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(54) **REFRIGERATION DEVICE**

(57) In an air-conditioning apparatus (1), 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 refrigerant flows sequentially through the compressor (21), the indoor heat exchanger (41), the expansion mechanisms (26, 24), and the outdoor heat exchanger (23) during a heating operation. The indoor heat exchanger (41) is a cross-fin type heat exchanger, and the outdoor heat exchanger (23) is a stacked heat exchanger. The expansion mechanisms (24, 26) include an upstream-side expansion mechanism for depressurizing refrigerant and a downstream-side expansion mechanism for depressurizing refrigerant that has been depressurized in the upstream-side expansion mechanism, and a refrigerant storage tank (25) for storing refrigerant depressurized by the upstream-side expansion mechanism is provided between the upstream-side expansion mechanism and the downstream-side expansion mechanism.

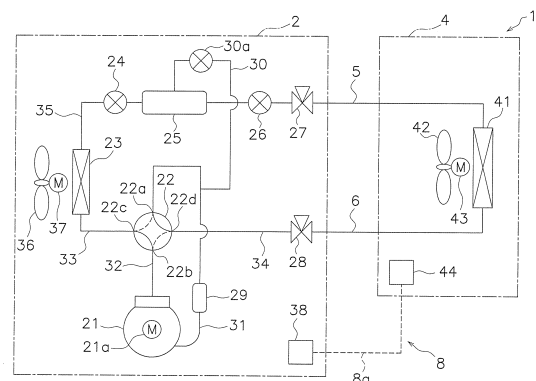


FIG. 1

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 Patent Literature 1 (Japanese Laid-open Patent Application No. 6-143991) 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] 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.

[0005] A refrigeration apparatus according to a first aspect is 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.

[0006] 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 exchanger 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.

[0007] 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.

[0008] 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.

[0009] 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.

[0010] A refrigeration apparatus according to a second aspect is 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.

[0011] 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.

[0012] 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.

[0013] 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.

[0014] A refrigeration apparatus according to a third aspect is the refrigeration apparatus according to the first or second aspect, wherein the refrigerant is R32.

[0015] When R32 is used as the refrigerant in the refrigeration apparatus, a refrigerant 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 refrigerant 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 refrigerant oil separate into two layers in the refrigerant storage tank which has a low pressure in the refrigeration cycle, and the refrigerant oil has difficulty returning to the compressor.

[0016] 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 refrigerant 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.

[0017] 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.

[0018] A refrigeration apparatus according to a fourth aspect is the refrigeration apparatus according to any of the first through third aspects, wherein 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.

[0019] In this refrigeration apparatus, similar to the refrigeration apparatus according to the first through third aspects described above, 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.

[0020] A refrigeration apparatus according to a fifth aspect is the refrigeration apparatus according to any of the first through third aspects, wherein 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.

[0021] In this refrigeration apparatus, similar to the refrigeration apparatus according to the first through third aspects described above, 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.

[0022] A refrigeration apparatus according to a sixth aspect is the refrigeration apparatus according to any of the first through third aspects, wherein 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.

[0023] In this refrigeration apparatus, similar to the refrigeration apparatus according to the first or second aspect described above, 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.

[0024] A refrigeration apparatus according to a seventh aspect is the refrigeration apparatus according to the second aspect, wherein the refrigerant is R32.

[0025] 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.

[0026] 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.

[0027] 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.

[0028] A refrigeration apparatus according to an eighth aspect is the refrigeration apparatus according to the second or seventh aspect, 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.

[0029] In this refrigeration apparatus, similar to the refrigeration apparatus according to the second aspect described above, 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] A refrigeration apparatus according to a ninth

aspect is the refrigeration apparatus according to any of the first through eighth 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.

[0031] 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.

[0032] 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.

[0033] A refrigeration apparatus according to a tenth aspect is the refrigeration apparatus according to the ninth aspect, wherein the bypass tube has a flow rate adjustment mechanism.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] A refrigeration apparatus according to an eleventh aspect is the refrigeration apparatus according to any of the first through tenth aspects, wherein the refrigerant storage tank is a gas-liquid separator.

[0039] 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.

[0040] 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

[0041]

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.

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 in Modification 2.

FIG. 7 is a longitudinal cross-sectional view of the outdoor heat exchanger in Modification 2.

DESCRIPTION OF EMBODIMENTS

[0042] 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

[0043] 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.

[0044] 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>

10 [0045] 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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>

[0050] 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.

[0051] 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 21 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.

[0052] 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 radiator 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.

[0053] 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.

[0054] The outdoor heat exchanger 23, which is a stacked heat exchanger, has primarily flat tubes 231, corrugated fins 232, and headers 233a, 233b, as shown in FIG. 3. 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 $\blacktriangle$ 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 stor-

age 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.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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.

[0061] 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>

[0062] 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.

[0063] 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 expansion 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

[0064] 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>

[0065] 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.

[0066] 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.

[0067] 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 ex-

changer 41.

[0068] 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.

[0069] 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.

[0070] 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.

[0071] 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.

[0072] 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>

[0073] 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.

[0074] 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.

[0075] The high-pressure refrigerant discharged from the compressor 21 is sent through the switching mechanism 22 to the outdoor heat exchanger 23.

[0076] 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.

[0077] 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.

[0078] 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.

[0079] 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

[0080] The air-conditioning apparatus 1 of the present embodiment has the following characteristics.

<A>

[0081] 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 100% or less of the capacity of the indoor heat exchanger 41.

[0082] 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.

[0083] 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.

[0084] 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.

[0085] 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.

[0086] 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.

[0087] 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>

[0088] 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.

[0089] However, in the air-conditioning apparatus 1, because the flow rate adjustment mechanism 30a is provided to the bypass tube 30, the liquid component of the gas-liquid two-phase refrigerant is depressurized and evaporated.

[0090] 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>

[0091] 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

[0092] 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.

[0093] 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.

[0094] 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.

[0095] 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 circumferential 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.

[0096] 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.

[0097] 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

[0098] In the above embodiment and Modification 1, an example 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.

[0099] However, the outdoor heat exchanger 23 is not

limited to the configurations in the above embodiment and Modification 1, and may be 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.

[0100] The same operational effects as those of the above embodiment and Modification 1 can be achieved in this case as well.

(6) Modification 3

[0101] In the above embodiment and Modification 1, an example 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.

[0102] However, the outdoor heat exchanger 23 is not limited to the configurations in the above embodiment and Modification 1, and 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.

[0103] 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

[0104] 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/or fins 236 in which notches 236a are formed. In the case of a refrigeration apparatus 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.

[0105] 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

[0106] In the above embodiment and Modifications 1 to 4, various refrigerants can be used as the refrigerant sealed within the refrigerant circuit 10, but R32, a type of HFC-based refrigerant, could be used as one type thereof, for example.

[0107] However, when R32 is used as the refrigerant in the refrigeration apparatus, refrigerant 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.

[0108] 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.

[0109] 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

[0110] The present invention is widely applicable in refrigeration apparatuses that can perform a cooling operation and a heating operation.

REFERENCE SIGNS LIST

[0111]

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

CITATION LIST

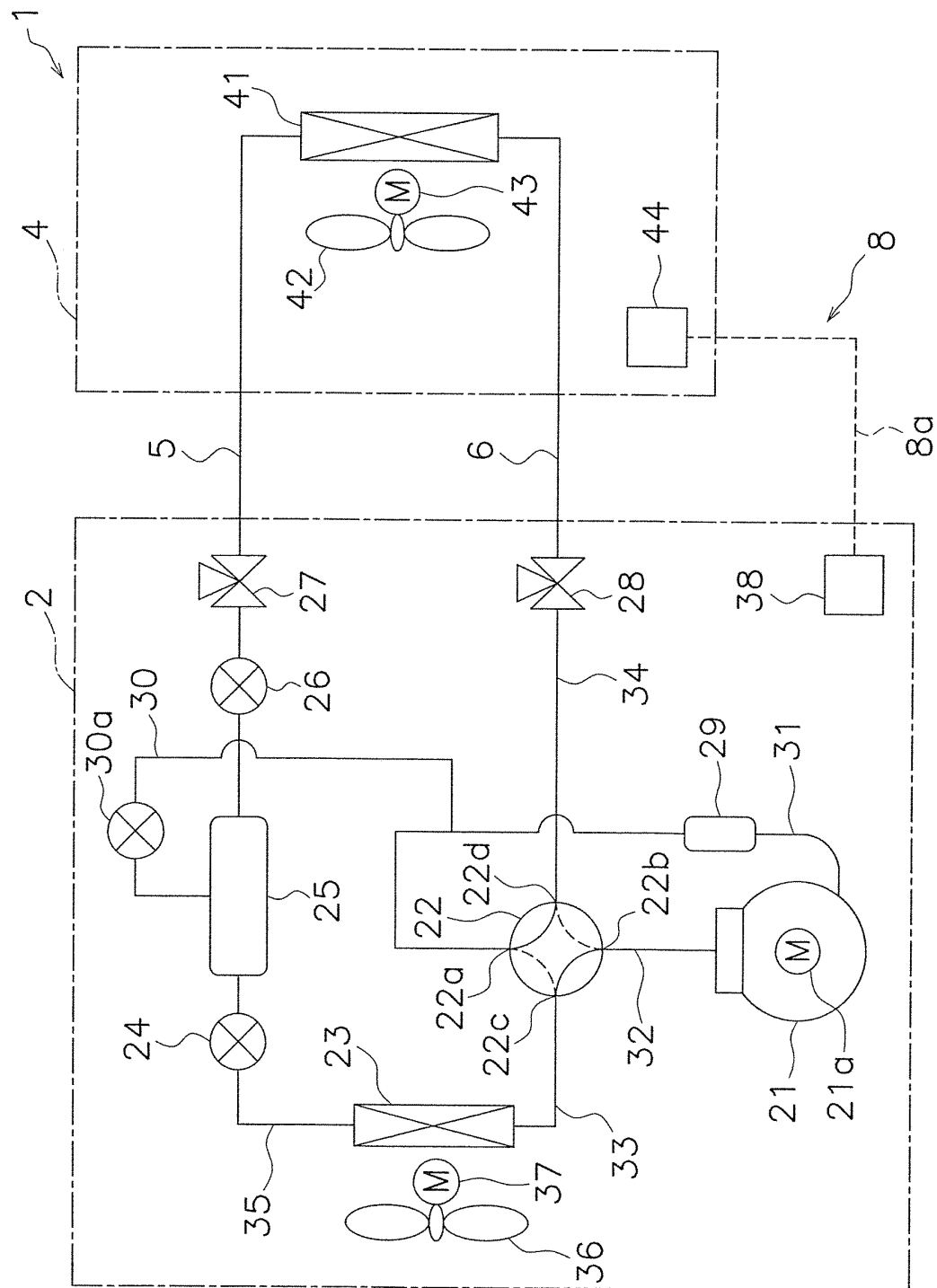
PATENT LITERATURE

[0112] <Patent Literature 1> Japanese Laid-open Patent Application No. 6-143991

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, the expansion mechanisms, and the outdoor heat exchanger during a heating operation; wherein the indoor heat exchanger is a cross-fin type heat exchanger and the outdoor heat exchanger is a stacked heat exchanger; 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 (25) 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.
2. 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, the expansion mechanisms, and the outdoor heat exchanger during a heating operation; wherein
 a capacity of the outdoor heat exchanger is 100% or less of a capacity of the indoor heat exchanger;
 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 (25) 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.
3. The refrigeration apparatus (1) according to claim 1 or 2, wherein the refrigerant is R32.
4. The refrigeration apparatus (1) according to any of claims 1 through 3, wherein 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 sandwiched between the adjacent flat tubes.
5. The refrigeration apparatus (1) according to any of claims 1 through 3, wherein 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.
6. The refrigeration apparatus (1) according to any of claims 1 through 3, wherein the outdoor heat exchanger (23) is a stacked heat exchanger having flat tubes molded into serpentine shapes, and fins inserted between mutually adjacent surfaces of the flat tubes.
7. The refrigeration apparatus (1) according to claim 2, wherein the refrigerant is R32.
8. The refrigeration apparatus (1) according to claim 2 or 7, wherein the outdoor heat exchanger (23) and the indoor heat exchanger (41) 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.
9. The refrigeration apparatus (1) according to any of claims 1 through 8, 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.
10. The refrigeration apparatus (1) according to claim 9, wherein the bypass tube (30) has a flow rate adjustment mechanism (30a).
11. The refrigeration apparatus (1) according to any of claims 1 through 10, wherein the refrigerant storage tank (25) is a gas-liquid separator.



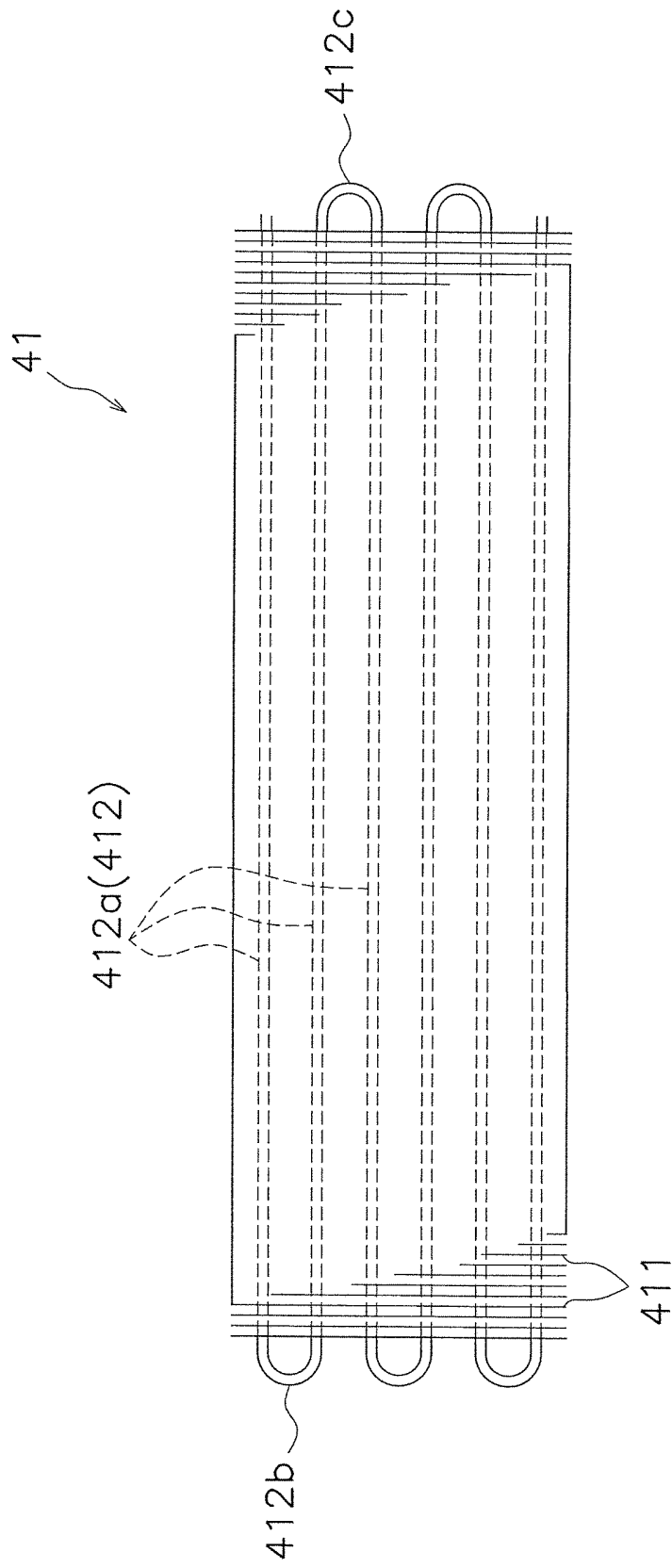


FIG. 2

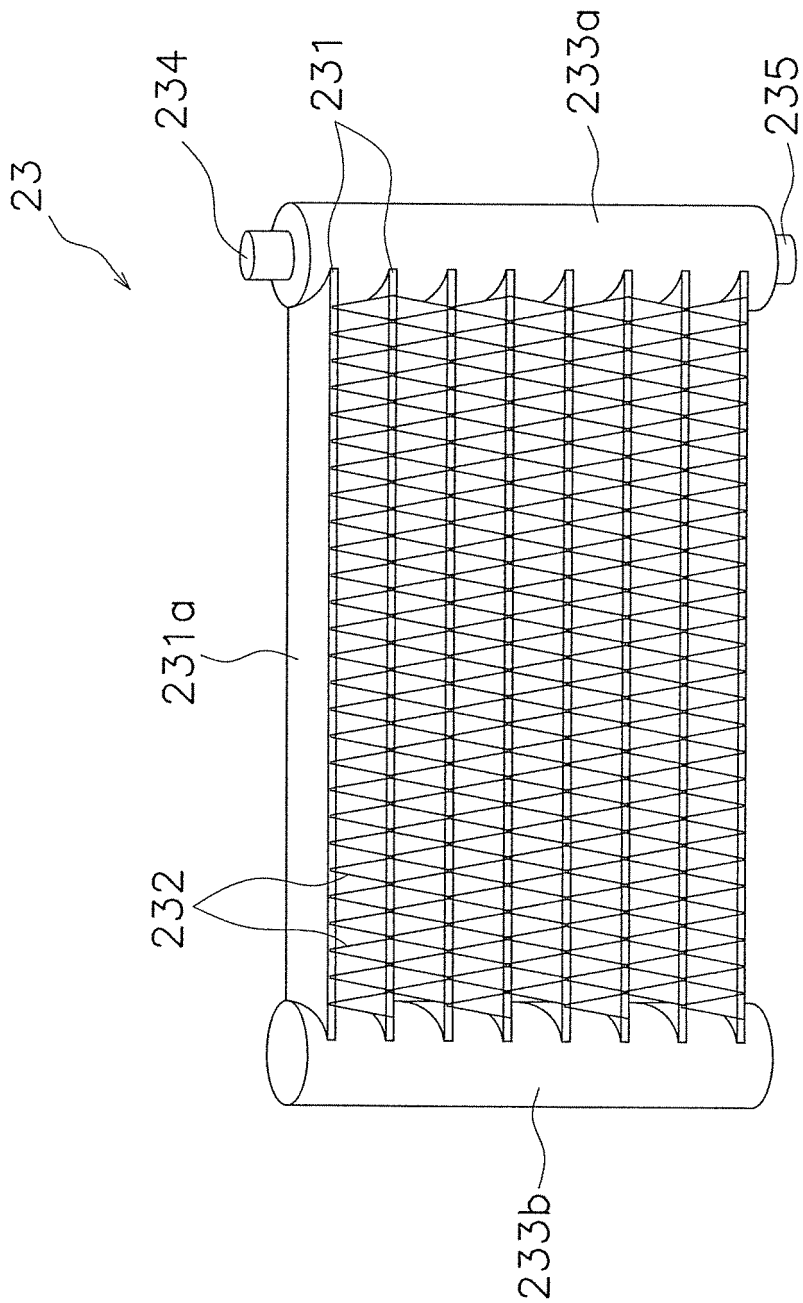


FIG. 3

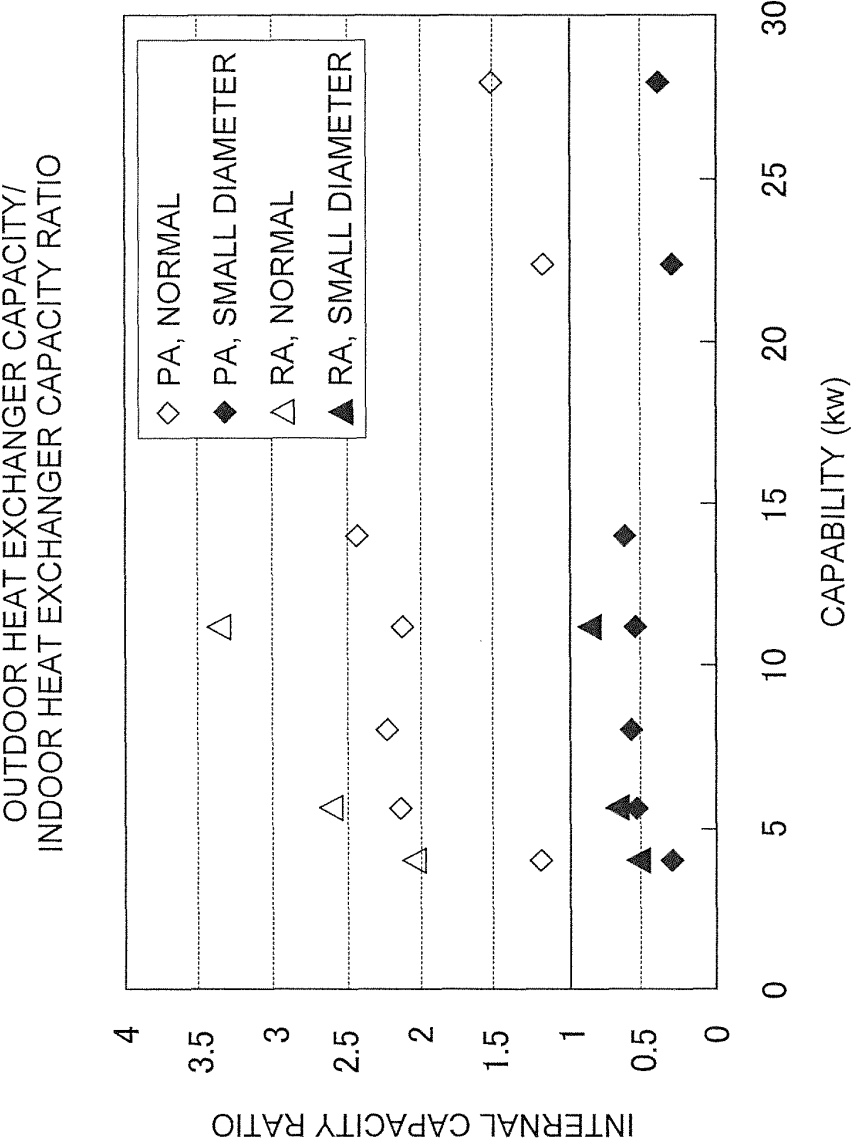


FIG. 4

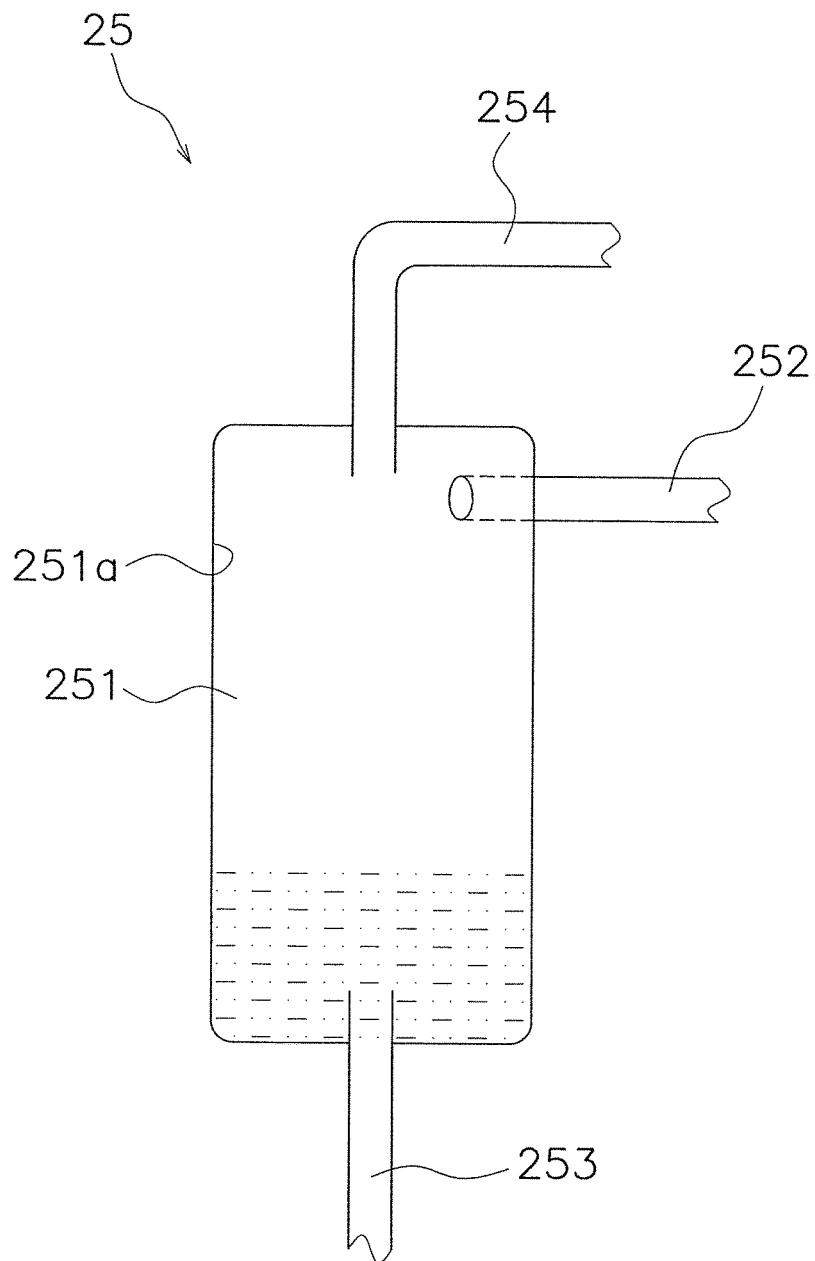


FIG. 5

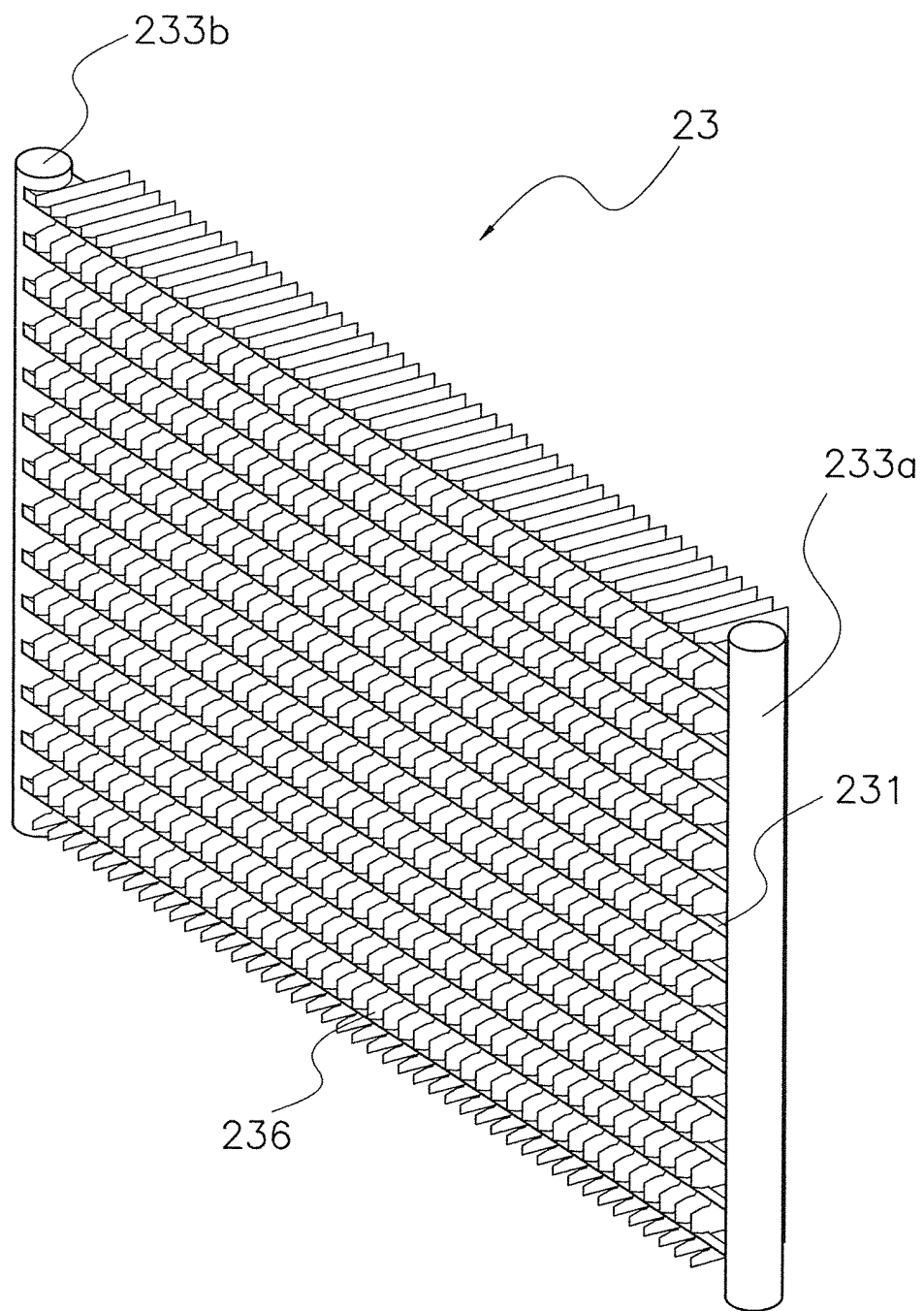


FIG. 6

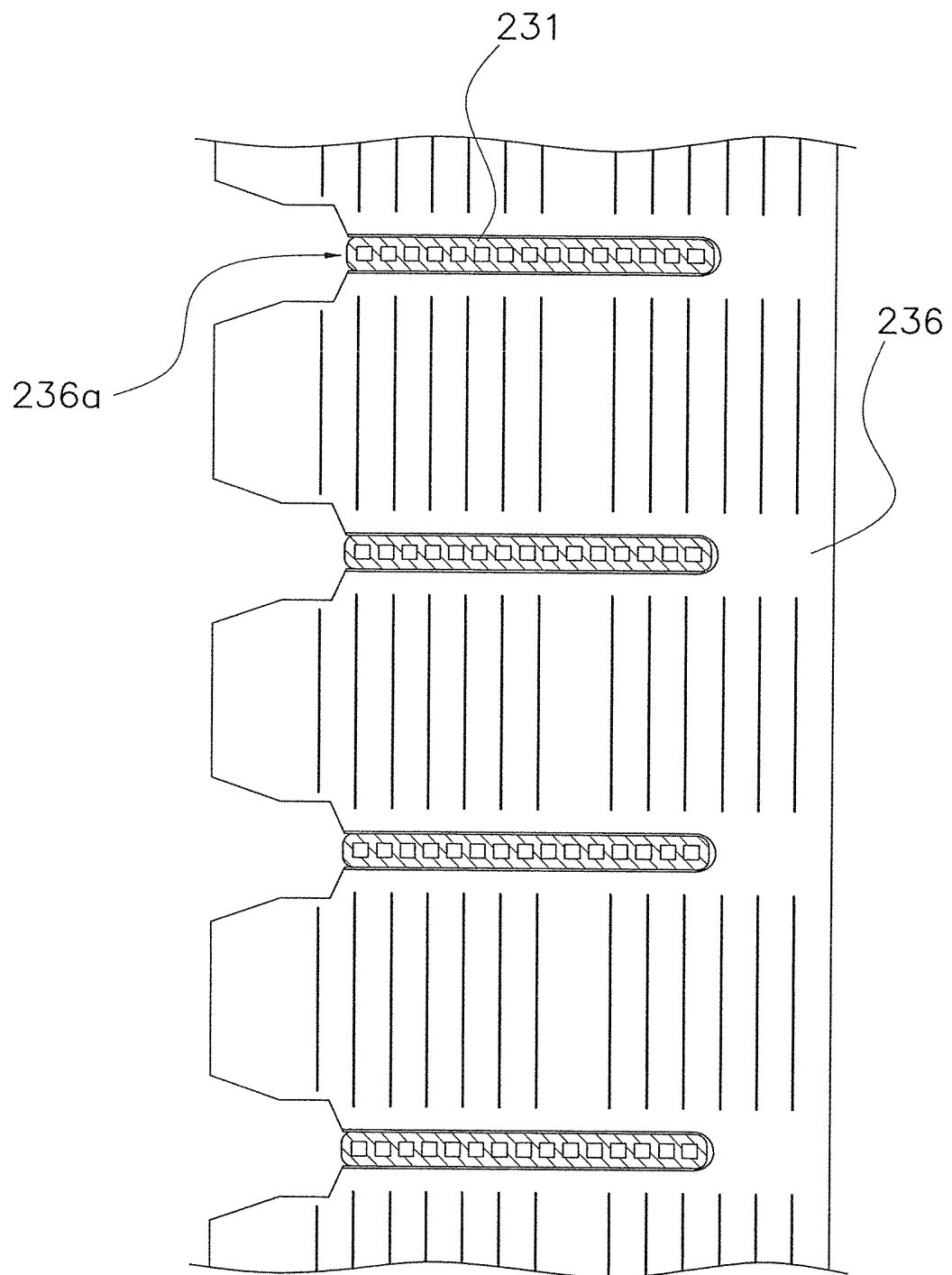


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/082912

A. CLASSIFICATION OF SUBJECT MATTER

F25B39/04(2006.01)i, 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)

F25B39/04, 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.
Y	JP 8-233378 A (Sanyo Electric Co., Ltd.), 13 September 1996 (13.09.1996), claims; paragraphs [0016] to [0023]; fig. 1 (Family: none)	1-11
Y	JP 2008-89292 A (Daikin Industries, Ltd.), 17 April 2008 (17.04.2008), claims; paragraphs [0057] to [0070], [0141]; fig. 2, 9 & US 2009/0272135 A1 & EP 2068101 A1 & WO 2008/029678 A1	1-11
Y	JP 10-332212 A (Toshiba Corp.), 15 December 1998 (15.12.1998), claims; paragraphs [0006], [0030] to [0032], [0043] to [0048]; fig. 8 to 10 (Family: none)	1-11

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
20 February, 2013 (20.02.13)Date of mailing of the international search report
05 March, 2013 (05.03.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/082912

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-299961 A (Daikin Industries, Ltd.), 24 December 2009 (24.12.2009), claims; paragraphs [0043] to [0049]; fig. 1 (Family: none)	2-11

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6143991 JP [0003]
- JP 6143991 A [0112]