refrigerant quantity for an air-cooling operation (cooling operation) and the optimal refrigerant quantity for an air-warming operation (heating operation). Accordingly, there is a difference between the capacity of an outdoor heat exchanger functioning as a heat radiator of refrigerant during the air-cooling operation and the capacity of an indoor heat exchanger functioning as a heat radiator of refrigerant during the air-warming operation. Because the capacity of the outdoor heat exchanger is greater than the capacity of the indoor heat exchanger, refrigerant that cannot be accommodated by the indoor heat exchanger during the air-warming operation is temporarily stored in a refrigerant storage tank or the like connected to an intake side of a compressor.

SUMMARY OF THE INVENTION

[0003] However, in the refrigeration apparatus described above, when a high-performance heat exchanger such as the one disclosed in JP S6-143991 A) is used as an outdoor heat exchanger, the capacity of the outdoor heat exchanger becomes equal to or less than the capacity of the indoor heat exchanger. Therefore, in this case, refrigerant that cannot be accommodated in the outdoor heat exchanger during the air-cooling operation (excess refrigerant) is produced, and the quantity of this refrigerant exceeds the quantity that can be stored in the refrigerant storage tank or the like.

[0004] Further, EP 2 075 519 A2 discloses a control unit judging whether a liquid refrigerant is included in a refrigerant injected into a compressor. The risk of liquid compression of the compressor is reduced, whereby the possibility of damage to the compressor is decreased and reliability and performance is improved.

[0005] Moreover, EP 2 068 101 A1 teaches an air-conditioner capable of simplifying conditions required for judging whether or not the amount of refrigerant is adequate. A refrigerant circuit performs a cooling operation in which an outdoor heat exchanger functions as a condenser of the refrigerant compressed in a compressor and an indoor heat exchanger functions as an evaporator of the refrigerant condensed in the outdoor heat exchanger.

[0006] JP 2009 299961 teaches a refrigeration device

capable of shortening a refrigerant recovering time and suppressing equipment costs. A compressor and first and second refrigerant pipings connected with a use-side heat exchanger and with a heat source-side heat exchanger are provided. A first closing valve can block off the refrigerant flow in the first refrigerant piping, and a second closing valve can block off the refrigerant flow in the second refrigerant piping. A switching means switches the refrigerant flow to the refrigerant flow of the reverse cycle reverse to the refrigerant flow inside of the first refrigerant piping, the second refrigerant piping and the use-side heat exchanger in the normal cycle operation. The refrigerant is recovered inside of the use-side heat exchanger by performing a reverse cycle operation in a state that the first closing valve is closed.

[0007] JP H10 332212 A refers to a refrigeration cycle of an air conditioner in which a compressor, a four-way valve, an indoor heat exchanger, an expansion valve, and an outdoor heat exchanger are sequentially connected by a refrigerant pipe. The expansion valve includes an upstream- and a downstream-side expansion mechanism with a refrigerant storage tank in between.

[0008] An object of the present invention is to provide a refrigeration apparatus capable of performing a cooling operation and a heating operation, wherein the excess refrigerant produced during the cooling operation can be accommodated when the capacity of the outdoor heat exchanger is equal to or less than the capacity of the indoor heat exchanger.

[0009] The refrigeration apparatus of the present invention is defined in claim 1.

[0010] A refrigeration apparatus according to a first aspect is at least a refrigeration apparatus in which a refrigerant flows sequentially through a compressor, an outdoor heat exchanger, expansion mechanisms, and an indoor heat exchanger during a cooling operation, and the refrigerant flows sequentially through the compressor, the indoor heat exchanger, the expansion mechanisms, and the outdoor heat exchanger during a heating operation. In this refrigeration apparatus, the indoor heat exchanger is a cross-fin type heat exchanger and the outdoor heat exchanger is a stacked heat exchanger. Moreover, the expansion mechanisms include an upstream-side expansion mechanism for depressurizing the refrigerant and a downstream-side expansion mechanism for depressurizing the refrigerant that has been depressurized in the upstream-side expansion mechanism, and a refrigerant storage tank for storing the refrigerant depressurized by the upstream-side expansion mechanism is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism.

[0011] A capacity of a stacked heat exchanger is less than a capacity of a cross-fin type heat exchanger having similar heat exchange performance. In a case of a refrigeration apparatus in which the outdoor heat exchanger and the indoor heat exchanger are both cross-fin type heat exchangers, and then only the outdoor heat ex-

changer is changed to a stacked heat exchanger having similar heat exchange performance, the capacity of this stacked outdoor heat exchanger will then not only be less than the capacity of a cross-fin type outdoor heat exchanger, but will also be less than the capacity of the cross-fin type indoor heat exchanger connected thereto.

[0012] Therefore, in such a refrigeration apparatus, an excess refrigerant is produced during the cooling operation due to the capacity of the outdoor heat exchanger being less than the capacity of the indoor heat exchanger. There is a risk that a refrigerant control will be hindered when too much of this excess refrigerant spreads from the indoor heat exchanger having a gas-phase portion to portions as far as an intake side of the compressor.

[0013] In view of this, the refrigerant storage tank for storing the refrigerant depressurized by the upstream-side expansion mechanism is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism, and the excess refrigerant that could not be accommodated in the outdoor heat exchanger during the cooling operation is thereby accommodated in the refrigerant storage tank positioned in the vicinity of the downstream side of the outdoor heat exchanger.

[0014] It is thereby possible to prevent hindrances to the refrigerant control in this refrigeration apparatus, because it is possible to prevent too much refrigerant from spreading from the indoor heat exchanger having a gas-phase portion to portions as far as the intake side of the compressor.

[0015] A refrigeration apparatus according to a second aspect is at least a refrigeration apparatus in which a refrigerant flows sequentially through a compressor, an outdoor heat exchanger, expansion mechanisms, and an indoor heat exchanger during a cooling operation, and refrigerant flows sequentially through the compressor, the indoor heat exchanger, the expansion mechanisms, and the outdoor heat exchanger during a heating operation. In this refrigeration apparatus, a capacity of the outdoor heat exchanger is 100% or less of a capacity of the indoor heat exchanger. Moreover, the expansion mechanisms include an upstream-side expansion mechanism for depressurizing the refrigerant and a downstream-side expansion mechanism for depressurizing the refrigerant that has been depressurized in the upstream-side expansion mechanism, and a refrigerant storage tank for storing the refrigerant depressurized by the upstream-side expansion mechanism is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism.

[0016] When the capacity of the outdoor heat exchanger is equal to or less than the capacity of the indoor heat exchanger, an excess refrigerant is produced during the cooling operation. There is a risk that a refrigerant control will be hindered when too much of this excess refrigerant spreads from the indoor heat exchanger having a gas-phase portion to portions as far as an intake side of the compressor.

[0017] In view of this, the refrigerant storage tank for storing the refrigerant depressurized by the upstream-side expansion mechanism is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism, and the excess refrigerant that could not be accommodated in the outdoor heat exchanger during the cooling operation is thereby accommodated in the refrigerant storage tank positioned in the vicinity of the downstream side of the outdoor heat exchanger.

[0018] It is thereby possible to prevent hindrances to the refrigerant control in this refrigeration apparatus, because it is possible to prevent too much refrigerant from spreading from the indoor heat exchanger having a gas-phase portion to portions as far as the intake side of the compressor.

[0019] In the refrigeration apparatus according to the invention, the refrigerant is R32.

[0020] When R32 is used as the refrigerant in the refrigeration apparatus, a refrigerator oil sealed with the refrigerant in order to lubricate the compressor tends to have extremely low solubility in low-temperature conditions. Therefore, at a low pressure in the refrigeration cycle, the solubility of the refrigerator oil greatly decreases due to the decrease in a refrigerant temperature. When R32 is used as the refrigerant in a conventional refrigeration apparatus having the refrigerant storage tank on the intake side of the compressor, for example, the refrigerant and the refrigerator oil separate into two layers in the refrigerant

[0021] The present invention is widely applicable in refrigeration apparatuses that can storage tank which has a low pressure in the refrigeration cycle, and the refrigerator oil has difficulty returning to the compressor.

[0022] However, because the refrigerant storage tank is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism in this refrigeration apparatus as described above, the refrigerator oil returns more readily to the compressor, in comparison to cases in which the refrigerant storage tank is provided to the intake side of the compressor.

[0023] Thus, in this refrigeration apparatus, due to the refrigerant storage tank being provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism, it is possible to resolve not only the problem of the excess refrigerant produced by the capacity of the outdoor heat exchanger being equal to or less than the capacity of the indoor heat exchanger, due to factors such as a stacked heat exchanger being used as the outdoor heat exchanger, but also the problem of oil returning to the compressor, caused by using R32 as the refrigerant.

[0024] In a refrigeration apparatus according to the present disclosure, the outdoor heat exchanger is a stacked heat exchanger having a plurality of flat tubes arrayed so as to be superposed set apart by gaps, and fins sandwiched between the adjacent flat tubes.

[0025] In this refrigeration apparatus, the refrigerant

quantity in the refrigeration apparatus is reduced because the capacity of the outdoor heat exchanger is equal to or less than the capacity of the indoor heat exchanger. The excess refrigerant is produced during the cooling operation in this refrigeration apparatus, but because this excess refrigerant can be accommodated in the refrigerant storage tank, hindrances to the refrigerant control can be prevented.

[0026] In a refrigeration apparatus according to the present invention, the outdoor heat exchanger is a stacked heat exchanger having a plurality of flat tubes arrayed so as to be superposed set apart by gaps, and fins having notches formed therein where the flat tubes are inserted.

[0027] In this refrigeration apparatus, the refrigerant quantity in the refrigeration apparatus is reduced because the capacity of the outdoor heat exchanger is equal to or less than the capacity of the indoor heat exchanger. The excess refrigerant is produced during the cooling operation in this refrigeration apparatus, but because this excess refrigerant can be accommodated in the refrigerant storage tank, hindrances to the refrigerant control can be prevented.

[0028] In a refrigeration apparatus according to the present disclosure, the outdoor heat exchanger is a stacked heat exchanger having flat tubes molded into serpentine shapes, and fins inserted between mutually adjacent surfaces of the flat tubes.

[0029] In this refrigeration apparatus, the refrigerant quantity in the refrigeration apparatus is reduced because the capacity of the outdoor heat exchanger is equal to or less than the capacity of the indoor heat exchanger. The excess refrigerant is produced during the cooling operation in this refrigeration apparatus, but because this excess refrigerant can be accommodated in the refrigerant storage tank, hindrances to the refrigerant control can be prevented.

[0030] In a refrigeration apparatus according to the present invention, the refrigerant is R32.

[0031] When R32 is used as the refrigerant in the refrigeration apparatus, a refrigerator oil sealed with the refrigerant in order to lubricate the compressor tends to have extremely low solubility in low-temperature conditions. Therefore, at a low pressure in the refrigeration cycle, the solubility of the refrigerator oil greatly decreases due to the decrease in a refrigerant temperature. When R32 is used as the refrigerant in a conventional refrigeration apparatus having the refrigerant storage tank on the intake side of the compressor, for example, the refrigerant and the refrigerator oil separate into two layers in the refrigerant storage tank which has a low pressure in the refrigeration cycle, and the refrigerator oil has difficulty returning to the compressor.

[0032] However, because the refrigerant storage tank is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism in this refrigeration apparatus as described above, the refrigerator oil returns more readily to the compressor, in

comparison to cases in which the refrigerant storage tank is provided to the intake side of the compressor.

[0033] Thus, in this refrigeration apparatus, due to the refrigerant storage tank being provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism, it is possible to resolve not only the problem of the excess refrigerant produced by the capacity of the outdoor heat exchanger being equal to or less than the capacity of the indoor heat exchanger, but also the problem of oil returning to the compressor, caused by using R32 as the refrigerant.

[0034] A refrigeration apparatus according to the present disclosure is the refrigeration apparatus, wherein the outdoor heat exchanger and the indoor heat exchanger are cross-fin type heat exchangers, and a diameter of heat transfer tubes in the outdoor heat exchanger is designed to be less than a diameter of heat transfer tubes in the indoor heat exchanger.

[0035] In this refrigeration apparatus, the refrigerant quantity in the refrigeration apparatus is reduced because the capacity of the outdoor heat exchanger is equal to or less than the capacity of the indoor heat exchanger. The excess refrigerant is produced during the cooling operation in this refrigeration apparatus, but because this excess refrigerant can be accommodated in the refrigerant storage tank, hindrances to the refrigerant control can be prevented.

[0036] A refrigeration apparatus according to a third aspect is the refrigeration apparatus according to any of the first and second aspects, further provided with a bypass tube for leading a gas component of the refrigerant accumulated in the refrigerant storage tank to the compressor or to a refrigerant tube on an intake side of the compressor.

[0037] In this refrigeration apparatus, the refrigerant depressurized in the upstream-side expansion mechanism is separated into a liquid component and the gas component in the refrigerant storage tank, and the gas component heads toward the bypass tube.

[0038] The gas component, which does not contribute to evaporation, thereby ceases to flow into the outdoor heat exchanger functioning as an evaporator of the refrigerant during the heating operation in this refrigeration apparatus, it is therefore possible to proportionately reduce the flow rate of the refrigerant flowing through the outdoor heat exchanger functioning as an evaporator of the refrigerant, and a depressurization loss in the refrigeration cycle can be reduced.

[0039] A refrigeration apparatus according to a fourth aspect is the refrigeration apparatus according to the third aspect, wherein the bypass tube has a flow rate adjustment mechanism.

[0040] When the operating frequency of the compressor is high, there is a risk that a gas-liquid two-phase refrigerant from the refrigerant storage tank will pass through the bypass tube, return to the compressor or the intake tube of the compressor, and be drawn into the compressor.

[0041] However, in this refrigeration apparatus, because the flow rate adjustment mechanism is provided to the bypass tube, the liquid component of the gas-liquid two-phase refrigerant is depressurized and evaporated.

[0042] It is thereby possible in this refrigeration apparatus to prevent the liquid component from returning to the compressor or the intake tube of the compressor.

[0043] During the heating operation in this refrigeration apparatus, the refrigerant that has passed through the flow rate adjustment mechanism converges with the refrigerant which has evaporated in the outdoor heat exchanger, and then heads to the compressor or the intake tube of the compressor. At this time, in the case that the flow rate adjustment mechanism is an electric expansion valve, the state of the refrigerant just before being drawn into the compressor can be adjusted more optimally by controlling the valve opening degree. Moreover, because the flow rate of the refrigerant returning to the compressor can be increased or reduced by controlling the valve opening degree of the flow rate adjustment mechanism, the refrigerant circulation flow rate, i.e. the flow rate of the refrigerant flowing through the indoor heat exchanger can be controlled according to the refrigeration load on the indoor heat exchanger side.

[0044] A refrigeration apparatus according to a fifth aspect is the refrigeration apparatus according to any of the first through fourth aspects, wherein the refrigerant storage tank is a gas-liquid separator.

[0045] In this refrigeration apparatus, the refrigerant storage tank composed of the gas-liquid separator has both a function of accumulating a liquid component and a function of separating the liquid component and a gas component.

[0046] This contributes to simplifying the apparatus configuration in this refrigeration apparatus because there is no need to provide both a container having a refrigerant storage function and a container having a gas-liquid separating function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047]

FIG. 1 is a schematic configuration diagram of an air conditioning apparatus as a refrigeration apparatus according to an embodiment 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 not having all of the features of an outdoor heat exchanger according to claim 1.

FIG. 4 is a graph showing the outdoor heat exchanger capacity/indoor heat exchanger capacity ratio according to capability.

FIG. 5 is a schematic cross-sectional view of a refrigerant storage tank in Modification 1.

FIG. 6 is an external perspective view of an outdoor

heat exchanger according to the invention.

FIG. 7 is a longitudinal cross-sectional view of the outdoor heat exchanger according to the invention.

DESCRIPTION OF EMBODIMENTS

[0048] An embodiment of the refrigeration apparatus according to the present invention and modifications thereof are described below with reference to the drawings. The specific configuration of the refrigeration apparatus according to the present invention is not limited to the following embodiment or the modifications thereof, and can be altered within a range that does not deviate from the scope of the invention.

(1) Configuration of air-conditioning apparatus

[0049] FIG. 1 is a schematic configuration diagram of an air-conditioning apparatus 1 as a refrigeration apparatus according to an embodiment of the present invention.

[0050] The air-conditioning apparatus 1 is a refrigeration apparatus capable of performing an air-cooling operation as a cooling operation and an air-warming operation as a heating operation by performing a vapor-compression refrigeration cycle. The air-conditioning apparatus 1 is configured primarily from the connection between an outdoor unit 2 and an indoor unit 4. The outdoor unit 2 and the indoor unit 4 are connected via a liquid refrigerant communication tube 5 and a gas refrigerant communication tube 6. Specifically, a vapor-compression refrigerant circuit 10 of the air-conditioning apparatus 1 is configured from the connection between the outdoor unit 2 and the indoor unit 4 via the refrigerant communication tubes 5, 6.

<Indoor unit>

[0051] The indoor unit 4, which is installed inside a room, constitutes part of the refrigerant circuit 10. The indoor unit 4 primarily has an indoor heat exchanger 41.

[0052] The indoor heat exchanger 41 is a heat exchanger that functions as an evaporator of refrigerant to cool indoor air during the air-cooling operation, and functions as a heat radiator of refrigerant during the air-warming operation to heat indoor air. A liquid side of the indoor heat exchanger 41 is connected to the liquid refrigerant communication tube 5, and a gas side of the indoor heat exchanger 41 is connected to the gas refrigerant communication tube 6.

[0053] The indoor heat exchanger 41, which is a cross-fin type heat exchanger, has primarily heat transfer fins 411 and heat transfer tubes 412, as shown in FIG. 2. FIG. 2 is a front view of the indoor heat exchanger 41. The heat transfer fins 411 are thin aluminum flat plates, and pluralities of through-holes are formed in the heat transfer fins 411. The heat transfer tubes 412 have straight tubes 412a inserted through the through-holes

of the heat transfer fins 411, and U-shaped tubes 412b, 412c linking the ends of adjacent straight tubes 412a together. The straight tubes 412a are firmly adhered to the heat transfer fins 411 by undergoing an expanding process after being inserted through the through-holes of the heat transfer fins 411. The straight tubes 412a and the first U-shaped tubes 412b are formed integrally, and the second U-shaped tubes 412c are linked to the ends of the straight tubes 412a by welding, soldering, or the like, after being inserted through the through-holes of the heat transfer fins 411 and undergoing the expanding process.

[0054] The indoor unit 4 also has an indoor fan 42 for drawing indoor air into the indoor unit 4 and supplying the air back into the room as supplied air after the air has exchanged heat with the refrigerant in the indoor heat exchanger 41. The indoor fan 42 is a centrifugal fan, a multi-blade fan, or the like driven by an indoor fan motor 43.

[0055] The indoor unit 4 has an indoor-side control part 44 for controlling the actions of the components constituting the indoor unit 4. The indoor-side control part 44, which has a microcomputer, a memory, and the like for performing control on the indoor unit 4, is designed to be capable of exchanging control signals and the like with a remote controller (not shown), and also of exchanging control signals and the like with the outdoor unit 2 via a transmission line 8a.

<Outdoor unit>

[0056] The outdoor unit 2, which is installed outside of the room, constitutes part of the refrigerant circuit 10. The outdoor unit 2 has primarily a compressor 21, a switching mechanism 22, an outdoor heat exchanger 23, a first expansion mechanism 24, a refrigerant storage tank 25, a second expansion mechanism 26, a liquid-side shutoff valve 27, and a gas-side shutoff valve 28.

[0057] The compressor 21 is a device for compressing low-pressure refrigerant in the refrigeration cycle to a high pressure. The compressor 21 has a sealed structure in which a rotary, scroll, or other type of displacement compression element (not shown) is rotatably driven by a compressor motor 21a controlled by an inverter. An intake tube 31 is connected to the intake side of the compressor 21, and a discharge tube 32 is connected to the discharge side. The intake tube 31 is a refrigerant tube connecting the intake side of the compressor 21 and a first port 22a of the switching mechanism 22. An accumulator 29 is provided to the intake tube 31. The discharge tube 32 is a refrigerant tube connecting the discharge side of the compressor 21 and a second port 22b of the switching mechanism 22.

[0058] The switching mechanism 22 is a mechanism for switching the direction of refrigerant flow in the refrigerant circuit 10. During the air-cooling operation, the switching mechanism 22 performs a switch that causes the outdoor heat exchanger 23 to function as a heat ra-

diator of refrigerant compressed in the compressor 21, and causes the indoor heat exchanger 41 to function as an evaporator of refrigerant that has radiated heat in the outdoor heat exchanger 23. Specifically, during the air-cooling operation, the switching mechanism 22 performs a switch that interconnects the second port 22b and a third port 22c, and interconnects the first port 22a and a fourth port 22d. The discharge side of the compressor 21 (the discharge tube 32 herein) and the gas side of the outdoor heat exchanger 23 (a first gas refrigerant tube 33 herein) are thereby connected (refer to the solid lines of the switching mechanism 22 in FIG. 1). Moreover, the intake side of the compressor 21 (the intake tube 31 herein) and the gas refrigerant communication tube 6 side (a second gas refrigerant tube 34 herein) are connected (refer to the solid lines of the switching mechanism 22 in FIG. 1). During the air-warming operation, the switching mechanism 22 performs a switch that causes the outdoor heat exchanger 23 to function as an evaporator of refrigerant that has radiated heat in the indoor heat exchanger 41, and causes the indoor heat exchanger 41 to function as a heat radiator of refrigerant that has been compressed in the compressor 21. Specifically, during the air-warming operation, the switching mechanism 22 performs a switch that interconnects the second port 22b and the fourth port 22d, and interconnects the first port 22a and the third port 22c. The discharge side of the compressor 21 (the discharge tube 32 herein) and the gas refrigerant communication tube 6 side (the second gas refrigerant tube 34 herein) are thereby connected (refer to the dashed lines of the switching mechanism 22 in FIG. 1). Moreover, the intake side of the compressor 21 (the intake tube 31 herein) and the gas side of the outdoor heat exchanger 23 (the first gas refrigerant tube 33 herein) are connected (refer to the dashed lines of the switching mechanism 22 in FIG. 1). The first gas refrigerant tube 33 is a refrigerant tube connecting the third port 22c of the switching mechanism 22 and the gas side of the outdoor heat exchanger 23. The second gas refrigerant tube 34 is a refrigerant tube connecting the fourth port 22d of the switching mechanism 22 and the gas refrigerant communication tube 6 side. The switching mechanism 22 herein is a four-way switching valve.

[0059] The outdoor heat exchanger 23 is a heat exchanger that functions as a heat radiator of refrigerant that uses outdoor air as a cooling source during the air-cooling operation, and functions as an evaporator of refrigerant that uses outdoor air as a heating source during the air-warming operation. The liquid side of the outdoor heat exchanger 23 is connected to a liquid refrigerant tube 35, and the gas side is connected to the first gas refrigerant tube 33. The liquid refrigerant tube 35 is a refrigerant tube connecting the liquid side of the outdoor heat exchanger 23 and the liquid refrigerant communication tube 5 side.

[0060] The outdoor heat exchanger 23, which is a stacked heat exchanger not having all features of claim 1, has primarily flat tubes 231, corrugated fins 232, and

headers 233a, 233b, as shown in FIG. 3. An example of an outdoor heat exchanger having all of the features according to claim 1 is shown in Figs. 6 and 7. FIG. 3 is an external perspective view of the outdoor heat exchanger 23. The flat tubes 231, which are molded from aluminum or an aluminum alloy, have flat surface parts 231a that serve as heat transfer surfaces and a plurality of internal flow channels (not shown) through which refrigerant flows. The flat tubes 231 are arrayed in multiple levels so as to be superposed set apart by gaps (air passage spaces) with the flat surface parts 231a being made to face up and down. The corrugated fins 232 are fins made of aluminum or an aluminum alloy, bent into a corrugated formation. The corrugated fins 232 are disposed in air passage spaces enclosed between vertically adjacent flat tubes 231, and the troughs and peaks thereof are in contact with the flat surface parts 231a of the flat tubes 231. The troughs, peaks, and flat surface parts 231a are bonded by soldering or the like. The headers 233a, 233b are linked to the ends of the flat tubes 231 arrayed in multiple levels in the vertical direction. The headers 233a, 233b have the function of supporting the flat tubes 231, the function of leading refrigerant into the internal flow channels of the flat tubes 231, and the function of collecting refrigerant coming out of the internal flow channels. When the outdoor heat exchanger 23 functions as a heat radiator of refrigerant, refrigerant flowing in through a first inlet/outlet 234 of the first header 233a is distributed mostly equally to the internal flow channels of the topmost flat tube 231, and the refrigerant flows toward the second header 233b. Having reached the second header 233b, the refrigerant is distributed mostly equally to the internal flow channels of the second highest flat tube 231, and the refrigerant flows toward the first header 233a. The refrigerant in the flat tubes 231 of odd-numbered levels flows toward the second header 233b, and the refrigerant in the flat tubes 231 of even-numbered levels flows toward the first header 233a. The refrigerant in the bottommost and even-numbered level flat tubes 231 flows toward the first header 233a, collects in the first header 233a, and flows out through a second inlet/outlet 235 of the first header 233a. When the outdoor heat exchanger 23 functions as an evaporator of refrigerant, refrigerant flows in through the second inlet/outlet 235 of the first header 233a, and after flowing through the flat tubes 231 and the headers 233a, 233b in the opposite direction of when the outdoor heat exchanger functions as a heat radiator of refrigerant, the refrigerant flows out through the first inlet/outlet 234 of the first header 233a. When the outdoor heat exchanger 23 functions as a heat radiator of refrigerant, the refrigerant flowing in the flat tubes 231 radiates heat to the air flow passing through the air passage spaces via the corrugated fins 232. When the outdoor heat exchanger 23 functions as an evaporator of refrigerant, the refrigerant flowing in the flat tubes 231 absorbs heat from the air flow passing through the air passage spaces via the corrugated fins 232. Due to a stacked heat exchanger such as the one

described above being used as the outdoor heat exchanger 23, the capacity of the outdoor heat exchanger 23 is less than the capacity of the indoor heat exchanger 41. This point is described using FIG. 4, giving a package air-conditioner as an example. FIG. 4 is a graph showing the outdoor heat exchanger capacity/indoor heat exchanger capacity ratio according to capability. In FIG. 4, the symbol $\diamond$ represents a normal type (a cross-fin type outdoor heat exchanger) of a package air-conditioner, the symbol $\blacklozenge$ represents a small diameter type of outdoor heat exchanger (a stacked outdoor heat exchanger) of a package air-conditioner, the symbol $\triangle$ represents a normal type (a cross-fin type outdoor heat exchanger) of a room air-conditioner, and the symbol A represents a small diameter type of outdoor heat exchanger (a stacked outdoor heat exchanger) of a room air-conditioner. According to FIG. 4, the outdoor heat exchanger capacity/indoor heat exchanger capacity ratio is less than 1.0 when only the outdoor heat exchanger is changed to a stacked heat exchanger having a similar heat exchange performance, in contrast to when the outdoor heat exchanger and the indoor heat exchanger are both cross-fin type heat exchangers. This means that not only is the capacity of a stacked heat exchanger less than the capacity of a cross-fin type outdoor heat exchanger, but it is also less than the capacity of a cross-fin type indoor heat exchanger 41 connected thereto. Therefore, in the air-conditioning apparatus 1, excess refrigerant is produced during the air-cooling operation. In view of this, in the air-conditioning apparatus 1, the excess refrigerant is accommodated in the refrigerant storage tank 25. According to FIG. 4, the refrigerant storage tank 25 for accommodating excess refrigerant is preferably used when the outdoor heat exchanger capacity/indoor heat exchanger capacity ratio is 0.3 to 0.9, but stable refrigerant control is made possible by using the refrigerant storage tank 25 also when the outdoor heat exchanger capacity/indoor heat exchanger capacity ratio is 1.0.

[0061] During the air-cooling operation, the first expansion mechanism 24 functions as an upstream-side expansion mechanism for depressurizing the refrigerant that has radiated heat in the outdoor heat exchanger 23 to an intermediate pressure in the refrigeration cycle, and during the air-warming operation, the first expansion mechanism 24 functions as a downstream-side expansion mechanism for depressurizing the refrigerant temporarily stored in the refrigerant storage tank 25 to a low pressure in the refrigeration cycle after the refrigerant has been depressurized in the second expansion mechanism 26 as an upstream-side expansion mechanism. The first expansion mechanism 24 is provided to a portion near the outdoor heat exchanger 23 in the liquid refrigerant tube 35. An electric expansion valve is used herein as the first expansion mechanism 24.

[0062] During the air-cooling operation, the second expansion mechanism 26 functions as a downstream-side expansion mechanism for depressurizing the refrigerant temporarily stored in the refrigerant storage tank 25 to a

low pressure in the refrigeration cycle, after the refrigerant has been depressurized in the first expansion mechanism 24 as an upstream-side expansion mechanism. During the air-warming operation, the second expansion mechanism 26 functions as an upstream-side expansion mechanism for depressurizing the refrigerant that has radiated heat in the indoor heat exchanger 41 to an intermediate pressure in the refrigeration cycle. The second expansion mechanism 26 is provided to a portion of the liquid refrigerant tube 35 that is near the liquid-side shutoff valve 27. An electric expansion valve is used herein as the second expansion mechanism 26.

[0063] The refrigerant storage tank 25, which is provided between the first expansion mechanism 24 and the second expansion mechanism 26, is a container that can collect refrigerant as excess refrigerant, after the refrigerant has been depressurized by the first expansion mechanism 24 or second expansion mechanism 26 functioning as an upstream-side expansion mechanism. For example, in a case in which the liquid refrigerant quantity that can be accommodated in the indoor heat exchanger 41 is 1100 cc during the air-warming operation in which the indoor heat exchanger 41 functions as a heat radiator of refrigerant, and the liquid refrigerant quantity that can be accommodated in the outdoor heat exchanger 23 is 800 cc during the air-cooling operation in which the outdoor heat exchanger 23 functions as a heat radiator of refrigerant, 300 cc of leftover liquid refrigerant that could not be accommodated in the outdoor heat exchanger 23 during the air-cooling operation is temporarily accommodated in the refrigerant storage tank 25. The refrigerant just before entering the refrigerant storage tank 25, for example, also includes a gas component produced when the refrigerant is depressurized in the first expansion mechanism 24 or second expansion mechanism 26 functioning as an upstream-side expansion mechanism. Therefore, the refrigerant is separated into a liquid component and a gas component after entering the refrigerant storage tank 25, the liquid refrigerant is stored in the downstream side, and the gas component is stored in the upstream side. The gas refrigerant separated in the refrigerant storage tank 25 passes through a bypass tube 30 and flows to the intake tube 31 of the compressor 21. The liquid refrigerant separated in the refrigerant storage tank 25 flows to the outdoor heat exchanger 23 after being depressurized in the second expansion mechanism 26 or first expansion mechanism 24 functioning as an upstream-side expansion mechanism. The bypass tube 30 is provided so as to connect the top part of the refrigerant storage tank 25 and the middle portion of the intake tube 31. A flow rate adjustment mechanism 30a is provided in the middle of the bypass tube 30. An electric expansion valve is used herein as the flow rate adjustment mechanism 30a. The outlet of the bypass tube 30 may also be connected directly to the compressor 21, rather than being connected to the middle portion of the intake tube 31.

[0064] The liquid-side shutoff valve 27 and the gas-

side shutoff valve 28 are valves provided to ports connecting with external devices and tubing (specifically, the liquid refrigerant communication tube 5 and the gas refrigerant communication tube 6). The second expansion mechanism 26 is provided to an end of the liquid refrigerant tube 35. The liquid-side shutoff valve 27 is provided to an end of the second gas refrigerant tube 34.

[0065] The outdoor unit 2 has an outdoor fan 36 for drawing outdoor air into the outdoor unit 2 and expelling the air to the exterior after the air has undergone heat exchange with the refrigerant in the outdoor heat exchanger 23. The outdoor fan 36 herein is a propeller fan or the like driven by an outdoor fan motor 37.

[0066] The outdoor unit 2 has an outdoor-side control part 38 for controlling the actions of the components constituting the outdoor unit 2. The outdoor-side control part 38, which has a microcomputer, a memory, and the like for performing control on the outdoor unit 2, is designed to be capable of exchanging control signals and the like with an indoor-side control part 44 of the indoor unit 4 via the transmission line 8a. Specifically, a control part 8 for performing the operation controls for the entire air-conditioning apparatus 1 is configured by the indoor-side control part 44, the outdoor-side control part 38, and the transmission line 8a which connects the control parts 38, 44.

[0067] The control part 8 is designed to be capable of controlling the actions of the various devices and valves 21a, 22, 24, 26, 30a, 37, 43, etc., on the basis of various operation settings, the values detected by various sensors, and the like.

<Refrigerant communication tubes>

[0068] The refrigerant communication tubes 5, 6, which are refrigerant tubes machined onsite when the air-conditioning apparatus 1 is installed in an installation location such as a building, have various lengths and/or tube diameters according to the installation location and/or installation conditions such as the combination of the outdoor unit and the indoor unit.

[0069] As described above, the refrigerant circuit 10 of the air-conditioning apparatus 1 is configured from the connection between the outdoor unit 2, the indoor unit 4, and the refrigerant communication tubes 5, 6. During the air-cooling operation as a cooling operation, the refrigerant circuit 10 is designed to perform a refrigeration cycle in which refrigerant flows sequentially through the compressor 21, the outdoor heat exchanger 23, the first expansion mechanism 24 as an upstream-side expansion mechanism, the refrigerant storage tank 25, the second expansion mechanism 26 as a downstream-side expansion mechanism, and the indoor heat exchanger 41. During the air-warming operation as a heating operation, the refrigerant circuit 10 is designed to perform a refrigeration cycle in which refrigerant flows sequentially through the compressor 21, the indoor heat exchanger 41, the second expansion mechanism 26 as an upstream-side ex-

pansion mechanism, the refrigerant storage tank 25, the first expansion mechanism 24 as a downstream-side expansion mechanism, and the outdoor heat exchanger 23. The air-conditioning apparatus 1 is designed to be capable of performing various operations such as the air-cooling operation and the air-warming operation, by means of the control part 8 configured from the indoor-side control part 44 and the outdoor-side control part 38.

(2) Actions of air conditioning apparatus

[0070] The air-conditioning apparatus 1 can perform an air-cooling operation and an air-warming operation as described above. The actions of the air-conditioning apparatus 1 during the air-cooling operation and the air-warming operation are described below.

<Air-warming operation>

[0071] During the air-warming operation, a switch is performed in which the switching mechanism 22 is in the state shown by the dashed lines in FIG. 1, i.e., the second port 22b and the fourth port 22d are communicated, and the first port 22a and the third port 22c are communicated.

[0072] In this refrigerant circuit 10, low-pressure refrigerant in the refrigeration cycle is drawn into the compressor 21 and discharged after being compressed to a high pressure.

[0073] The high-pressure refrigerant discharged from the compressor 21 is sent through the switching mechanism 22, the gas-side shutoff valve 28, and the gas refrigerant communication tube 6 to the indoor heat exchanger 41.

[0074] The high-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with indoor air and radiates heat in the indoor heat exchanger 41. The indoor air is thereby heated. Because the capacity of the indoor heat exchanger 41 is greater than the capacity of the outdoor heat exchanger 23, most of the liquid refrigerant is accommodated in the indoor heat exchanger 41 during the air-warming operation.

[0075] The high-pressure refrigerant that has radiated heat in the indoor heat exchanger 41 is sent through the liquid refrigerant communication tube 5 and the liquid-side shutoff valve 27 to the second expansion mechanism 26 functioning as an upstream-side expansion mechanism.

[0076] The refrigerant sent to the second expansion mechanism 26 is depressurized to an intermediate pressure by the second expansion mechanism 26, and is then sent to the refrigerant storage tank 25. The refrigerant just before entering the refrigerant storage tank 25 includes a gas component produced when the refrigerant is depressurized in the second expansion mechanism 26, but after entering the refrigerant storage tank 25, the refrigerant is divided into a liquid component and a gas component, the liquid refrigerant is stored in the lower side, and the gas refrigerant is stored in the upper side.

At this time, because the flow rate adjustment mechanism 30a of the bypass tube 30 is controlled to an open state, the gas refrigerant in the refrigerant storage tank 25 passes through the bypass tube 30 and heads to the intake tube 31 of the compressor 21. The liquid refrigerant in the refrigerant storage tank 25 is sent to the outdoor heat exchanger 23 after being depressurized to a low pressure by the first expansion mechanism 24 functioning as a downstream-side expansion mechanism.

[0077] The low-pressure refrigerant sent to the outdoor heat exchanger 23 undergoes heat exchange with outdoor air supplied by the outdoor fan 36 and evaporates in the outdoor heat exchanger 23. At this time, the refrigerant flowing into the outdoor heat exchanger 23 is reduced by the gas-liquid separating process in the refrigerant storage tank 25, as well as the process of drawing the gas-liquid separated gas refrigerant through the bypass tube 30 into the compressor 21. Therefore, the flow rate of refrigerant flowing through the outdoor heat exchanger 23 decreases, pressure loss can be reduced proportionately, and the depressurization loss in the refrigeration cycle can therefore be reduced.

[0078] The low-pressure refrigerant evaporated in the outdoor heat exchanger 23 is drawn through the switching mechanism 22 back into the compressor 21.

<Air-cooling operation>

[0079] During the air-cooling operation, a switch is performed in which the switching mechanism 22 is in the state shown by the solid lines in FIG. 1, i.e., the second port 22b and the third port 22c are communicated, and the first port 22a and the fourth port 22d are communicated.

[0080] In this refrigerant circuit 10, low-pressure refrigerant in the refrigeration cycle is drawn into the compressor 21 and discharged after being compressed to a high pressure.

[0081] The high-pressure refrigerant discharged from the compressor 21 is sent through the switching mechanism 22 to the outdoor heat exchanger 23.

[0082] The high-pressure refrigerant sent to the outdoor heat exchanger 23 undergoes heat exchange with outdoor air and radiates heat in the outdoor heat exchanger 23.

[0083] The high-pressure refrigerant that has radiated heat in the outdoor heat exchanger 23 is sent to the first expansion mechanism 24 functioning as an upstream-side expansion mechanism, depressurized to an intermediate pressure by the first expansion mechanism 24, and then sent to the refrigerant storage tank 25. Because the capacity of the outdoor heat exchanger 23 is equal to or less than the capacity of the indoor heat exchanger 41 here, the outdoor heat exchanger 23 is not able to accommodate all of the liquid refrigerant during the air-cooling operation. Therefore, the liquid refrigerant that could not be accommodated in the outdoor heat exchanger 23 is accumulated in the refrigerant storage tank

25, and the refrigerant storage tank 25 is filled with liquid refrigerant. The refrigerant just before entering the refrigerant storage tank 25 includes a gas component produced when the refrigerant is depressurized in the first expansion mechanism 24, but after entering the refrigerant storage tank 25, the refrigerant is divided into a liquid component and a gas component, the liquid refrigerant is stored in the lower side, and the gas refrigerant is stored in the upper side. At this time, because the flow rate adjustment mechanism 30a of the bypass tube 30 is controlled to an open state, the gas refrigerant in the refrigerant storage tank 25 passes through the bypass tube 30 and heads to the intake tube 31 of the compressor 21. The liquid refrigerant in the refrigerant storage tank 25 is sent through the liquid-side shutoff valve 27 and the liquid refrigerant communication tube 5 to the indoor heat exchanger 41 after being depressurized to a low pressure by the second expansion mechanism 26 functioning as a downstream-side expansion mechanism.

[0084] The low-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with indoor air and evaporates in the indoor heat exchanger 41. The indoor air is thereby cooled. At this time, the refrigerant flowing into the indoor heat exchanger 41 is reduced by the gas-liquid separating process in the refrigerant storage tank 25, as well as the process of drawing the gas-liquid separated gas refrigerant through the bypass tube 30 into the compressor 21. Therefore, the flow rate of refrigerant flowing through the indoor heat exchanger 41 decreases, pressure loss can be reduced proportionately, and the depressurization loss in the refrigeration cycle can therefore be reduced.

[0085] The low-pressure refrigerant evaporated in the indoor heat exchanger 41 is drawn through the gas refrigerant communication tube 6, the gas-side shutoff valve 28, and the switching mechanism 22 back into the compressor 21.

(3) Characteristics of air-conditioning apparatus

[0086] The air-conditioning apparatus 1 of the present embodiment has the following characteristics.

<A>

[0087] In the air-conditioning apparatus 1, as described above, the indoor heat exchanger 41 is a cross-fin type heat exchanger, the outdoor heat exchanger 23 is a stacked heat exchanger, and the capacity of the outdoor heat exchanger 23 is, not according to the invention, 100% or, according to the invention, less of the capacity of the indoor heat exchanger 41.

[0088] Therefore, in the air-conditioning apparatus 1, excess refrigerant is produced during the air-cooling operation as a cooling operation. When too much of this excess refrigerant spreads from the indoor heat exchanger 41 having a gas-phase portion to portions as far as the intake side of the compressor 21, there is a risk that

refrigerant control will be hindered.

[0089] In view of this, in the air-conditioning apparatus 1, the refrigerant storage tank 25 for storing refrigerant depressurized by an upstream-side expansion mechanism is provided between one of the first expansion mechanism 24 and the second expansion mechanism 26 as an upstream-side expansion mechanism, and the other of the first expansion mechanism 24 and the second expansion mechanism 26 as a downstream-side expansion mechanism, as described above. In the air-conditioning apparatus 1, the excess refrigerant that can no longer be accommodated in the outdoor heat exchanger 23 during the air-cooling operation is then accommodated in the refrigerant storage tank 25 positioned in the vicinity of the downstream side of the outdoor heat exchanger 23.

[0090] It is thereby possible to prevent hindrances to refrigerant control in the air-conditioning apparatus 1 because it is possible to prevent too much refrigerant from spreading from the indoor heat exchanger 41 having a gas-phase portion to portions as far as the intake side of the compressor 21.

[0091] In the air-conditioning apparatus 1, a bypass tube 30 is provided as described above. The bypass tube 30 is designed to lead the gas component of the refrigerant accumulated in the refrigerant storage tank 25 to either the compressor 21 or the intake tube 31 of the compressor 21.

[0092] In the air-conditioning apparatus 1, refrigerant depressurized in one of the first expansion mechanism 24 and the second expansion mechanism 26 as an upstream-side expansion mechanism is separated into a liquid component and a gas component in the refrigerant storage tank 25, and the gas component heads toward the bypass tube 30.

[0093] The gas component, which does not contribute to evaporation, thereby ceases to flow into the outdoor heat exchanger 23 functioning as an evaporator of refrigerant during the air-warming operation in the air-conditioning apparatus 1, it is therefore possible to proportionately reduce the flow rate of refrigerant flowing through the outdoor heat exchanger 23 functioning as an evaporator of refrigerant, and the depressurization loss in the refrigeration cycle can be reduced.

<C>

[0094] When the operating frequency of the compressor 21 is high, there is a risk that gas-liquid two-phase refrigerant from the refrigerant storage tank 25 will pass through the bypass tube 30, return to the compressor 21 or the intake tube 31 of the compressor 21, and be drawn into the compressor 21.

[0095] However, in the air-conditioning apparatus 1, because the flow rate adjustment mechanism 30a is pro-

vided to the bypass tube 30, the liquid component of the gas-liquid two-phase refrigerant is depressurized and evaporated.

[0096] It is thereby possible in the air-conditioning apparatus 1 to prevent the liquid component from returning to the compressor 21 or the intake tube 31 of the compressor 21.

<D>

[0097] During the air-warming operation in the air-conditioning apparatus 1, refrigerant that has passed through the flow rate adjustment mechanism 30a converges with refrigerant which has evaporated in the indoor heat exchanger 41 and/or the outdoor heat exchanger 23, and then heads to the compressor 21 or the intake tube 31 of the compressor 21. At this time, in the case that the flow rate adjustment mechanism 30a is an electric expansion valve, the state of the refrigerant just before being drawn into the compressor 21 can be adjusted more optimally by controlling the valve opening degree. Moreover, because the flow rate of refrigerant returning to the compressor 21 can be increased or reduced by controlling the valve opening degree of the flow rate adjustment mechanism 30a, the refrigerant circulation flow rate, i.e. the flow rate of refrigerant flowing through the indoor heat exchanger 41 can be controlled according to the refrigeration load on the indoor heat exchanger 41 side.

(4) Modification 1

[0098] In the above embodiment, a container for storing refrigerant is employed as the refrigerant storage tank 25, but refrigerant storage is not limited as such, and a cyclone-type gas-liquid separator such as the one shown in FIG. 5 may be employed, for example.

[0099] The refrigerant storage tank 25 of the present modification has primarily a cylindrical container 251, a first connecting tube 252, a second connecting tube 253, and a third connecting tube 254.

[0100] The first connecting tube 252 is linked in the tangential direction of the circumferential side wall of the cylindrical container 251, communicating the interior of the cylindrical container 251 and the second expansion mechanism 26 or first expansion mechanism 24 as a downstream-side expansion mechanism. The second connecting tube 253 is linked to the bottom wall of the cylindrical container 251, communicating the interior of the cylindrical container 251 and the first expansion mechanism 24 or second expansion mechanism 26 as an upstream-side expansion mechanism. The third connecting tube 254 is linked to the top wall of the cylindrical container 251, communicating the interior of the cylindrical container 251 and the bypass tube 30.

[0101] Due to this configuration, intermediate-pressure refrigerant flowing into the cylindrical container 251 through the first connecting tube 252 flows so as to eddy along the internal peripheral surface 251a of the circum-

ferential side wall of the cylindrical container 251, at which time the liquid refrigerant adheres to the internal peripheral surface 251a, and the liquid refrigerant and gas refrigerant are efficiently separated.

[0102] The liquid refrigerant falls due to gravity, accumulates in the lower side, and flows out of the cylindrical container 251 through the second connecting tube 253. The gas refrigerant rises while swirling, accumulates in the upper side, and flows out of the cylindrical container 251 through the third connecting tube 254.

[0103] In the present modification, gas-liquid separation can be efficiently performed because a cyclone-type gas-liquid separator is employed as the refrigerant storage tank 25 as described above. The refrigerant storage tank 25 composed of a gas-liquid separator has both a refrigerant storage function of accumulating liquid refrigerant and a function of separating the liquid component and gas component, thereby contributing to simplifying the apparatus configuration because there is no need to provide both a refrigerant storage container and a gas-liquid separator.

(5) Modification 2

[0104] In the above embodiment and Modification 1, an example not having all features of claim 1 was given in which the outdoor heat exchanger 23 is a stacked heat exchanger having a plurality of flat tubes 231 and corrugated fins 232. In this outdoor heat exchanger 23, the plurality of flat tubes 231 are arrayed so as to be superposed set apart by gaps, and the corrugated fins 232 are enclosed between adjacent flat tubes 231.

[0105] The outdoor heat exchanger 23 according to the present invention is a stacked heat exchanger having a plurality of flat tubes 231 arrayed so as to be superposed set apart by gaps, and fins 236 in which notches 236a are formed, the flat tubes 231 being inserted into the notches, as shown in FIGS. 6 and 7, for example.

[0106] The same operational effects as those of the above embodiment and Modification 1 can be achieved in this case as well.

(6) Modification 3

[0107] In the above embodiment and Modification 1, an example not having all features of claim 1 was given in which the outdoor heat exchanger 23 is a stacked heat exchanger having a plurality of flat tubes 231 and corrugated fins 232. In this outdoor heat exchanger 23, the plurality of flat tubes 231 are arrayed so as to be superposed set apart by gaps, and the corrugated fins 232 are enclosed between adjacent flat tubes 231.

[0108] Alternatively, an outdoor heat exchanger 23 according to the present disclosure may have a configuration in which the flat tubes are molded into serpentine shapes and the fins are enclosed between the mutually adjacent surfaces of the flat tubes, for example.

[0109] The same operational effects as those of the

above embodiment and Modifications 1 and 2 can be achieved in this case as well.

(7) Modification 4

[0110] In the above embodiment and Modifications 1 to 3, the outdoor heat exchanger 23 is a stacked heat exchanger having a plurality of flat tubes 231, corrugated fins 232, and fins 236 in which notches 236a are formed. In the case of a refrigeration apparatus which is presently not claimed and in which the outdoor heat exchanger 23 is cooled by water during the air-cooling operation, for example, the outdoor heat exchanger 23 and the indoor heat exchanger 41 may both be cross-fin type heat exchangers, configured such that the diameter of the heat transfer tubes in the outdoor heat exchanger 23 is less than the diameter of the heat transfer tubes in the indoor heat exchanger 41.

[0111] The same operational effects as those of the above embodiment and Modifications 1 to 3 can be achieved in this case as well.

(8) Modification 5

[0112] In the above embodiment and Modifications 1 to 4, as the refrigerant sealed within the refrigerant circuit 10, R32, a type of HFC-based refrigerant is used.

[0113] However, when R32 is used as the refrigerant in the refrigeration apparatus, refrigerator oil sealed with the refrigerant in order to lubricate the compressor 21 tends to have extremely low solubility in low-temperature conditions. Therefore, at a low pressure in the refrigeration cycle, the solubility of the refrigerator oil greatly decreases due to the decrease in refrigerant temperature. During the air-cooling operation in the refrigerant circuit 10, there is low pressure in the refrigeration cycle in the circuit portion beginning after passing through the second expansion mechanism 26 functioning as a downstream-side expansion mechanism and leading through the indoor heat exchanger 41 up to intake in the compressor 21. During the air-warming operation, there is low pressure in the refrigeration cycle in the circuit portion beginning after passing through the first expansion mechanism 24 functioning as a downstream-side expansion mechanism and leading through the outdoor heat exchanger 23 up to intake in the compressor 21. The refrigerator oil when R32 is used as the refrigerant could be ether-based synthetic oil having any compatibility with R32, mineral oil or alkyl benzene-based synthetic oil having no compatibility with R32, or the like. With ether-based synthetic oil, compatibility is lost when the temperature decreases to about -5°C, and with mineral oil or alkyl benzene-based synthetic oil, there is no compatibility at conditions of higher temperature than ether-based synthetic oil. When R32 is used as the refrigerant in a conventional refrigeration apparatus having a refrigerant storage tank on the intake side of the compressor, for example, the refrigerant and the refrigerator oil separate into two layers in the

refrigerant storage tank which has a low pressure in the refrigeration cycle, and the refrigerator oil has difficulty returning to the compressor.

[0114] However, in the refrigeration apparatus 1 of the present modification, because a refrigerant storage tank 25 is provided between the first and second expansion mechanisms 24, 26 as an upstream-side expansion mechanism and a downstream-side expansion mechanism as indicated in the above embodiment and Modifications 1 to 4, two-layer separation is less likely to occur in the intake side of the compressor 21 and refrigerator oil returns more readily to the compressor 21, in comparison to cases in which the refrigerant storage tank is provided to the intake side of the compressor 21.

[0115] Thus, in the refrigeration apparatus 1 of the present modification, due to the refrigerant storage tank 25 being provided between the first and second expansion mechanisms 24, 26 as an upstream-side expansion mechanism and a downstream-side expansion mechanism, it is possible to resolve not only the problem of excess refrigerant produced by the capacity of the outdoor heat exchanger 23 being equal to or less than the capacity of the indoor heat exchanger 41, due to factors such as a stacked heat exchanger being used as the outdoor heat exchanger 23, but also the problem of oil returning to the compressor 21, caused by using R32 as the refrigerant.

INDUSTRIAL APPLICABILITY

[0116] The present invention is widely applicable in refrigeration apparatuses that can perform a cooling operation and a heating operation.

REFERENCE SIGNS LIST

[0117]

1	Air-conditioning apparatus (refrigeration apparatus)
21	Compressor
23	Outdoor heat exchanger
24, 26	Expansion mechanisms
25	Refrigerant storage tank
30	Bypass tube
30a	Flow rate adjustment mechanism
41	Indoor heat exchanger

Claims

1. A refrigeration apparatus (1) in which a refrigerant flows sequentially through a compressor (21), an outdoor heat exchanger (23), expansion mechanisms (24, 26), and an indoor heat exchanger (41) during a cooling operation, and the refrigerant flows sequentially through the compressor, the indoor heat exchanger (41), the expansion mechanisms (24,

26), and the outdoor heat exchanger (23) during a heating operation; wherein

a capacity of the outdoor heat exchanger (23), which is the liquid refrigerant quantity that can be accommodated in the outdoor heat exchanger (41), which is the liquid refrigerant quantity that can be accommodated in the indoor heat exchanger;

the expansion mechanisms (24, 26) include an upstream-side expansion mechanism (24) for depressurizing the refrigerant that has radiated heat in the outdoor heat exchanger (23) to an intermediate pressure in the refrigeration cycle, and a downstream-side expansion mechanism (26) for depressurizing the refrigerant that has been depressurized in the upstream-side expansion mechanism (24) and temporarily stored in a refrigerant storage tank (25) to a low pressure in the refrigeration cycle; and

wherein the refrigerant storage tank (25) is provided between the upstream-side expansion mechanism (24) and the downstream-side expansion mechanism (26);

wherein the refrigeration apparatus further comprising a control part (8) for performing an operation control,

wherein the refrigeration apparatus (1) is configured to control the cooling operation by means of the control part (8), wherein the refrigerant depressurized by the upstream-side expansion mechanism (24) to the intermediate pressure in the refrigerant cycle is stored in the refrigerant storage tank (25) and an excess refrigerant produced during the cooling operation due to the capacity of the outdoor heat exchanger (23) being less than the capacity of the indoor heat exchanger (41) is accommodated in the refrigerant storage tank (25),

the refrigeration apparatus further comprising an outdoor unit (2), an indoor unit (4) and liquid refrigerant communication tube (5), wherein the outdoor heat exchanger (23), upstream-side expansion mechanism (24) and the downstream-side expansion mechanism (26) are provided in the outdoor unit (2), and the indoor heat exchanger (41) is provided in the indoor unit (4), and the indoor unit (4) and the outdoor unit (2) are connected via the liquid refrigerant communication tube (5);

wherein the refrigerant is R32,

the outdoor heat exchanger (23) is a stacked heat exchanger having a plurality of flat tubes arrayed so as to be superposed set apart by gaps, and fins having notches formed therein where the flat tubes are inserted, and wherein the refrigeration apparatus comprises

a switching mechanism (22) for switching the direction of refrigerant flow in the refrigeration apparatus.

2. The refrigeration apparatus (1) of claim 1, wherein the indoor heat exchanger (41) is a cross-fin type heat exchanger.
3. The refrigeration apparatus (1) according to any of claims 1 and 2, further provided with: a bypass tube (30) for leading a gas component of the refrigerant accumulated in the refrigerant storage tank (25) to the compressor (21) or to a refrigerant tube on an intake side of the compressor.
4. The refrigeration apparatus (1) according to claim 3, wherein the bypass tube (30) has a flow rate adjustment mechanism (30a).
5. The refrigeration apparatus (1) according to any of claims 1 through 4, wherein the refrigerant storage tank (25) is a gas-liquid separator.

Patentansprüche

1. Kühleinrichtung (1), bei der ein Kältemittel während eines Kühlvorgangs nacheinander durch einen Kompressor (21), einen Außenwärmetauscher (23), Expansionsmechanismen (24, 26) und einen Innenraumwärmetauscher (41) strömt und das Kältemittel während eines Heizvorgangs nacheinander durch den Kompressor, den Innenraumwärmetauscher (41), die Expansionsmechanismen (24, 26) und den Außenwärmetauscher (23) strömt; wobei eine Kapazität des Außenwärmetauschers (23), die die Menge an flüssigem Kältemittel ist, die in dem Außenwärmetauscher untergebracht werden kann, geringer ist als eine Kapazität des Innenraumwärmetauschers (41), die die Menge an flüssigem Kältemittel ist, die in dem Innenraumwärmetauscher untergebracht werden kann; die Expansionsmechanismen (24, 26) einen stromaufwärtsseitigen Expansionsmechanismus (24) zum Herabsetzen des Drucks des Kältemittels, das Wärme in dem Außenwärmetauscher (23) abgestrahlt hat, auf einen Zwischendruck in dem Kältekreislauf und einen stromabwärtsseitigen Expansionsmechanismus (26) zum Herabsetzen des Drucks des Kältemittels, dessen Druck in dem stromaufwärtsseitigen Expansionsmechanismus (24) herabgesetzt wurde und das vorübergehend in einem Kältemittelspeichertank (25) gespeichert wurde, auf einen niedrigen Druck in dem Kältekreislauf einschließen; und wobei der Kältemittelspeichertank (25) zwischen

dem stromaufwärtsseitigen Expansionsmechanismus (24) und dem stromabwärtsseitigen Expansionsmechanismus (26) bereitgestellt ist;

wobei die Kühleinrichtung weiter einen Steuerteil (8) zur Durchführung einer Betriebssteuerung umfasst, wobei die Kühleinrichtung (1) so konfiguriert ist, dass sie den Kühlbetrieb mit Hilfe des Steuerteils (8) steuert, wobei

das Kältemittel, dessen Druck durch den stromaufwärtsseitigen Expansionsmechanismus (24) auf den Zwischendruck in dem Kältemittelkreislauf herabgesetzt wurde, in dem Kältemittelspeichertank (25) gespeichert wird und ein während des Kühlvorgangs aufgrund der Kapazität des Außenwärmetauschers (23), die geringer als die Kapazität des Innenraumwärmetauschers (41) ist, erzeugtes überschüssiges Kältemittel in dem Kältemittelspeichertank (25) untergebracht wird,

die Kühleinrichtung weiter eine Außeneinheit (2), eine Innenraumeinheit (4) und ein Flüssigkältemittel-Verbindungsrohr (5) umfasst, wobei der Außenwärmetauscher (23), der stromaufwärtsseitige Expansionsmechanismus (24) und der stromabwärtsseitige Expansionsmechanismus (26) in der Außeneinheit (2) bereitgestellt sind, und der Innenraumwärmetauscher (41) in der Innenraumeinheit (4) bereitgestellt ist, und die Innenraumeinheit (4) und die Außeneinheit (2) über das Flüssigkältemittel-Verbindungsrohr (5) verbunden sind;

wobei das Kältemittel R32 ist,

der Außenwärmetauscher (23) ein Plattenwärmetauscher ist, der eine Vielzahl von flachen Rohren, die so angeordnet sind, dass sie übereinander liegen und durch Zwischenräume voneinander getrennt sind, und Rippen aufweist, in welchen Kerben ausgebildet sind, in die die flachen Rohre eingesetzt sind, und

wobei die Kühleinrichtung einen Schaltungsmechanismus (22) zum Umschalten der Richtung des Kühlmittelflusses in der Kühleinrichtung umfasst.

2. Kühleinrichtung (1) nach Anspruch 1, wobei der Innenraumwärmetauscher (41) ein Kreuzrippen-Wärmetauscher ist.
3. Kühleinrichtung (1) nach einem der Ansprüche 1 und 2, weiter bereitgestellt mit:
einem Bypassrohr (30) zum Leiten einer Gaskomponente des in dem Kältemittelspeichertank (25) angesammelten Kältemittels zu dem Kompressor (21) oder zu einem Kältemittelrohr an einer Ansaugseite des Kompressors.
4. Kühleinrichtung (1) nach Anspruch 3, wobei das Bypassrohr (30) einen Mechanismus (30a) zur Einstellung der Durchflussrate aufweist.
5. Kühleinrichtung (1) nach einem der Ansprüche 1 bis

4, wobei der Kältemittelspeichertank (25) ein Gas-Flüssigkeits-Abscheider ist.

5 Revendications

1. Appareil de réfrigération (1) dans lequel un réfrigérant circule de manière séquentielle à travers un compresseur (21), un échangeur de chaleur extérieur (23), des mécanismes de détente (24, 26) et un échangeur de chaleur intérieur (41) pendant une opération de refroidissement, et le réfrigérant circule de manière séquentielle à travers le compresseur, l'échangeur de chaleur intérieur (41), les mécanismes de détente (24, 26) et l'échangeur de chaleur extérieur (23) pendant une opération de chauffage ; dans lequel
une capacité de l'échangeur de chaleur extérieur (23), qui est la quantité de réfrigérant liquide qui peut être reçue dans l'échangeur de chaleur extérieur, est inférieure à une capacité de l'échangeur de chaleur intérieur (41), qui est la quantité de réfrigérant liquide qui peut être reçue dans l'échangeur de chaleur intérieur ;
les mécanisme de détente (24, 26) incluent un mécanisme de détente côté amont (24) pour détendre le réfrigérant qui a émis de la chaleur dans l'échangeur de chaleur extérieur (23) à une pression intermédiaire dans le cycle de réfrigération, et un mécanisme de détente côté aval (26) pour détendre le réfrigérant qui a été détendu dans le mécanisme de détente côté amont (24) et stocké temporairement dans un réservoir de stockage de réfrigérant (25) à une faible pression dans le cycle de réfrigération ; et dans lequel le réservoir de stockage de réfrigérant (25) est disposé entre le mécanisme de détente côté amont (24) et le mécanisme de détente côté aval (26) ;
dans lequel l'appareil de réfrigération comprend en outre une partie de commande (8) pour effectuer une commande d'opération,
dans lequel l'appareil de réfrigération (1) est configuré pour commander l'opération de refroidissement au moyen de la partie de commande (8), dans lequel le réfrigérant détendu par le mécanisme de détente côté amont (24) à la pression intermédiaire dans le cycle de réfrigération est stocké dans le réservoir de stockage de réfrigérant (25) et un réfrigérant en excès produit pendant l'opération de refroidissement en raison de la capacité de l'échangeur de chaleur extérieur (23) qui est inférieure à la capacité de l'échangeur de chaleur intérieur (41) est contenu dans le réservoir de stockage de réfrigérant (25),
l'appareil de réfrigération comprenant en outre une unité extérieure (2), une unité intérieure (4) et un tube de communication de réfrigérant liquide (5), dans lequel l'échangeur de chaleur extérieur (23), le mécanisme de détente côté amont (24) et le méca-

nisme de détente côté aval (26) sont disposés dans l'unité extérieure (4), et l'unité intérieure (2) et l'unité extérieure (4) sont reliées par le biais du tube de communication de réfrigérant liquide (5) ;

dans lequel le réfrigérant est le R32,

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l'échangeur de chaleur extérieur (23) est un échangeur de chaleur empilé ayant une pluralité de tubes plats disposés en réseau de sorte à être superposés en étant séparés par des espaces, et des ailettes ayant des encoches formées à l'intérieur de celles-ci dans lesquelles les tubes plats sont insérés, et dans lequel l'appareil de réfrigération comprend un mécanisme de commutation (22) pour commuter la direction d'écoulement de réfrigérant dans l'appareil de réfrigération.

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2. Appareil de réfrigération (1) selon la revendication 1, dans lequel

l'échangeur de chaleur intérieur (41) est un échangeur de chaleur de type à ailettes transversales.

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3. Appareil de réfrigération (1) selon l'une quelconque des revendications 1 et 2, pourvu en outre :

d'un tube de dérivation (30) pour conduire un composant gazeux du réfrigérant accumulé dans le réservoir de stockage de réfrigérant (25) jusqu'au compresseur (21) ou jusqu'à un tube de réfrigérant sur un côté admission du compresseur.

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4. Appareil de réfrigération (1) selon la revendication 3, dans lequel

le tube de dérivation (30) comporte un mécanisme de réglage de débit d'écoulement.

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5. Appareil de réfrigération (1) selon l'une quelconque des revendications 1 à 4, dans lequel

le réservoir de stockage de réfrigérant (25) est un séparateur gaz-liquide.

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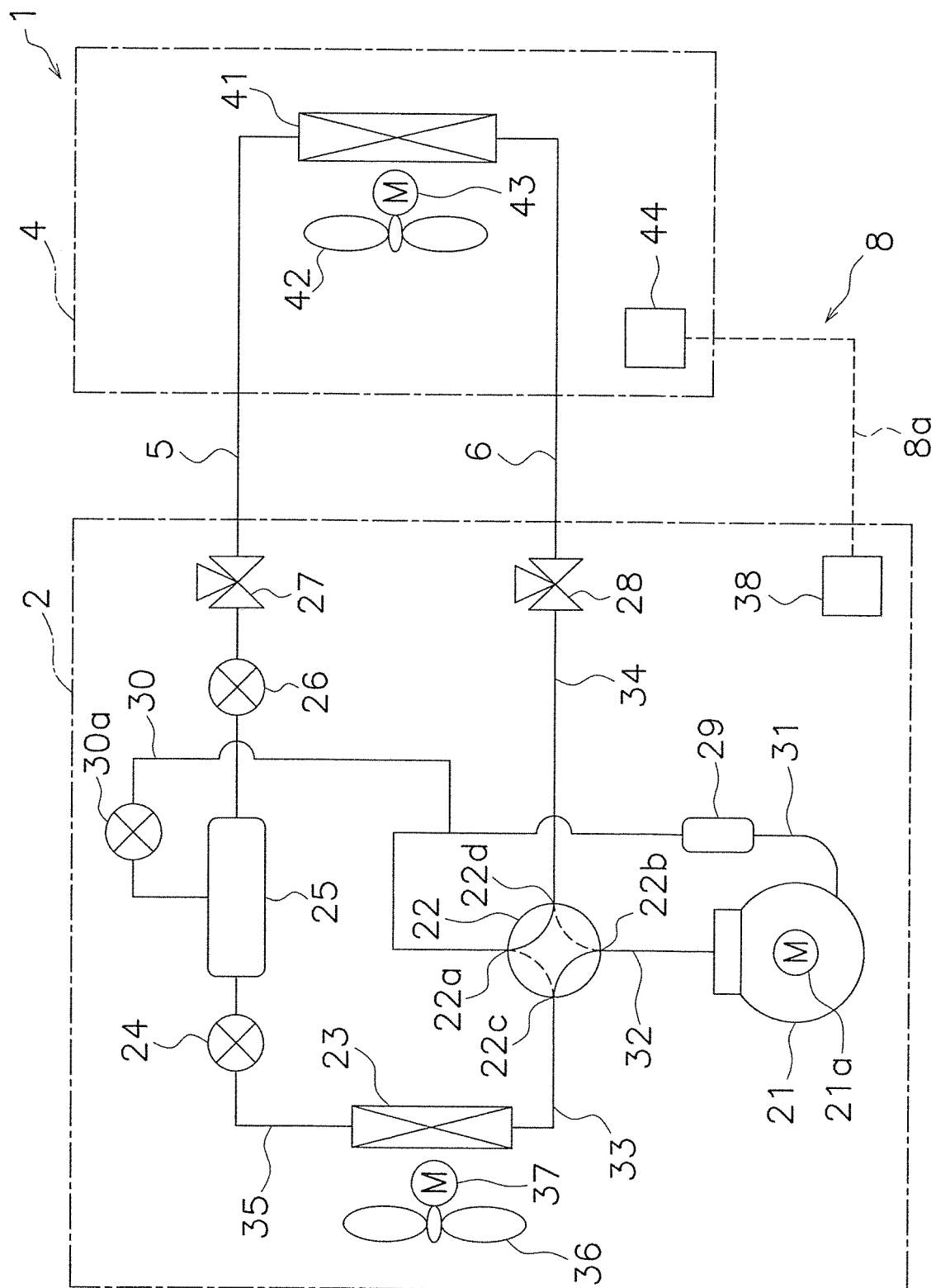


FIG. 1

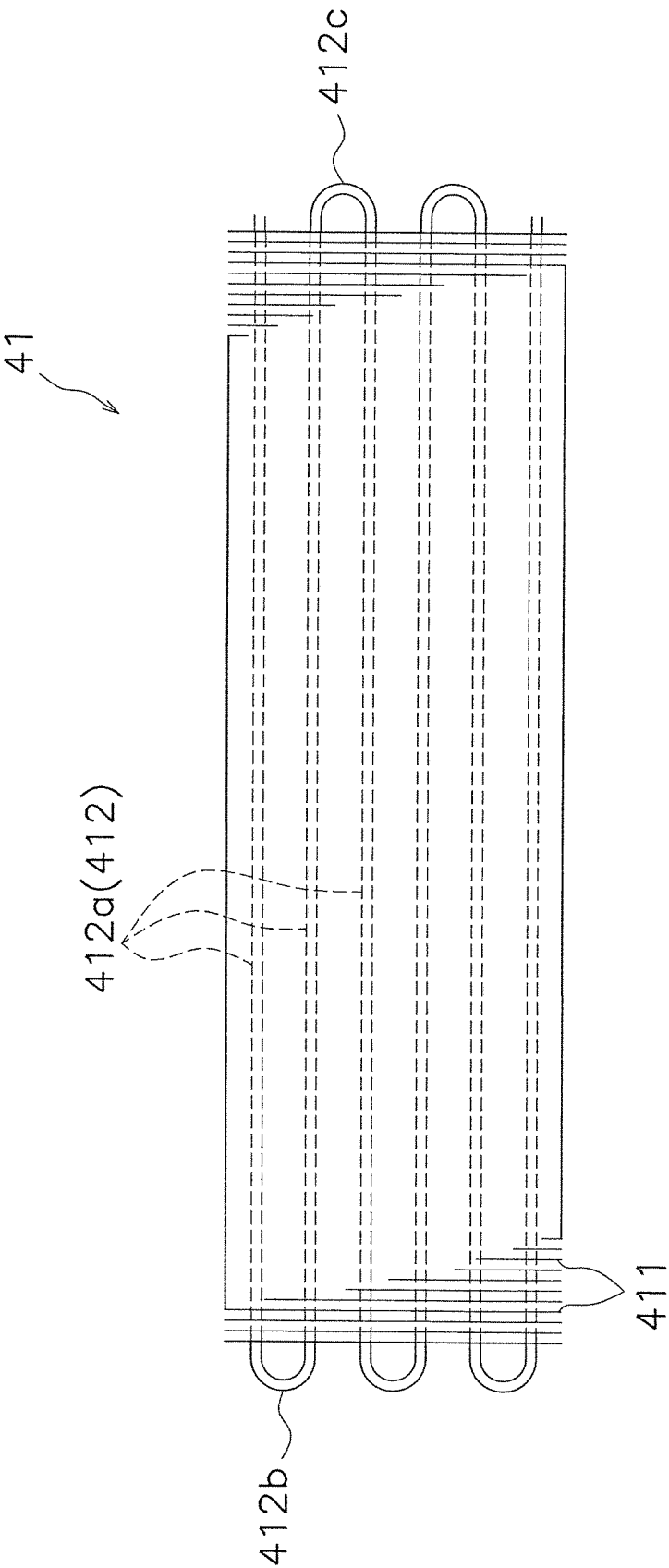


FIG. 2

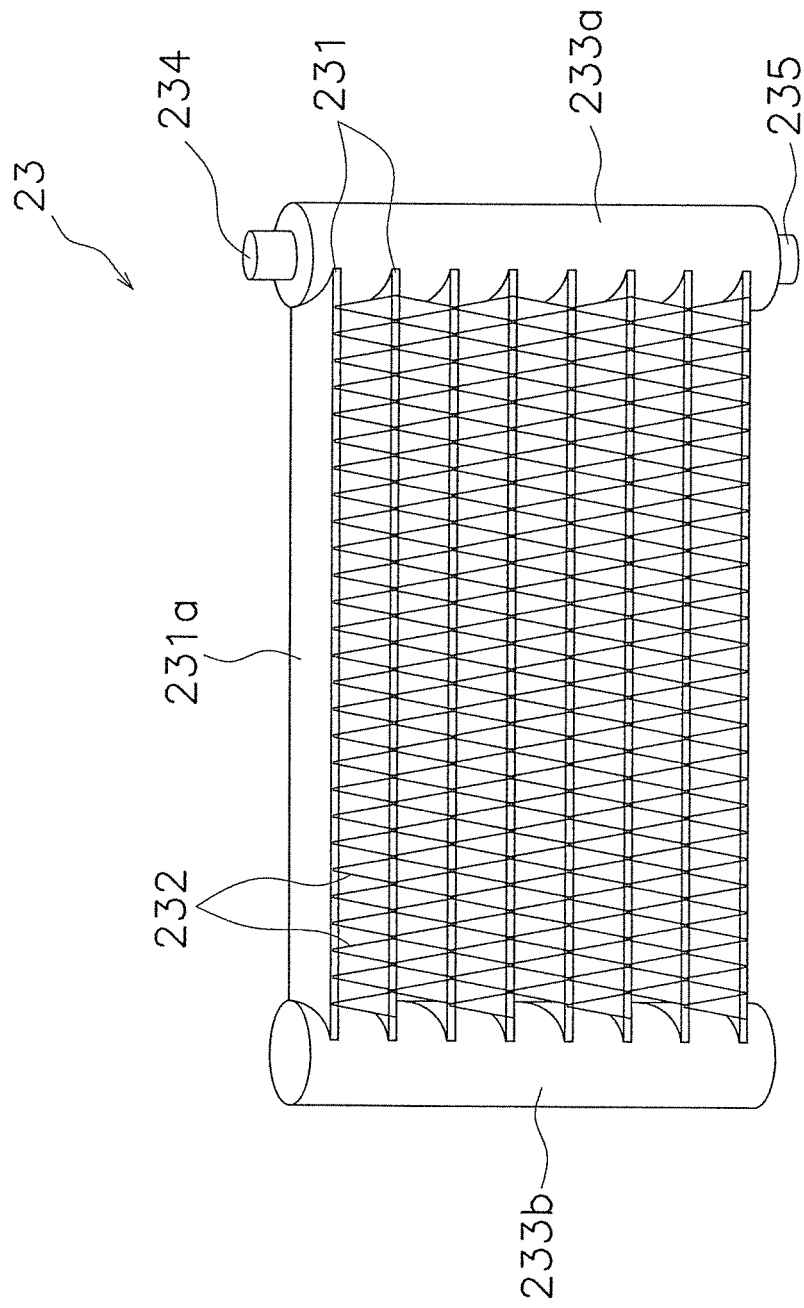


FIG. 3

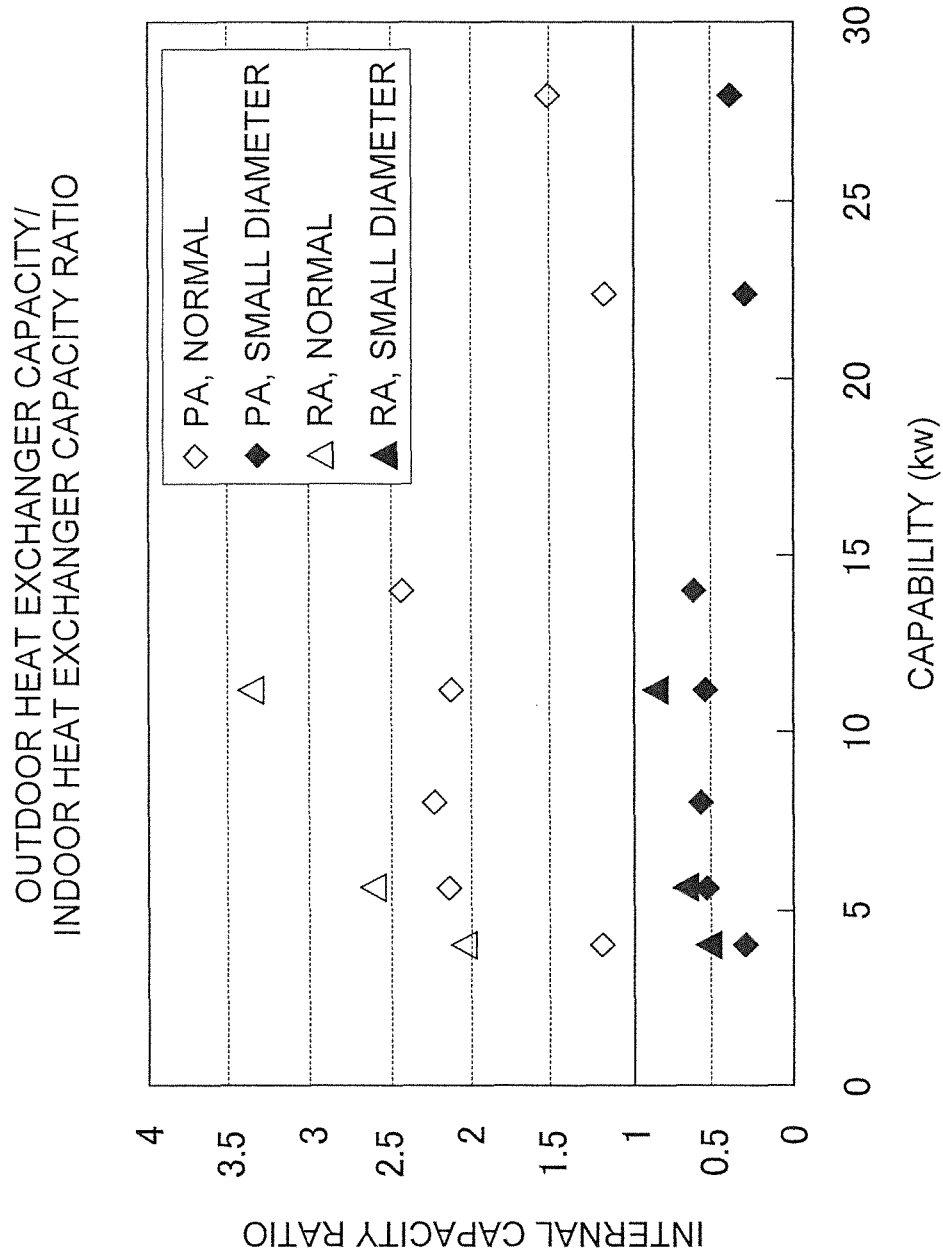


FIG. 4

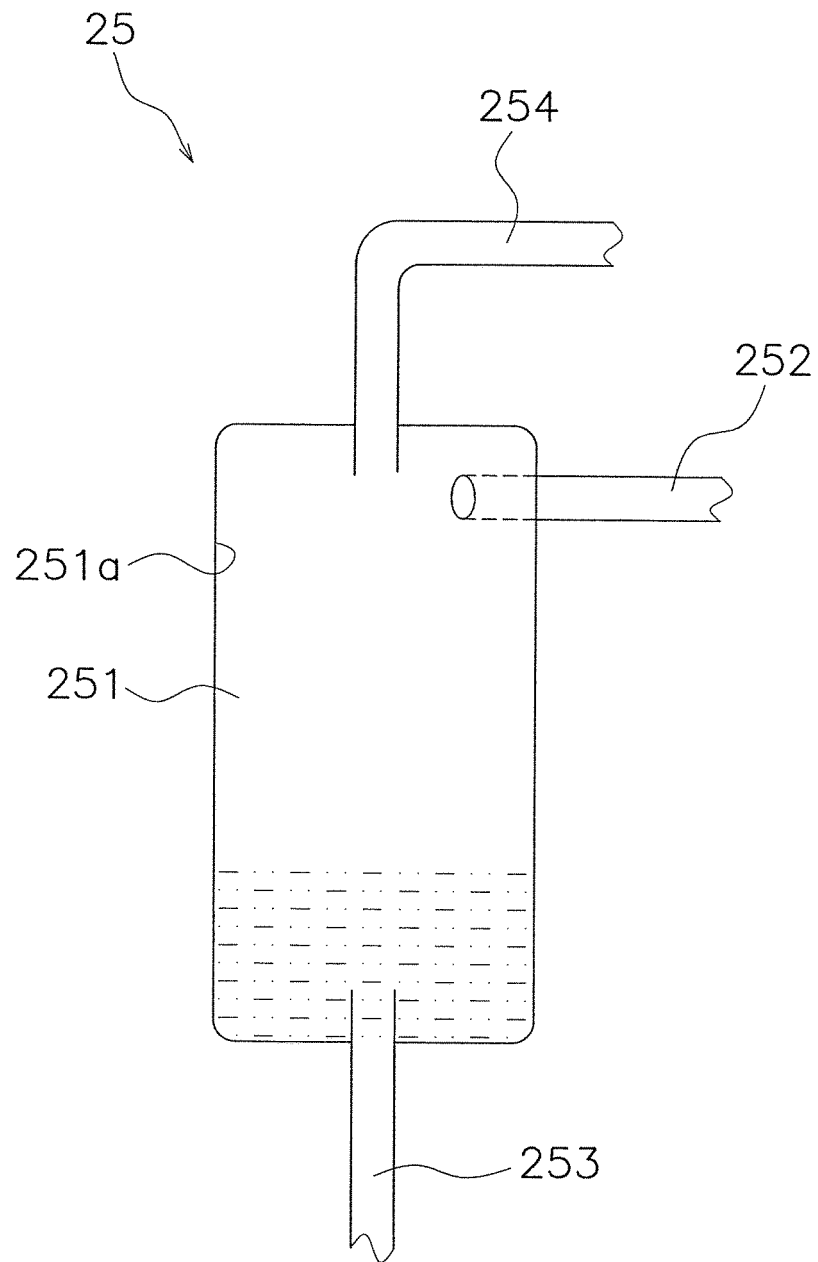


FIG. 5

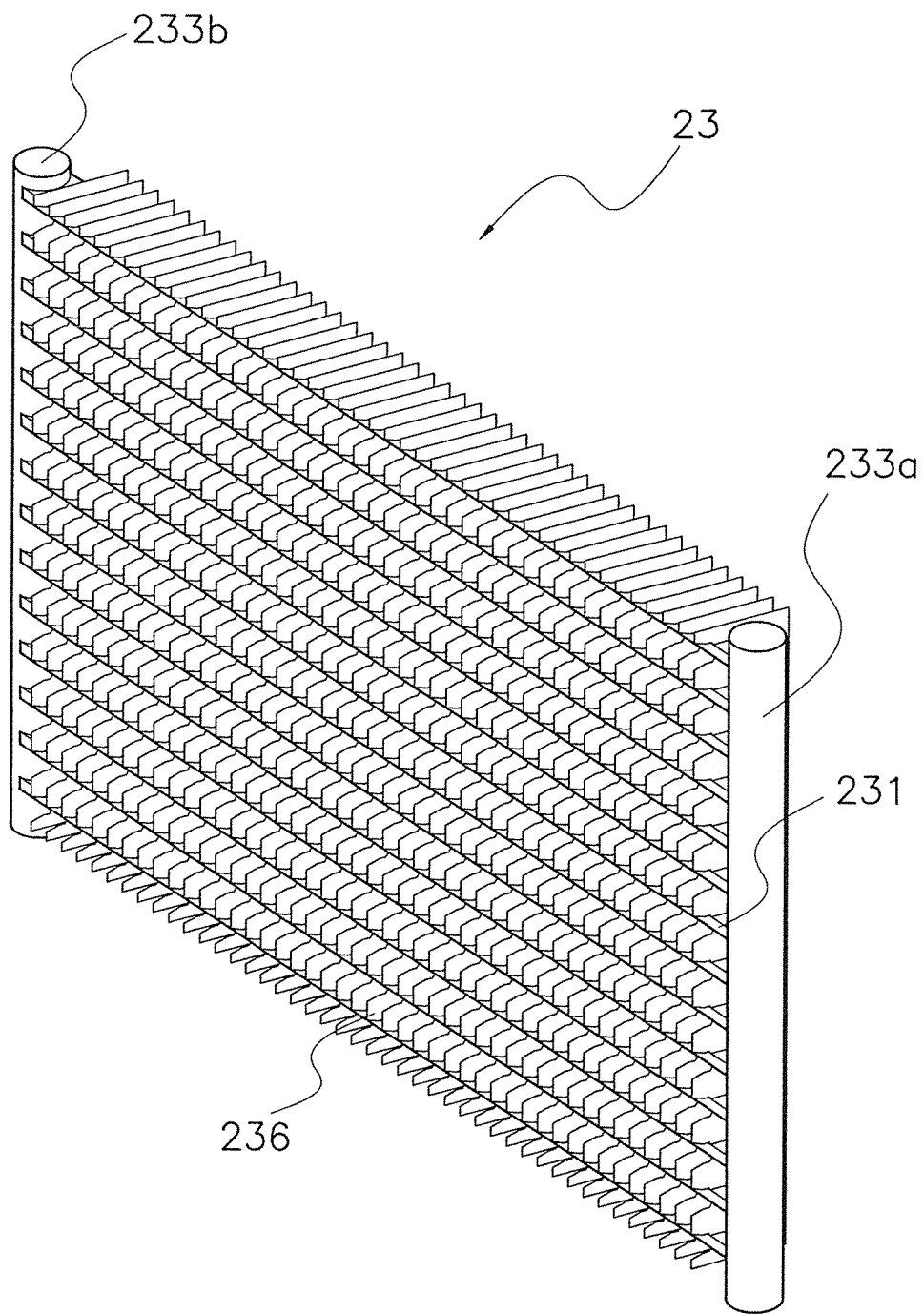


FIG. 6

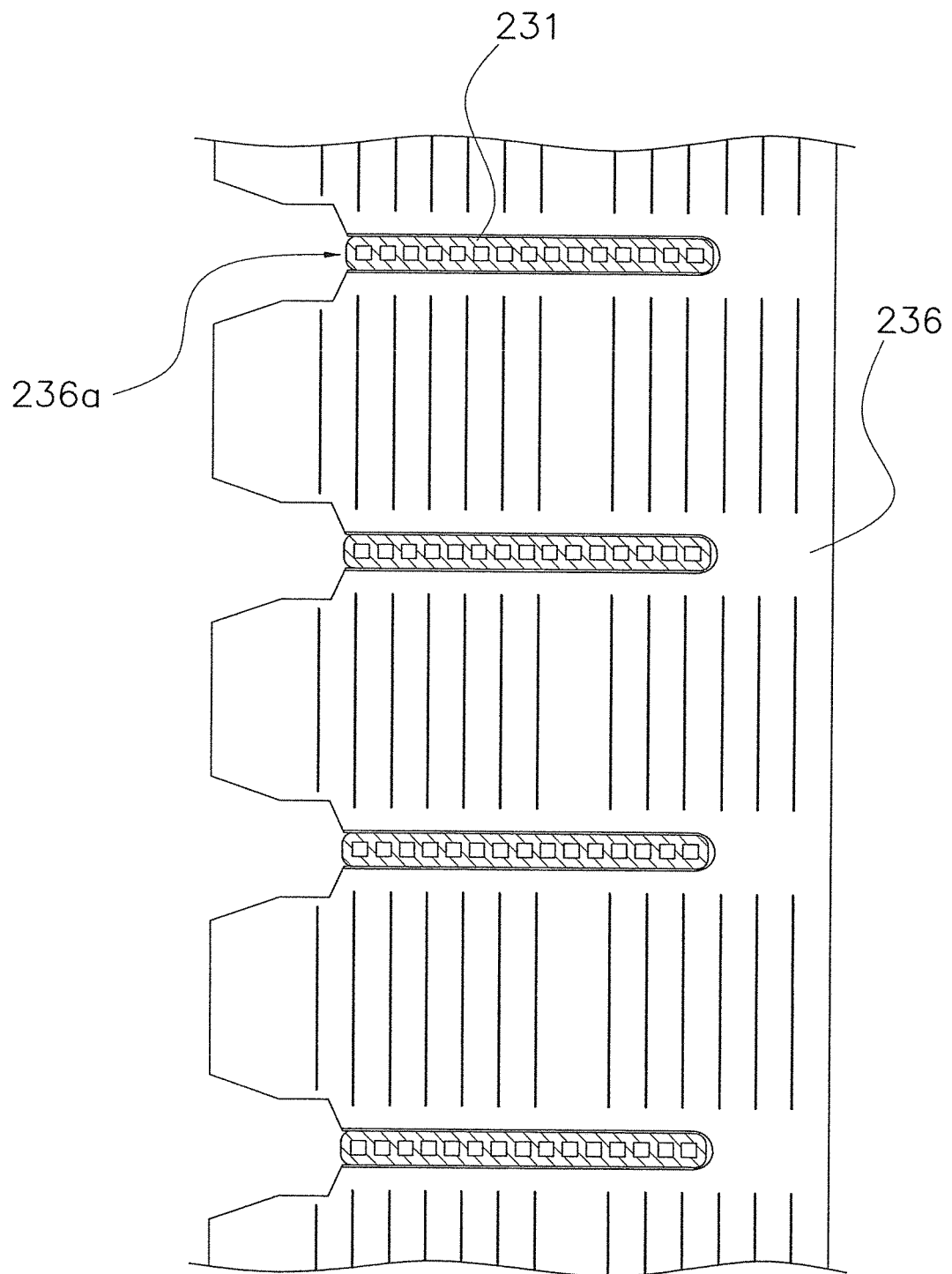


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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