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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

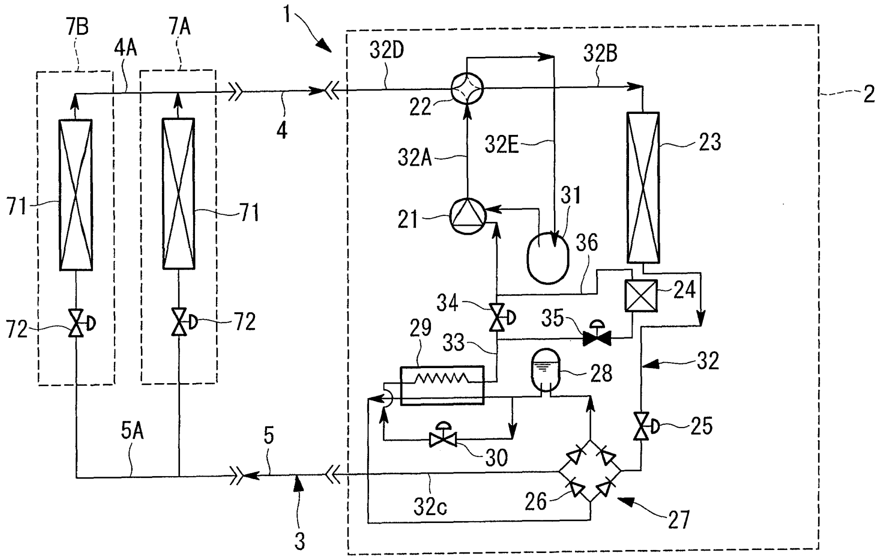
(72) Inventor: **ENYA, Atsushi**
Nagoya-shi
Aichi 453-8515 (JP)

(74) Representative: **Intes, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(54) HEAT PUMP TYPE AIR CONDITIONER

(57) An object is to provide a heat-pump air conditioner that can reliably prevent an outdoor heat exchanger and a drain pan from freezing during heating, while maintaining high capacity and high performance, without affecting the cooling/heating capacity and performance. In a heat-pump air conditioner 1 provided with a gas injection circuit 33 that injects an intermediate-pressure refrigerant into an intermediate intake port 21A of a compressor 21, an auxiliary heat exchanger 24 having an anti-freezing function is provided at a lower part of the outdoor heat exchanger 23, and a liquefied injection circuit 36 is connected, which, after the intermediate-pressure refrigerant vaporized in the gas injection circuit 33 is switched by switching valves 34 and 35 to be introduced into the auxiliary heat exchanger 24, guides the refrigerant to the intermediate intake port 21A of the compressor 21.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a heat-pump air conditioner in which an auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger.

Background Art

[0002] In heat-pump air conditioners, during a heating operation, the moisture in the air freezes in the form of frost and deposits on an outdoor heat exchanger serving as an evaporator. Because this inhibits heat exchange, deposition of frost should be detected and a defrosting (frost removing) operation for melting frost should be performed. However, when used in cold climate areas or at a low outside-air temperature, a phenomenon whereby drain water that has dripped due to defrosting refreezes at a lower part of the outdoor heat exchanger or on a drain pan is observed. In this case, the lower part of the outdoor heat exchanger is clogged by ice, and the ice grows by alternating between melting and freezing. This may result in not only a decrease in capacity, but also, in the worst case, damage to the heat exchanger, deformation of the drain pan, or the like.

[0003] To counter this, conventionally, various proposals have been made in which an auxiliary heat exchanger having an anti-freezing function, a receiver tank, or a heater is provided at the lower part of the outdoor heat exchanger, so that the lower part of the outdoor heat exchanger and the drain pan are heated during a heating operation and during defrosting and are prevented from freezing (see Patent Citations 1 to 4).

That is, Patent Citation 1 discloses providing an anti-freezing coil at the lower part of the outdoor heat exchanger. A gas refrigerant or a liquid refrigerant at an intermediate pressure, led out of a refrigerant reservoir tank, is introduced into the anti-freezing coil during heating and during defrosting.

[0004] Patent Citation 2 discloses providing an auxiliary heat exchanger at the lower part of the outdoor heat exchanger. Part of a hot gas refrigerant discharged from a compressor is branched off and is circulated through the auxiliary heat exchanger, and then is merged again at an inlet of a four-way valve, so that the hot gas refrigerant flows constantly. Patent Citation 3 discloses providing an auxiliary heat exchanger at the lower part of the outdoor heat exchanger. During heating, a gas-liquid two phase refrigerant having passed through a heating throttle and a hot gas refrigerant discharged from a compressor are introduced into the auxiliary heat exchanger. Furthermore, Patent Citation 4 discloses providing a receiver tank at a lower part of the outdoor heat exchanger. A refrigerant is circulated during both cooling and heating.

[0005]

Patent Citation 1:
Japanese Unexamined Patent Application, Publication No. Sho 60-8665

Patent Citation 2:
Japanese Unexamined Patent Application, Publication No. Sho 60-114666

Patent Citation 3:
Japanese Unexamined Patent Application, Publication No. Hei 7-280378

Patent Citation 4:
Japanese Unexamined Patent Application, Publication No. 2006-97992

Disclosure of Invention

[0006] All of the disclosures in Patent Citations 1 to 4 have the effect of preventing the lower part of the outdoor heat exchanger or the drain pan from freezing. However, on the other hand, some of them have demerits in terms of the cooling/heating capacity and performance, and they are not satisfactory as heat-pump air conditioners for cold climate areas, the freezing conditions of which are becoming more and more severe, and as heat-pump air conditioners required to increase the operating range, such as cooling and heating at a low outside-air temperature and cooling and heating under overload conditions.

[0007] More specifically, the disclosure in Patent Citation 1 relates to an air conditioner specialized for heating, and the structure thereof cannot be applied to a heat-pump air conditioner capable of both cooling and heating operations. The disclosures in Patent Citations 2 and 4 have a problem of a decrease in heating capacity, because, during heating, the amount of heat released from the indoor heat exchanger decreases by an amount corresponding to the amount of heat released from the auxiliary heat exchanger and the receiver tank. The disclosure in Patent Citation 3 has a problem of causing a decrease in heating capacity, because, during heating, the hot gas refrigerant from the compressor is mixed, through the throttle and the auxiliary heat exchanger, with the low-pressure gas-liquid two phase refrigerant having been reduced in pressure by the heating throttle, decreasing the amount of heat absorbed by the outdoor heat exchanger. Furthermore, although there is a method in which a heater is separately provided, such a method is undesirable since it leads to excessive energy consumption. Accordingly, there is a demand for a heat-pump air conditioner that can reliably prevent the outdoor heat exchanger and the drain pan from freezing without affecting the capacity and performance.

[0008] The present invention has been made in view of the above-described circumstances, and an object thereof is to provide a heat-pump air conditioner that can reliably prevent the outdoor heat exchanger and the drain pan from freezing during heating while maintaining high capacity and high performance, without affecting the capacity and performance.

[0009] To solve the above-described problems, a heat-pump air conditioner of the present invention employs the following solutions.

That is, a heat-pump air conditioner according to a first aspect of the present invention forms a refrigeration cycle by sequentially connecting, at least, a compressor, a four-way control valve, an outdoor heat exchanger, an outdoor electric expansion valve, an indoor electric expansion valve, and an indoor heat exchanger, and has a gas injection circuit provided in the refrigeration cycle. The gas injection circuit vaporizes part of liquid refrigerant in the cycle, cools the liquid refrigerant using latent heat of vaporization, and injects vaporized intermediate-pressure refrigerant into an intermediate intake port of the compressor. An auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger. A liquefied injection circuit is connected, which, after the intermediate-pressure refrigerant vaporized in the gas injection circuit is switched by a switching valve to be introduced into the auxiliary heat exchanger, guides the refrigerant to the intermediate intake port of the compressor.

[0010] According to the first aspect of the present invention, with an economizer effect due to the gas injection circuit, both the capacity and the performance can be improved. At the same time, during a heating operation and during defrosting, the intermediate-pressure refrigerant vaporized in the gas injection circuit and in a saturated gas state can be introduced into the auxiliary heat exchanger through the liquefied injection circuit by the switching valve, and the refrigerant converted into a gas-liquid two phase or a liquid by releasing heat and being cooled can be liquid-injected from the intermediate intake port of the compressor. Thus, the heating capacity can be further increased when the amounts of circulated refrigerant are the same, and the discharging temperature of the refrigerant can be effectively restricted by increasing the cooling effect. Furthermore, by keeping the intermediate-pressure refrigerant condensed by releasing heat in the auxiliary heat exchanger at a temperature of 0 °C or more, the lower part of the outdoor heat exchanger and the drain pan can be heated and prevented from freezing during a heating operation and during defrosting.

[0011] A heat-pump air conditioner according to a second aspect of the present invention forms a refrigeration cycle by sequentially connecting, at least, a compressor, a four-way control valve, an outdoor heat exchanger, an outdoor electric expansion valve, an indoor electric expansion valve, and an indoor heat exchanger, and has a gas injection circuit provided in the refrigeration cycle. The gas injection circuit vaporizes part of liquid refrigerant in the cycle, cools the liquid refrigerant using latent heat of vaporization, and injects vaporized intermediate-pressure refrigerant into an intermediate intake port of the compressor. An auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger. The auxiliary heat exchanger is connected in parallel to the outdoor electric expansion valve through a check valve that allows a flow of condensed refrigerant from the outdoor heat exchanger, and a bypass circuit having an on-off valve is provided between an intake pipe of the compressor and a point between the check valve and the auxiliary heat exchanger.

[0012] According to the second aspect of the present invention, with an economizer effect due to the gas injection circuit, both the capacity and the performance can be improved. At the same time, because a high-pressure liquid refrigerant can be constantly supplied to the auxiliary heat exchanger during a heating operation and during defrosting, the lower part of the outdoor heat exchanger and drain pan can be heated by this high-pressure liquid refrigerant. Furthermore, because the refrigerant supplied to the auxiliary heat exchanger and reduced in temperature by releasing heat can be returned to the intake pipe side of the compressor by the bypass circuit, it does not remain in the auxiliary heat exchanger and freeze by being supercooled or does not lower the amount of heat absorption by being mixed with the refrigerant flowing into the outdoor heat exchanger via the outdoor electric expansion valve. Thus, the lower part of the outdoor heat exchanger and the drain pan can be prevented from freezing, without lowering the heating capacity. Note that, because there is no possibility of freezing when the outside-air temperature is high (≥ 0 °C), the operation may be performed with the on-off valve of the bypass circuit closed. Furthermore, because the auxiliary heat exchanger can be used as a condenser during a cooling operation, the cooling capacity is not lowered.

[0013] In the above-described heat-pump air conditioner of the present invention, the bypass circuit may be provided with a refrigerant regulating throttle.

[0014] In this structure, the amount of refrigerant that is returned from the auxiliary heat exchanger to the intake pipe of the compressor through the bypass circuit can be appropriately controlled with the refrigerant regulating throttle provided in the bypass circuit, and the heating effect provided by the high-pressure liquid refrigerant can be ensured. Thus, while the liquid refrigerant is prevented from remaining in the auxiliary heat exchanger, the anti-freezing function of the lower part of the outdoor heat exchanger and the drain pan can be reliably maintained.

[0015] In any one of the heat-pump air conditioners of the present invention, a supercooling coil may be provided in parallel with the check valve and the auxiliary heat exchanger, between the outdoor heat exchanger and the outdoor electric expansion valve.

[0016] In this structure, because the refrigerant can be supercooled by the supercooling coil provided between the outdoor heat exchanger and the outdoor electric expansion valve during cooling, the cooling capacity can be improved. On the other hand, because the supercooling coil functioning as a condenser during heating does not lower the vaporizing performance of the outdoor heat exchanger, it does not cause a reduction in the heating capacity.

[0017] A heat-pump air conditioner according to a third aspect of the present invention forms a refrigeration cycle by sequentially connecting, at least, a compressor, a four-way control valve, an outdoor heat exchanger, an outdoor electric expansion valve, an indoor electric expansion valve, and an indoor heat exchanger, and has a gas injection circuit provided in the refrigeration cycle. The gas injection circuit vaporizes part of liquid refrigerant in the cycle, cools the liquid refrigerant using latent heat of vaporization, and injects vaporized intermediate-pressure refrigerant into an intermediate intake port of the compressor. An auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger. A hot-gas bypass circuit that introduces part of the hot gas discharged from the compressor into the auxiliary heat exchanger through a first on-off valve and guides the refrigerant to a point between the outdoor heat exchanger and the outdoor electric expansion valve through a second on-off valve; a first bypass circuit that guides the refrigerant at the point between the outdoor electric expansion valve and the outdoor heat exchanger to an intake pipe of the compressor via the second on-off valve, the auxiliary heat exchanger, a third on-off valve, and a refrigerant regulating throttle during heating; and a second bypass circuit that condenses, in the auxiliary heat exchanger, the hot gas introduced through the first on-off valve during heating or during defrosting and guides the hot gas to the intake pipe of the compressor via a fourth on-off valve and the refrigerant regulating throttle, are provided.

[0018] According to the third aspect of the present invention, with an economizer effect due to the gas injection circuit, both the capacity and the performance can be improved. At the same time, because part of the hot gas discharged from the compressor can be introduced to the auxiliary heat exchanger through the hot-gas bypass circuit, the auxiliary heat exchanger can be made to function as a condenser during a normal cooling operation to increase the condensing performance and to improve the cooling capacity. Furthermore, during cooling at a low outside-air temperature, the bypass of the hot gas can be stopped by the first on-off valve so that the condenser is substantially reduced in size to restrict the condensing performance. Therefore, the cooling operation can be continued while maintaining a high pressure. Furthermore, during a heating operation, because the refrigerant adiabatically expanded by the outdoor electric expansion valve can be guided through the first bypass circuit to the auxiliary heat exchanger, which can be made to function as an evaporator, the amount of heat absorption can be increased to improve the heating capacity. At the same time, under overload heating conditions at a high outside-air temperature, by introducing the hot gas to the auxiliary heat exchanger through the second bypass circuit and making the auxiliary heat exchanger function as a radiator, it can be used to adjust the heating capacity. Furthermore, during defrosting, by introducing the hot gas to the auxiliary heat exchanger through the second bypass circuit, the lower part of the outdoor heat exchanger and the drain pan can be heated and prevented from freezing.

[0019] In the above-described heat-pump air conditioner of the present invention, the first bypass circuit and the second bypass circuit may be provided with a common refrigerant regulating throttle.

[0020] In this structure, the common refrigerant regulating throttle provided in the first bypass circuit and the second bypass circuit appropriately controls the amount of refrigerant bypassed through the first bypass circuit and the second bypass circuit to the intake pipe of the compressor via the auxiliary heat exchanger. Thus, the auxiliary heat exchanger can be made to properly function as an evaporator, a radiator, a heater, or the like. Thus, the auxiliary heat exchanger can be effectively used not only to prevent the lower part of the outdoor heat exchanger and the drain pan from freezing, but also to adjust the heating capacity. At the same time, the operating range can be expanded and the structure can be simplified.

[0021] According to the heat-pump air conditioner of the present invention, with an economizer effect, both the capacity and the performance can be improved. At the same time, during heating and during defrosting, because the auxiliary heat exchanger provided at the lower part of the outdoor heat exchanger can be made to function as a condenser for the intermediate-pressure refrigerant vaporized in the gas injection circuit, the lower part of the outdoor heat exchanger and the drain pan can be reliably prevented from freezing by means of the released heat. Furthermore, because the gas-liquid two phase or liquid refrigerant having been condensed in the auxiliary heat exchanger can be liquid-injected from the intermediate intake port of the compressor, the heating capacity can be further improved and the refrigerant discharging temperature can be effectively restricted. Thus, the operating range can be expanded.

[0022] Furthermore, according to the heat-pump air conditioner of the present invention, improvement of the capacity and performance due to an economizer effect can be obtained. At the same time, because the high-pressure liquid refrigerant can be constantly supplied to the auxiliary heat exchanger provided at the lower part of the outdoor heat exchanger during heating and during defrosting, the lower part of the outdoor heat exchanger and the drain pan can be reliably prevented from freezing by means of the released heat. Furthermore, because the high-pressure liquid refrigerant is returned to the intake pipe side of the compressor by the bypass circuit, freezing of the refrigerant remaining in the auxiliary heat exchanger or a decrease in the amount of heat absorption due to the supercooled refrigerant entering the outdoor heat exchanger does not occur. Thus, high capacity and high performance can be reliably maintained.

[0023] Furthermore, according to the heat-pump air conditioner of the present invention, improvement of the capacity and performance due to an economizer effect can be obtained. At the same time, because the auxiliary heat exchanger provided at the lower part of the outdoor heat exchanger can be made to function as a condenser during cooling, the condensing performance can be increased to improve the cooling capacity. Furthermore, during cooling at a low outside-air temperature, the function as a condenser can be aborted to restrict the condensing performance, so that the cooling operation can be continued while keeping the high pressure. Thus, the operating range can be expanded. Furthermore, because the auxiliary heat exchanger can be made to function as an evaporator during heating, and can be made to function as a radiator under overload heating conditions, it can be used to improve the heating capacity and to adjust the capacity. Furthermore, because it can be made to function as a radiator during defrosting, the lower part of the outdoor heat exchanger and the drain pan can be heated and reliably prevented from freezing.

Brief Description of Drawings

[0024]

[FIG. 1] FIG. 1 is a diagram showing a cooling cycle of a heat-pump air conditioner according to a first embodiment of the present invention.
[FIG. 2] FIG. 2 is a diagram showing a heating cycle of the heat-pump air conditioner according to the first embodiment of the present invention.
[FIG. 3] FIG. 3 is a diagram showing a cooling cycle of a heat-pump air conditioner according to a second embodiment of the present invention.
[FIG. 4] FIG. 4 is a diagram showing a heating cycle of the heat-pump air conditioner according to the second embodiment of the present invention.
[FIG. 5] FIG. 5 is a schematic enlarged view of a lower part of an example of an outdoor heat exchanger, which is applied to the heat-pump air conditioner according to the second embodiment of the present invention.
[FIG. 6] FIG. 6 is a schematic enlarged view of a lower part of another example of an outdoor heat exchanger, which is applied to the heat-pump air conditioner according to the second embodiment of the present invention.
[FIG. 7] FIG. 7 is a diagram showing a cooling cycle of a heat-pump air conditioner according to a third embodiment of the present invention.
[FIG. 8] FIG. 8 is a diagram showing a heating cycle of the heat-pump air conditioner according to the third embodiment of the present invention.
[FIG. 9] FIG. 9 is a diagram showing an overload heating cycle of the heat-pump air conditioner according to the third embodiment of the present invention.
[FIG. 10] FIG. 10 is a diagram showing a defrosting cycle of the heat-pump air conditioner according to the third embodiment of the present invention.

Explanation of Reference:

[0025]

1: heat-pump air conditioner
3: refrigeration cycle
21: compressor
21A: intermediate intake port
22: four-way control valve
23: outdoor heat exchanger
23A: supercooling coil
24: auxiliary heat exchanger
25: outdoor electric expansion valve
29: intermediate heat exchanger
33: gas injection circuit
34, 35: solenoid-operated switching valve (switching valve)
36: liquefied injection circuit
40: check valve
41: on-off valve
42: refrigerant regulating throttle
43: bypass circuit
50: first on-off valve
52: second on-off valve
53: hot-gas bypass circuit
54: third on-off valve
55: refrigerant regulating throttle
56: first bypass circuit
57: fourth on-off valve
58: second bypass circuit
71: indoor heat exchanger
72: indoor electric expansion valve

Best Mode for Carrying Out the Invention

[0026] Embodiments of the present invention will be described below with reference to the drawings.

First Embodiment

[0027] A first embodiment of the present invention will be described below using FIGS. 1 and 2.
FIGS. 1 and 2 show refrigerant circuit diagrams of a heat-pump air conditioner according to the first embodiment of the present invention, in which FIG. 1 shows a cooling cycle, and FIG. 2 shows a heating cycle. Herein, a multi-type heat-pump air conditioner 1, in which a plurality of indoor units are connected in parallel, is shown. The multi-type heat-pump air conditioner 1 is formed of an outdoor unit 2, a refrigerant gas pipe 4 and a refrigerant liquid pipe 5 led out of the outdoor unit 2, and a plurality of indoor units 7A and 7B that are connected in parallel between the refrigerant gas pipe 4 and the refrigerant liquid pipe 5. Needless to say, the number of indoor units 7A and 7B is not limited to two, and three or more indoor units can be connected where appropriate.
[0028] The outdoor unit 2 includes an inverter-driven compressor 21 that compresses refrigerant; a four-way

control valve 22 that switches the circulation direction of the refrigerant; an outdoor heat exchanger 23 that performs heat exchange between the refrigerant and the outside air; an auxiliary heat exchanger 24 having an anti-freezing function, provided integrally at a lower part of the outdoor heat exchanger 23; an outdoor electric expansion valve (EEVH) 25 for heating; a bridge circuit 27 consisting of a combination of four check valves 26; a receiver 28 that reserves the liquid refrigerant; an intermediate heat exchanger 29 that supercools the liquid refrigerant using latent heat of vaporization of the refrigerant diverted from the liquid pipe; an electric expansion valve (EEVSC) 30 that controls the amount of refrigerant to be diverted to the intermediate heat exchanger 29; and an accumulator 31 that separates liquid from the refrigerant gas to be taken into the compressor 21 and reserves the liquid refrigerant. As it is known, they are connected by refrigerant pipes including a discharge pipe 32A, a gas pipe 32B, a liquid pipe 32C, a gas pipe 32D, and an intake pipe 32E, forming an outdoor-side refrigerant circuit 32.

[0029] Furthermore, a gas injection circuit 33, which injects the intermediate-pressure refrigerant vaporized by the intermediate heat exchanger 29 into an intermediate intake port 21A provided in the compressor 21, is provided between the intermediate heat exchanger 29 and the compressor 21. To this gas injection circuit 33 is connected a liquefied injection circuit 36 that guides the intermediate-pressure refrigerant vaporized by the intermediate heat exchanger 29 to the intermediate intake port 21A of the compressor 21 via the auxiliary heat exchanger 24 having an anti-freezing function, which is provided at the lower part of the outdoor heat exchanger 23, through the solenoid-operated switching valves 34 and 35. The solenoid-operated switching valves 34 and 35 may be substituted by a three-way control valve.

[0030] Furthermore, the refrigerant gas pipe 4 and the refrigerant liquid pipe 5 are refrigerant pipes connected to a gas-side service valve and a liquid-side service valve (not shown) provided on the outdoor unit 2 side, and the lengths thereof are determined in accordance with the distances between the outdoor unit 2 and the indoor units 7A and 7B connected thereto, at the time of installation at the site. An appropriate number of branching devices (not shown) are provided at intermediate locations in the refrigerant gas pipe 4 and refrigerant liquid pipe 5, and an appropriate number of indoor units 7A and 7B are connected through these branching devices. Thus, an enclosed refrigeration cycle 3 is formed. Each of the indoor units 7A and 7B includes an indoor heat exchanger 71 that performs heat exchange between the refrigerant and the indoor air to condition the indoor air, an indoor electric expansion valve (EEVC) 72 for cooling, and an indoor fan (not shown) that circulates the indoor air through the indoor heat exchanger 71, and is connected to the branching devices through a branch gas pipe 4A and a branch liquid pipe 5A on the indoor side.

[0031] In the above-described multi-type heat-pump air conditioner 1, a cooling operation is performed as follows.

After a high-temperature, high-pressure refrigerant gas compressed by the compressor 21 is discharged into the discharge pipe 32A, as indicated by an arrow in FIG. 1, the refrigerant gas is circulated toward the gas pipe 32B by the four-way control valve 22 and is then condensed and liquefied by undergoing heat exchange with the outside air, which is blown by an outdoor fan (not shown), in the outdoor heat exchanger 23. After passing through the outdoor electric expansion valve 25 through the liquid pipe 32C, the liquid refrigerant is guided via the bridge circuit 27 to the receiver 28 and is reserved therein, so that the circulated amount is adjusted. In a process of passing through the intermediate heat exchanger 29 through the liquid pipe 32C, part of the liquid refrigerant flowing out of the receiver 28 is diverted from the liquid pipe 32C and is cooled by undergoing heat exchange with the intermediate-pressure refrigerant having been adiabatically expanded by the electric expansion valve (EEVSC) 30. Thus, the liquid refrigerant is supercooled to a predetermined degree and is led out of the outdoor unit 2 into the refrigerant liquid pipe 5, through the bridge circuit 27 and liquid pipe 32C. The liquid refrigerant led out into the refrigerant liquid pipe 5 is diverted into the branch liquid pipe 5A of the indoor units 7A and 7B by a branching device (not shown).

[0032] The liquid refrigerant diverted into the branch liquid pipe 5A flows into each of the indoor units 7A and 7B and is adiabatically expanded by the indoor electric expansion valve (EEVC) 72. The liquid refrigerant converted into a gas-liquid two phase flow flows in the indoor heat exchanger 71. The indoor heat exchanger 71 performs heat exchange with the refrigerant and the indoor air circulated by the indoor fan (not shown), and the indoor air is cooled and used to cool the room. On the other hand, the refrigerant converted into gas reaches the branching device through the branch gas pipe 4A and is merged with the refrigerant gas from the other one of the indoor units 7A and 7B at the refrigerant gas pipe 4. The refrigerant gas merged at the refrigerant gas pipe 4 returns again to the outdoor unit 2, passes through the gas pipe 32D and the four-way control valve 22, reaches the intake pipe 32E, and is introduced into the accumulator 31. Liquid contained in the refrigerant gas is separated by the accumulator 31, and only gas is taken into the compressor 21. This refrigerant is compressed again in the compressor 21. The cooling operation is performed by repeating the above-described cycle.

[0033] On the other hand, a heating operation is performed as follows.

After a high-temperature, high-pressure refrigerant gas compressed by the compressor 21 is discharged into the discharge pipe 32A, as indicated by an arrow in FIG. 2, the refrigerant gas is circulated toward the gas pipe 32D by the four-way control valve 22. This refrigerant is led out of the outdoor unit 2 through the refrigerant gas pipe 4 and is introduced into the indoor units 7A and 7B through the branch gas pipe 4A connected to the refrigerant gas pipe 4 via the branching device. The high-temperature, high-pressure refrigerant gas introduced into each of the indoor units 7A and 7B is subjected to heat exchange with the indoor air circulated by the indoor fan (not shown) in the indoor heat exchanger 71, and the indoor air is heated and used to heat the room. On the other hand, the liquid refrigerant condensed and liquefied by undergoing heat exchange with the indoor air passes through the indoor electric expansion valve (EEVC) 72 and the branch liquid pipe 5A, is merged with the refrigerant from the other one of the indoor units 7A and 7B, and returns to the outdoor unit 2 through the refrigerant liquid pipe 5. Note that, during heating, in the indoor units 7A and 7B, the degree of opening of the indoor electric expansion valve (EEVC) 72 is controlled so that the degree of supercooling of the refrigerant is a constant value at the outlet of the indoor heat exchanger 71, serving as a condenser.

[0034] The refrigerant returned to the outdoor unit 2 passes through the liquid pipe 32C and the bridge circuit 27, flows into the receiver 28, and is reserved therein so that the circulated amount is adjusted. The liquid refrigerant flowing out of the receiver 28 is supercooled similarly to the case of the cooling in the intermediate heat exchanger 29, passes through the liquid pipe 32C and the bridge circuit 27, and reaches the outdoor electric expansion valve (EEVH) 25, where it is adiabatically expanded. Then, the liquid refrigerant passes through the liquid pipe 32C and flows into the outdoor heat exchanger 23. The outdoor heat exchanger 23 performs heat exchange with the refrigerant and the outside air blown by the outdoor fan (not shown), and the refrigerant is vaporized by absorbing heat from the outside air. This refrigerant is introduced from the outdoor heat exchanger 23 into the accumulator 31 through the gas pipe 32B, the four-way control valve 22, and the intake pipe 32E. Liquid contained in the refrigerant gas is separated by the accumulator 31, and only gas is taken into the compressor 21. This refrigerant is compressed again in the compressor 21. The heating operation is performed by repeating the above-described cycle.

[0035] Furthermore, during a heating operation at a low outside-air temperature, the moisture in the outside air may freeze in the form of frost and deposit on the surface of the outdoor heat exchanger 23. Because this frost inhibits heat exchange in the outdoor heat exchanger 23, when deposition of frost is detected, a defrosting (frost removing) operation for melting frost is performed. The defrosting operation is performed by switching the refrigeration cycle 3 to the cooling cycle by the four-way control valve 22. This causes the high-temperature, high-pressure refrigerant gas (hot gas) discharged from the compressor 21 to be introduced into the outdoor heat exchanger 23, and the heat thereof heats and melts the frost on the surface of the heat exchanger from the inside. The melted frost falls, as drain water, onto the drain pan (the bottom plate of the indoor unit 2) on which the outdoor heat exchanger 23 is installed, and is discharged outside from a drain port.

[0036] Furthermore, during the above-described cooling operation, because the solenoid-operated switching valve 34 is opened and the solenoid-operated switching valve 35 is closed, the intermediate-pressure refrigerant vaporized by cooling the liquid refrigerant in the intermediate heat exchanger 29 passes through the gas injection circuit 33 and is directly injected into the compression chamber from the intermediate intake port 21A of the compressor 21. With an economizer effect due to this gas injection, an increase in cooling capacity and improvement of COP (coefficient of performance) are expected. Thus, a high-capacity, high-efficiency (high-performance) heat-pump air conditioner 1 can be realized.

[0037] On the other hand, also during the heating operation and defrosting operation, similarly to the above, the intermediate-pressure refrigerant vaporized by cooling the liquid refrigerant in the intermediate heat exchanger 29 passes through the gas injection circuit 33 and is guided to the intermediate intake port 21A of the compressor 21. However, in this case, because the solenoid-operated switching valve 34 is switched to "close" and the solenoid-operated switching valve 35 is switched to "open", the saturated intermediate-pressure refrigerant gas having left the intermediate heat exchanger 29 is guided from the gas injection circuit 33 to the liquefied injection circuit 36 and is introduced into the auxiliary heat exchanger 24 provided at the lower part of the outdoor heat exchanger 23. The intermediate-pressure refrigerant gas is subjected to heat exchange with the outside air circulated by the outdoor fan and is re-condensed by releasing heat to the outside air to be converted into a gas-liquid two phase or liquid refrigerant.

[0038] This gas-liquid two phase or liquid refrigerant is guided from the auxiliary heat exchanger 24 to the intermediate intake port 21A of the compressor 21 via the liquefied injection circuit 36 and is liquid-injected into the compression chamber. With the liquid injection effect, a further increase in heating capacity and improvement of COP (coefficient of performance) are expected. Thus, a high-capacity, high-efficiency heat-pump air conditioner 1 can be realized. Furthermore, with the improvement of the cooling effect achieved by the liquid injection, the discharging temperature of the refrigerant is effectively restricted. Thus, the operating range can be expanded. Furthermore, the lower part of the outdoor heat exchanger 23 and the drain pan (the bottom plate of the outdoor unit 2), on which the outdoor heat exchanger 23 is installed, can be heated by the above-described heat release.

[0039] Accordingly, this embodiment provides the following advantages.

As it is known, not only can both the capacity and the performance be improved with the economizer effect due to the gas injection, but also the auxiliary heat exchanger 24 provided at the lower part of the outdoor heat exchanger 23 can be made to function as a condenser for the intermediate-pressure refrigerant vaporized in the gas injection circuit 33 during heating and during defrosting. Therefore, it is possible to heat the lower part of the outdoor heat exchanger 23 and the drain pan with the released heat and to prevent them from freezing. Furthermore, because the gas-liquid two phase or liquid refrigerant condensed in the auxiliary heat exchanger 24 can be liquid-injected from the intermediate intake port 21A of the compressor 21, the heating capacity can be further improved and the discharging temperature of the refrigerant can be effectively restricted. Thus, the operating range can be expanded. Accordingly, it is possible to prevent the outdoor heat exchanger 23 and the drain pan from freezing while maintaining the high performance and high capacity of the heat-pump air conditioner 1.

Second Embodiment

[0040] Next, a second embodiment of the present invention will be described using FIGS. 3 to 6.
This embodiment is different from the above-described first embodiment in the refrigerant-circulation circuit for the auxiliary heat exchanger 24 provided at the lower part of the outdoor heat exchanger 23. Because the other structures are the same as the first embodiment, descriptions thereof will be omitted.
FIGS. 3 and 4 show refrigerant circuit diagrams of a heat-pump air conditioner according to the second embodiment of the present invention, in which FIG. 3 shows a cooling cycle, and FIG. 4 shows a heating cycle. In this embodiment, the bridge circuit 27 is omitted, and the gas injection circuit 33 is configured to function only during cooling.

[0041] In this embodiment, the auxiliary heat exchanger 24 having an anti-freezing function provided at the lower part of the outdoor heat exchanger 23 is connected in parallel to the outdoor electric expansion valve 25, and the refrigerant condensed in the outdoor heat exchanger 23 can be circulated through the check valve 40. This embodiment has a structure in which a bypass circuit 43 having an on-off valve 41 and a refrigerant regulating throttle (capillary tube) 42 is connected between the intake pipe 32E at an inlet of the accumulator 31 and a point between the auxiliary heat exchanger 24 and the check valve 40. Furthermore, between the outdoor heat exchanger 23 and the outdoor electric expansion valve 25, a supercooling coil 23A is provided in parallel with the check valve 40 and the auxiliary heat exchanger 24.

[0042] FIGS. 5 and 6 show enlarged views of the lower part of the outdoor heat exchanger 23. The above-mentioned outdoor heat exchanger 23, the auxiliary heat exchanger 24, and the supercooling coil 23A are formed as a single-plate fin-and-tube heat exchanger. The upper part is the outdoor heat exchanger 23 having a structure in which the refrigerant is diverted to a plurality of circuits and is circulated in a plurality of stages of heat exchange tubes. The lower part is the supercooling coil 23A that is formed of two stages of heat exchange tubes and is connected in series with the outdoor heat exchanger 23 and the outdoor electric expansion valve 25. The auxiliary heat exchanger 24 is formed of one stage of heat exchange tube at the bottom, and the lower end thereof is disposed on the drain pan 44 so as to be in contact therewith.
Note that FIG. 5 is a structure applied to the indoor unit 2 of a type in which the outside air is horizontally taken in and is blown out upward, and FIG. 6 is a structure applied to the indoor unit 2 of a type in which the outside air is horizontally taken in and is horizontally blown out without changing the direction.

[0043] In the above-described structure, because the flow of the refrigerant during a cooling operation, during a heating operation, and during a defrosting operation is substantially the same as that according to the above-described first embodiment, a description thereof will be omitted. Operations of the auxiliary heat exchanger 24, the supercooling coil 23A, the on-off valve 41, the bypass circuit 43, etc., will be described below.
During cooling, the on-off valve 41 is closed. Therefore, the refrigerant is not circulated through the bypass circuit 43. Part of the refrigerant condensed in the outdoor heat exchanger 23 is supercooled by the supercooling coil 23A, passes through the outdoor electric expansion valve 25 (fully open), and reaches the receiver 28. Another part of the refrigerant passes through the check valve 40, reaches the auxiliary heat exchanger 24, where it is supercooled, and flows in the receiver 28. Thus, the condensed refrigerant is supercooled by the auxiliary heat exchanger 24 and the supercooling coil 23A and can be supplied to the receiver 28. Furthermore, by causing the gas injection circuit 33 to function, cooling can be performed while operating the heat-pump air conditioner 1 with high efficiency and high capacity.

[0044] On the other hand, during heating and during defrosting, the on-off valve 41 is opened to circulate the refrigerant through the bypass circuit 43. In this case, the high-pressure liquid refrigerant supplied from the receiver 28, in a process of being adiabatically expanded by the outdoor electric expansion valve 25 and, in the form of a gas-liquid two phase flow, circulated sequentially through the supercooling coil 23A and the outdoor heat exchanger 23, is vaporized by absorbing heat from the outside air and is circulated through the gas pipe 32B toward the compressor 21. Furthermore, part of the high-pressure liquid refrigerant from the receiver 28 flows in the auxiliary heat exchanger 24 connected in parallel to the outdoor electric expansion valve 25 and is supercooled by releasing heat to the outside air having a low temperature. By heating the lower part of the outdoor heat exchanger 23 and the drain pan 44 to a temperature higher than freezing temperature utilizing the heat released from the auxiliary heat exchanger 24, they can be prevented from freezing.

[0045] As has been described above, the high-pressure liquid refrigerant always flows into the auxiliary heat exchanger 24. However, if it is kept enclosed in the auxiliary heat exchanger 24, the temperature thereof drops, and, if the temperature drops to 0 °C or below, it freezes. Therefore, the refrigerant in the auxiliary heat exchanger 24 is reduced in pressure by the refrigerant regulating throttle 42 and is returned to the intake pipe 32E through the bypass circuit 43 by a predetermined amount at a time. Thus, it is possible to prevent the occurrence of freezing due to the refrigerant being supercooled to 0 °C or below. Furthermore, because there is no need to flow the refrigerant supercooled in the auxiliary heat exchanger 24 toward the outdoor heat exchanger 23, the heat absorbing effect of the supercooling coil 23A and outdoor heat exchanger 23 is not inhibited.

[0046] Accordingly, this embodiment provides the following advantages.

With the economizer effect due to the gas injection, not only can the capacity and performance during cooling be improved, but also a high-pressure liquid refrigerant can be constantly supplied to the auxiliary heat exchanger 24 provided at the lower part of the outdoor heat exchanger 23 during heating and during defrosting. Thus, the lower part of the outdoor heat exchanger 23 and the drain pan 44 can be heated by the heat released from the high-pressure liquid refrigerant and can be reliably prevented from freezing. Furthermore, because the high-pressure liquid refrigerant supplied to the auxiliary heat exchanger 24 is returned by the bypass circuit 43 toward the intake pipe 32E of the compressor 21, the occurrence of freezing due to the refrigerant remaining in the auxiliary heat exchanger 24 or a reduction in the amount of heat absorption due to the supercooled refrigerant flowing in the outdoor heat exchanger 23 can be eliminated. Accordingly, it is possible to prevent the outdoor heat exchanger 23 and the drain pan from freezing while maintaining the high performance and high capacity of the heat-pump air conditioner 1.

Third Embodiment

[0047] Next, a third embodiment of the present invention will be described using FIGS. 7 to 10.

This embodiment is different from the above-described first and second embodiments in the refrigerant-circulation circuit for the auxiliary heat exchanger 24 provided at the lower part of the outdoor heat exchanger 23. Because the other structures are the same as the first and second embodiments, descriptions thereof will be omitted.

FIGS. 7 to 10 show refrigerant circuit diagrams of a heat-pump air conditioner according to a third embodiment of the present invention, in which FIG. 7 shows a cooling cycle, FIG. 8 shows a heating cycle, FIG. 9 shows an overload heating cycle, and FIG. 10 shows a defrosting cycle. In the heat-pump air conditioner 1 according to this embodiment, the bridge circuit 27 is omitted, and the gas injection circuit 33 is configured to function only during cooling.

[0048] In this embodiment, a hot-gas bypass circuit 53 is connected to the auxiliary heat exchanger 24 having an anti-freezing function provided at the lower part of the outdoor heat exchanger 23. The hot-gas bypass circuit 53 is connected, at one end, to the discharge pipe 32A of the compressor 21 and is connected to the auxiliary heat exchanger 24 through a first on-off valve 50 and a check valve 51. The other end is connected, via the auxiliary heat exchanger 24, through a second on-off valve 52, to the liquid pipe 32C at a point between the outdoor heat exchanger 23 and the outdoor electric expansion valve 25.

[0049] Furthermore, the above-described hot-gas bypass circuit 53 is provided with a first bypass circuit 56 that branches off from a point between the auxiliary heat exchanger 24 and the check valve 51 and is connected to the intake pipe 32E at the inlet of the accumulator 31 through a third on-off valve 54 and a refrigerant regulating throttle 55, and a second bypass circuit 58 that branches off from a point between the auxiliary heat exchanger 24 and the second on-off valve 52 and is connected to the intake pipe 32E at the inlet of the accumulator 31 through a fourth on-off valve 57 and the refrigerant regulating throttle 55.

[0050] In the above-described structure, because the flow of the refrigerant during a cooling operation, during a heating operation, and during a defrosting operation is substantially the same as that according to the above-described first embodiment, a description thereof will be omitted. Operations of the auxiliary heat exchanger 24, the hot-gas bypass circuit 53, the first bypass circuit 56, and the second bypass circuit 58 will be described below.

During cooling, the first on-off valve 50 and the second on-off valve 52 are opened, and the third on-off valve 54 and the fourth on-off valve 57 are closed. Thus, part of the high-temperature, high-pressure hot gas refrigerant discharged from the compressor 21 flows from the discharge pipe 32A, via the hot-gas bypass circuit 53, into the auxiliary heat exchanger 24. This refrigerant is subjected to heat exchange with the outside air in the auxiliary heat exchanger 24 to be condensed and liquefied, is then merged, in the liquid pipe 32C, with the refrigerant having been condensed in the outdoor heat exchanger 23, passes through the outdoor electric expansion valve 25 (fully open), and flows into the receiver 28. Thus, while the auxiliary heat exchanger 24 is made to function as a condenser during cooling, the heat-pump air conditioner 1 can be operated with high capacity and high efficiency to perform cooling.

[0051] Furthermore, during cooling at a low outside-air temperature, in which the outside-air temperature is low, the first on-off valve 50 can be closed to block the hot-gas bypass circuit 53, so that the flow of the hot gas refrigerant into the auxiliary heat exchanger 24 can be stopped. Because this provides substantially the same effect as a reduction in size of the condenser, the condensing performance can be restricted. Therefore, by controlling the condensing pressure to keep the high pressure at a predetermined pressure or more, the cooling operation can be continued.

[0052] On the other hand, during heating, the first on-off valve 50 and the fourth on-off valve 57 are closed, and the second on-off valve 52 and the third on-off valve 54 are opened. Thus, part of the gas-liquid two phase refrigerant having been adiabatically expanded in the outdoor electric expansion valve 25 flows through the second on-off valve 52 into the auxiliary heat exchanger 24, absorbs heat from the outside air, and is vaporized. This refrigerant is guided, via the third on-off valve 54 and the refrigerant regulating throttle 55, from the first bypass circuit 56 to the intake pipe 32E at the inlet of the accumulator 31, is merged with the refrigerant vaporized via the outdoor heat exchanger 23, and is then taken into the compressor 21. Thus, while the auxiliary heat exchanger 24 is made to function as an evaporator during heating, the heat-pump air conditioner 1 can be operated with high capacity and high efficiency to perform heating.

[0053] When the outside-air temperature rises during a heating operation, reducing the heating load and leading to overload heating conditions, the first on-off valve 50 and the fourth on-off valve 57 are opened, and the second on-off valve 52 and the third on-off valve 54 are closed. This allows part of the high-temperature, high-pressure hot gas refrigerant discharged from the compressor 21 to flow from the discharge pipe 32A, through the hot-gas bypass circuit 53, into the auxiliary heat exchanger 24. This refrigerant, after releasing heat to the outside air to be condensed in the auxiliary heat exchanger 24, is guided from the fourth on-off valve 57, via the second bypass circuit 58, through the refrigerant regulating throttle 55, to the intake pipe 32E at the inlet of the accumulator 31. Thus, by making the auxiliary heat exchanger 24 function as a radiator under overload heating conditions, the operation can be continued while adjusting the heating capacity.

[0054] Furthermore, during defrosting, the first on-off valve 50 and the fourth on-off valve 57 are opened, and the second on-off valve 52 and the third on-off valve 54 are closed. Thus, part of the high-temperature, high-pressure hot gas refrigerant discharged from the compressor 21 flows from the discharge pipe 32A, via the hot-gas bypass circuit 53, into the auxiliary heat exchanger 24. This refrigerant releases heat in the auxiliary heat exchanger 24 and is used to heat the lower part of the outdoor heat exchanger 23 and the drain pan 44 (see FIGS. 5 and 6). The refrigerant condensed by releasing heat is guided from the fourth on-off valve 57, via the second bypass circuit 58, through the refrigerant regulating throttle 55, to the intake pipe 32E at the inlet of the accumulator 31. Thus, by making the auxiliary heat exchanger 24 function as a radiator during defrosting, it can be used to prevent the drain water, resulting from melted frost, from refreezing.

[0055] Accordingly, this embodiment provides the following advantages.

With the economizer effect due to the gas injection, not only can the capacity and performance during cooling be improved, but also the auxiliary heat exchanger 24 provided at the lower part of the outdoor heat exchanger 23 can be made to function as a condenser during cooling. Thus, the cooling capacity can be improved by increasing the condensing performance. Furthermore, because the function as a condenser can be aborted to restrict the condensing performance during cooling at a low outside-air temperature, it is possible to continue the cooling operation while keeping the high pressure at a predetermined pressure or more. Thus, the operating range can be expanded. Furthermore, because the auxiliary heat exchanger 24 can be made to function as an evaporator during heating and can be made to function as a radiator under overload heating conditions, it can be used to improve and adjust the heating capacity. In addition, because the auxiliary heat exchanger 24 can be made to function as a radiator during defrosting, the lower part of the outdoor heat exchanger 23 and the drain pan can be heated and reliably prevented from freezing. Accordingly, it is possible to prevent the outdoor heat exchanger 23 and the drain pan from freezing while maintaining the high performance and high capacity of the heat-pump air conditioner 1.

[0056] Note that the present invention is not limited to the invention according to the above-described embodiments, but may be appropriately modified within a scope not departing from the spirit thereof. For example, although the above-described embodiments have been described taking a multi-type heat-pump air conditioner as an example, the heat-pump air conditioner need not necessarily be a multi type, and the present invention can of course be applied to a single-type heat-pump air conditioner having one indoor unit. Furthermore, although the case where there is one outdoor unit 2 has been described, the heat-pump air conditioner is not limited to this, but may be of a multi-outdoor-unit type, in which a plurality of outdoor units 2 are provided in parallel. Furthermore, the outdoor unit 2 may be of a type in which a plurality of compressors 21 or a plurality of outdoor heat exchangers 23 and outdoor fans are provided in parallel.

[0057] In addition, although, in the second and third embodiments, the gas injection circuit 33 is configured to function only during cooling, the gas injection circuit 33 may be, similarly to the first embodiment, configured to function also during heating. Furthermore, although the gas injection circuit 33 of a type which uses the intermediate heat exchanger 29 has been described, it may of course be configured to use a gas liquid separator instead of the intermediate heat exchanger 29.

Claims

1. A heat-pump air conditioner that forms a refrigeration cycle by sequentially connecting, at least, a compressor, a four-way control valve, an outdoor heat exchanger, an outdoor electric expansion valve, an indoor electric expansion valve, and an indoor heat

exchanger, and that has a gas injection circuit provided in the refrigeration cycle, the gas injection circuit vaporizing part of liquid refrigerant in the cycle, cooling the liquid refrigerant using latent heat of vaporization, and injecting vaporized intermediate-pressure refrigerant into an intermediate intake port of the compressor,
wherein an auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger, and
wherein a liquefied injection circuit is connected, which, after the intermediate-pressure refrigerant vaporized in the gas injection circuit is switched by a switching valve to be introduced into the auxiliary heat exchanger, guides the refrigerant to the intermediate intake port of the compressor.

2. A heat-pump air conditioner that forms a refrigeration cycle by sequentially connecting, at least, a compressor, a four-way control valve, an outdoor heat exchanger, an outdoor electric expansion valve, an indoor electric expansion valve, and an indoor heat exchanger, and that has a gas injection circuit provided in the refrigeration cycle, the gas injection circuit vaporizing part of liquid refrigerant in the cycle, cooling the liquid refrigerant using latent heat of vaporization, and injecting vaporized intermediate-pressure refrigerant into an intermediate intake port of the compressor,
wherein an auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger, and
wherein the auxiliary heat exchanger is connected in parallel to the outdoor electric expansion valve through a check valve that allows a flow of condensed refrigerant from the outdoor heat exchanger, and a bypass circuit having an on-off valve is provided between an intake pipe of the compressor and a point between the check valve and the auxiliary heat exchanger.

3. The heat-pump air conditioner according to claim 2, wherein the bypass circuit is provided with a refrigerant regulating throttle.

4. The heat-pump air conditioner according to claim 2 or 3,
wherein a supercooling coil is provided in parallel with the check valve and the auxiliary heat exchanger, between the outdoor heat exchanger and the outdoor electric expansion valve.

5. A heat-pump air conditioner that forms a refrigeration cycle by sequentially connecting, at least, a compressor, a four-way control valve, an outdoor heat exchanger, an outdoor electric expansion valve, an indoor electric expansion valve, and an indoor heat exchanger, and that has a gas injection circuit provided in the refrigeration cycle, the gas injection circuit vaporizing part of liquid refrigerant in the cycle, cooling the liquid refrigerant using latent heat of vaporization, and injecting vaporized intermediate-pressure refrigerant into an intermediate intake port of the compressor,
wherein an auxiliary heat exchanger having an anti-freezing function is provided at a lower part of the outdoor heat exchanger, and
wherein a hot-gas bypass circuit that introduces part of the hot gas discharged from the compressor into the auxiliary heat exchanger through a first on-off valve and guides the refrigerant to a point between the outdoor heat exchanger and the outdoor electric expansion valve through a second on-off valve; a first bypass circuit that guides the refrigerant at the point between the outdoor electric expansion valve and the outdoor heat exchanger to an intake pipe of the compressor via the second on-off valve, the auxiliary heat exchanger, a third on-off valve, and a refrigerant regulating throttle during heating; and a second bypass circuit that condenses, in the auxiliary heat exchanger, the hot gas introduced through the first on-off valve during heating or during defrosting and guides the hot gas to the intake pipe of the compressor via a fourth on-off valve and the refrigerant regulating throttle, are provided.

6. The heat-pump air conditioner according to claim 6, wherein the first bypass circuit and the second bypass circuit are provided with a common refrigerant regulating throttle.

FIG. 1

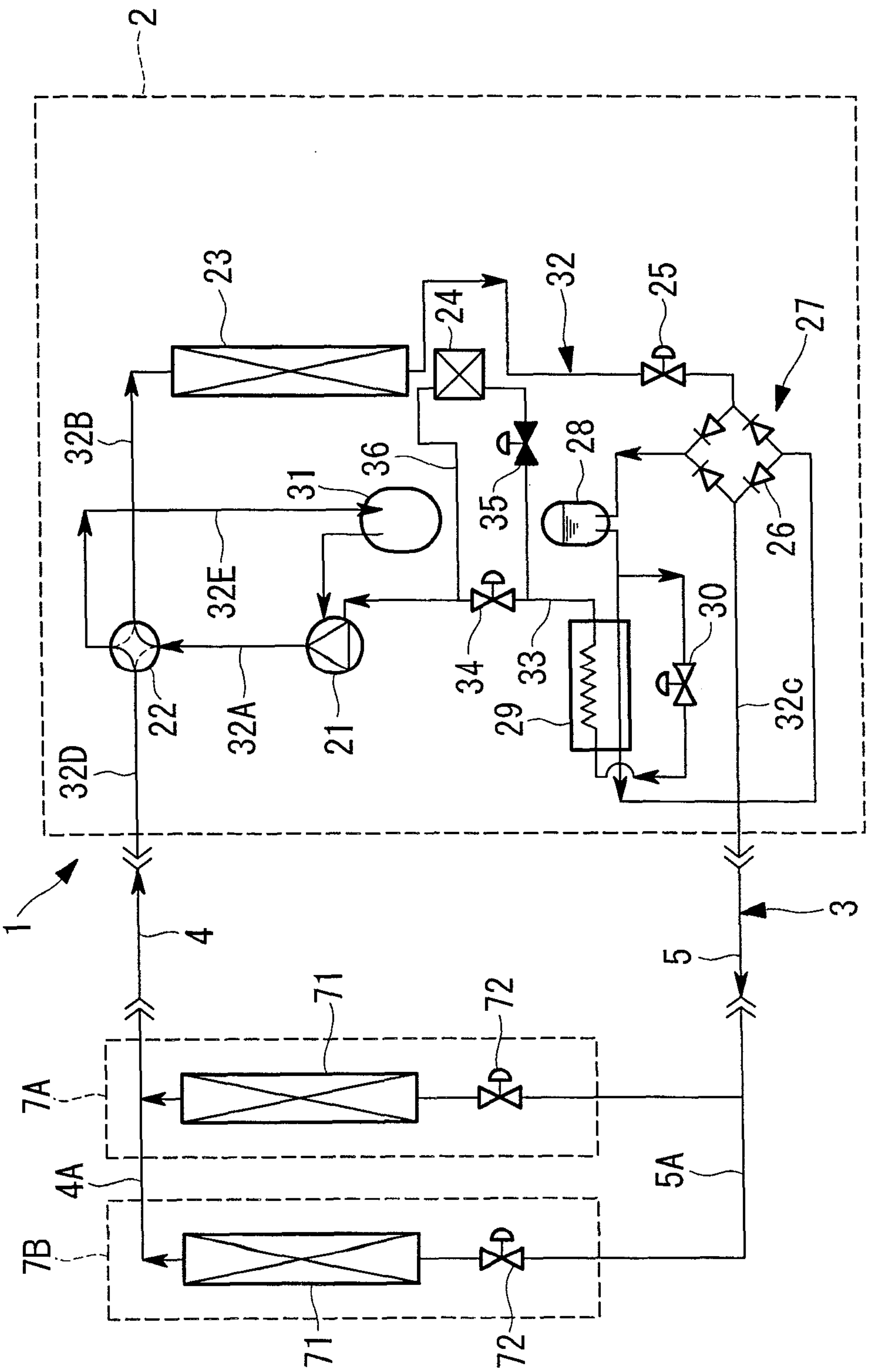
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FIG. 2

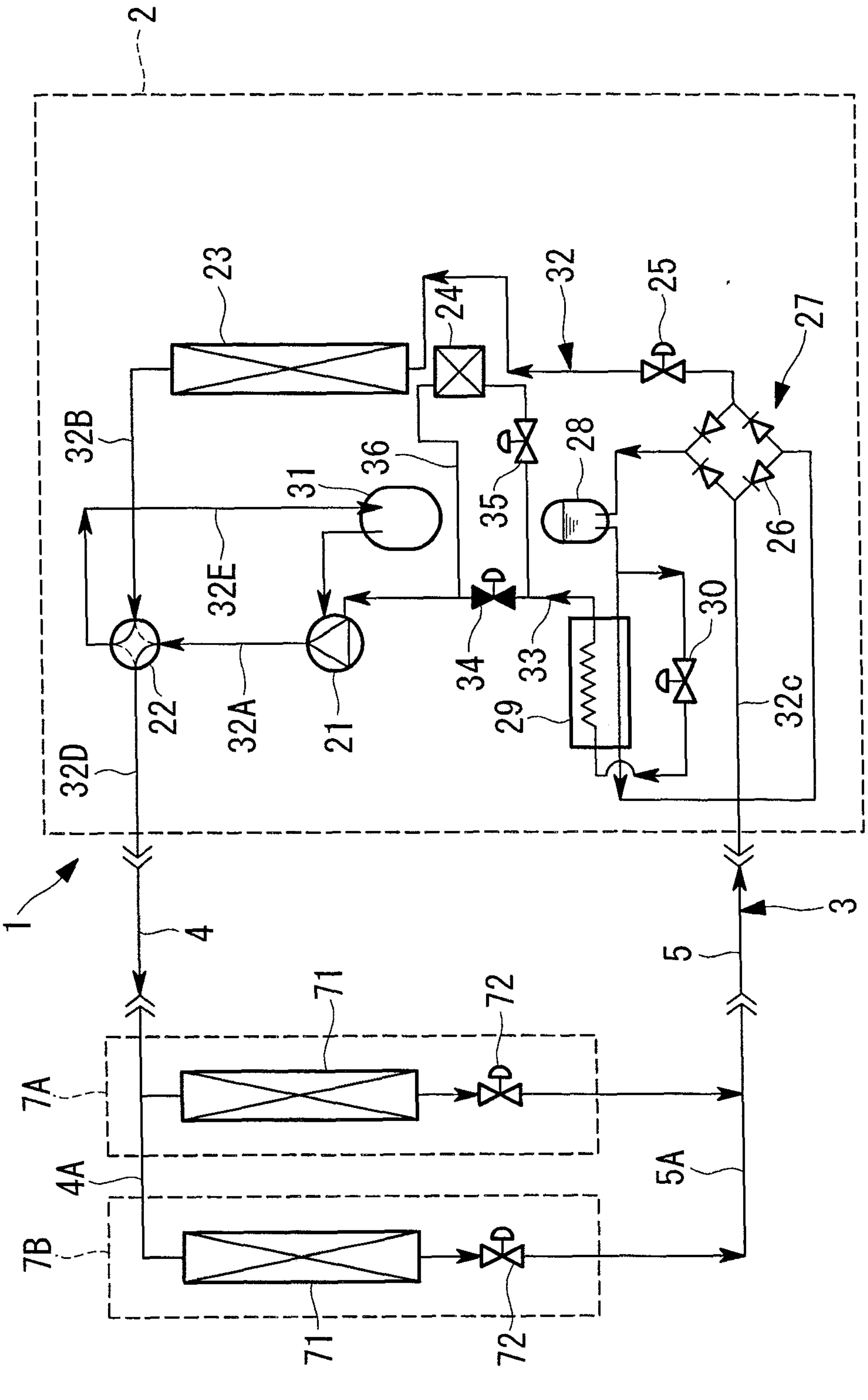
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FIG. 3

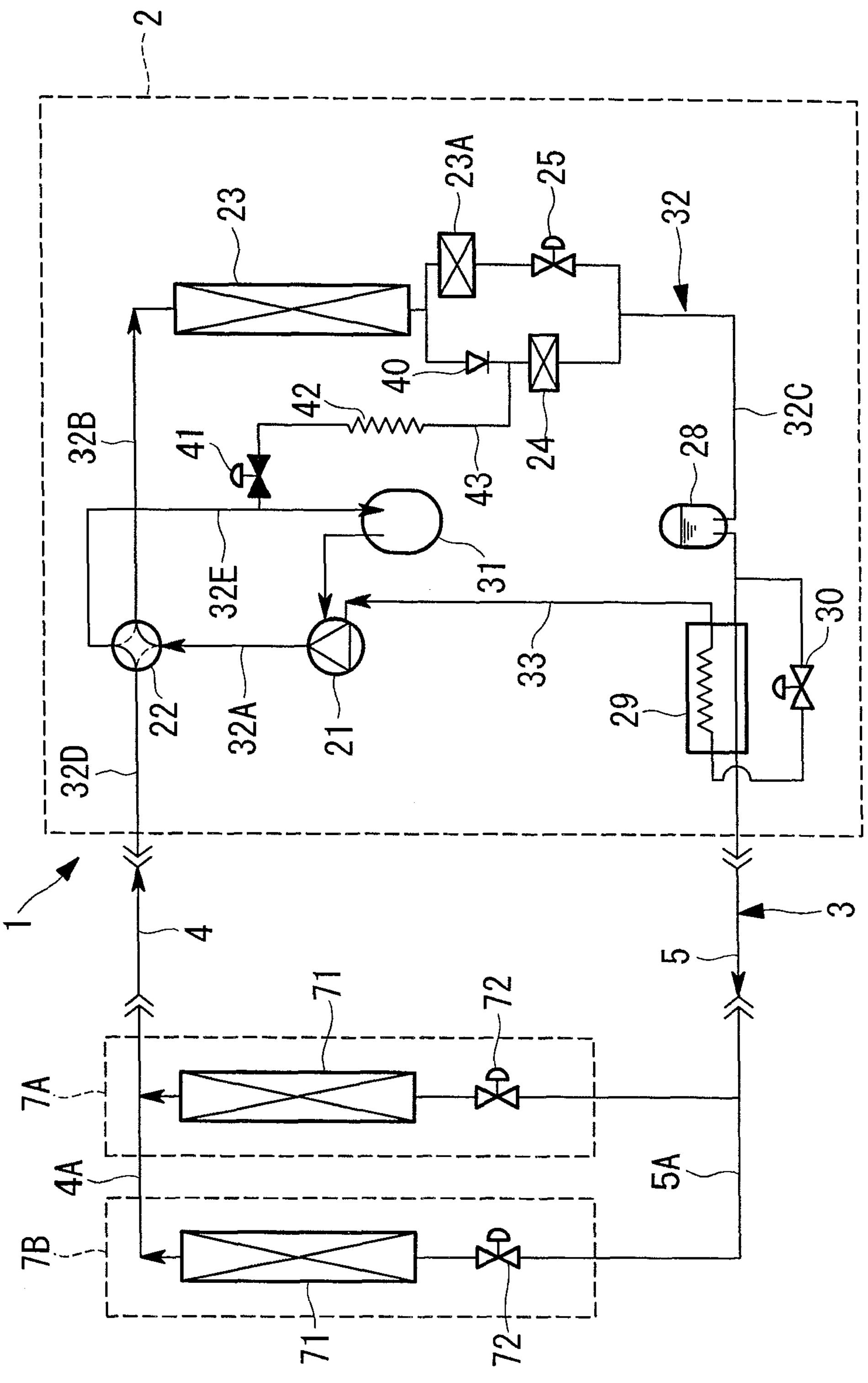
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FIG. 4

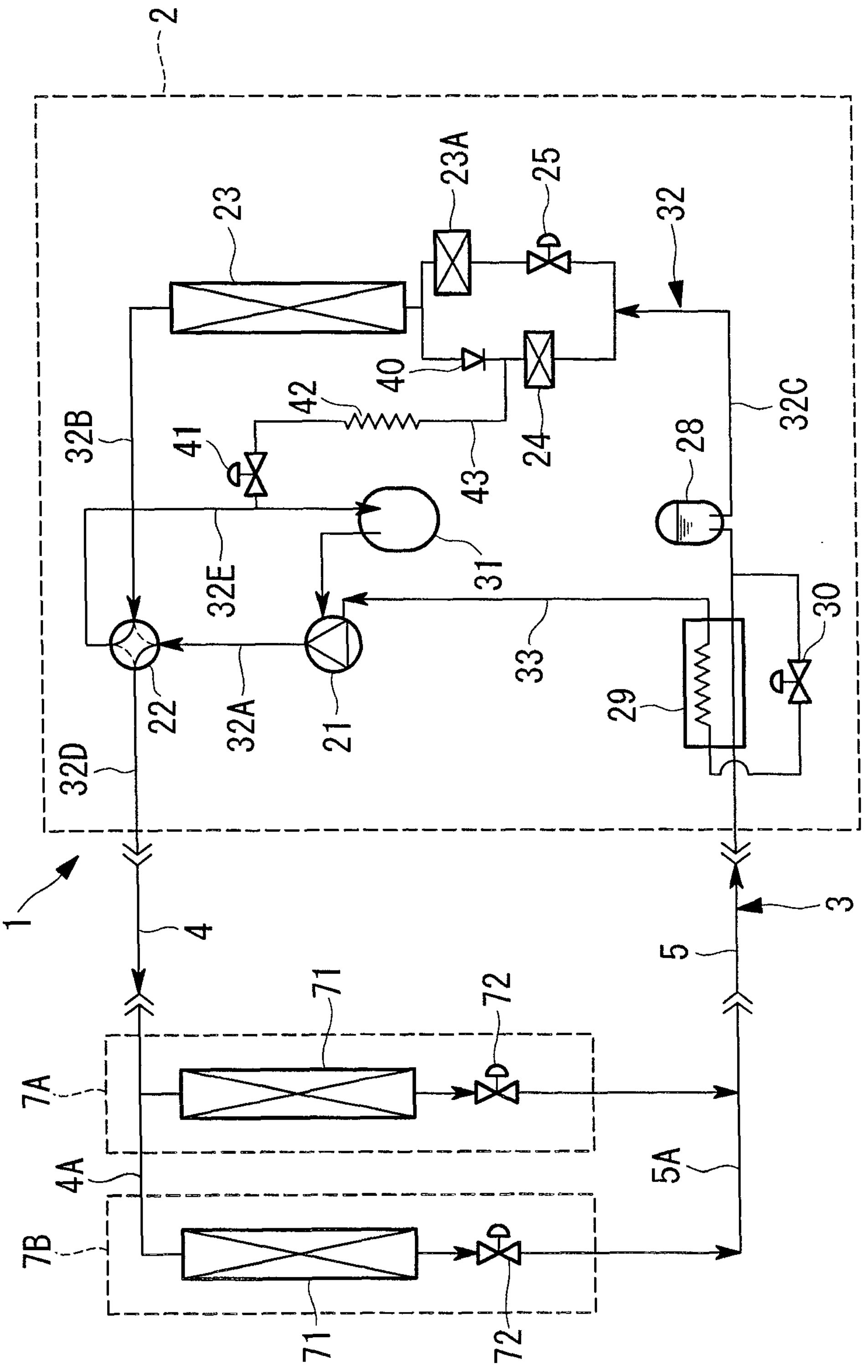
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FIG. 5

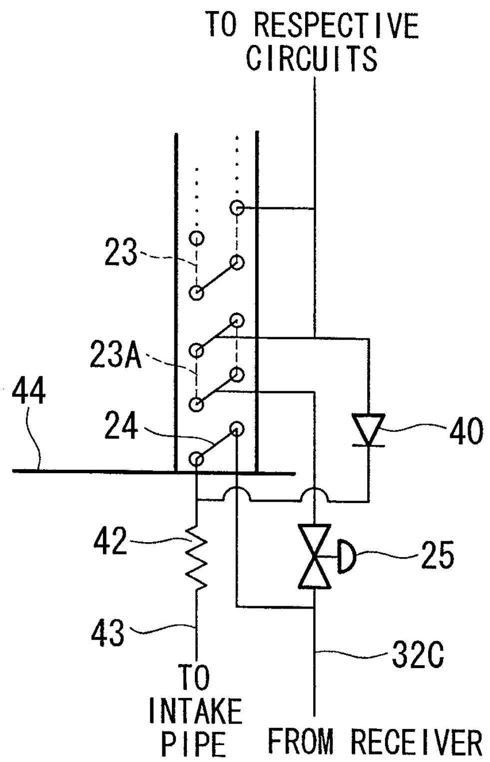
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FIG. 6

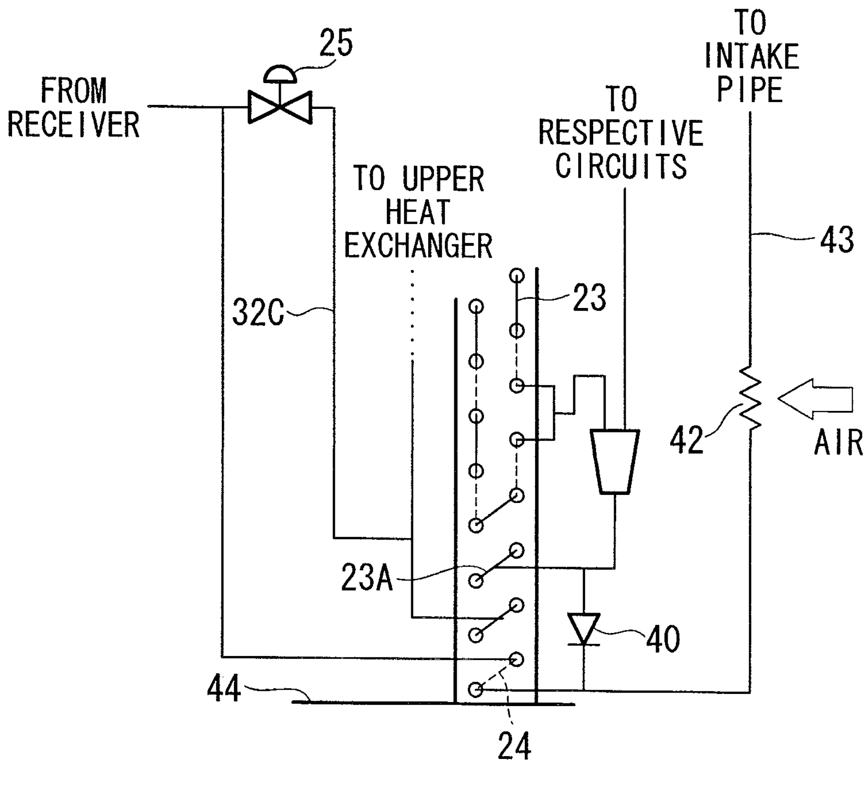
25
FROM RECEIVER
TO INTAKE PIPE
TO RESPECTIVE CIRCUITS
TO UPPER HEAT EXCHANGER
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FIG. 7

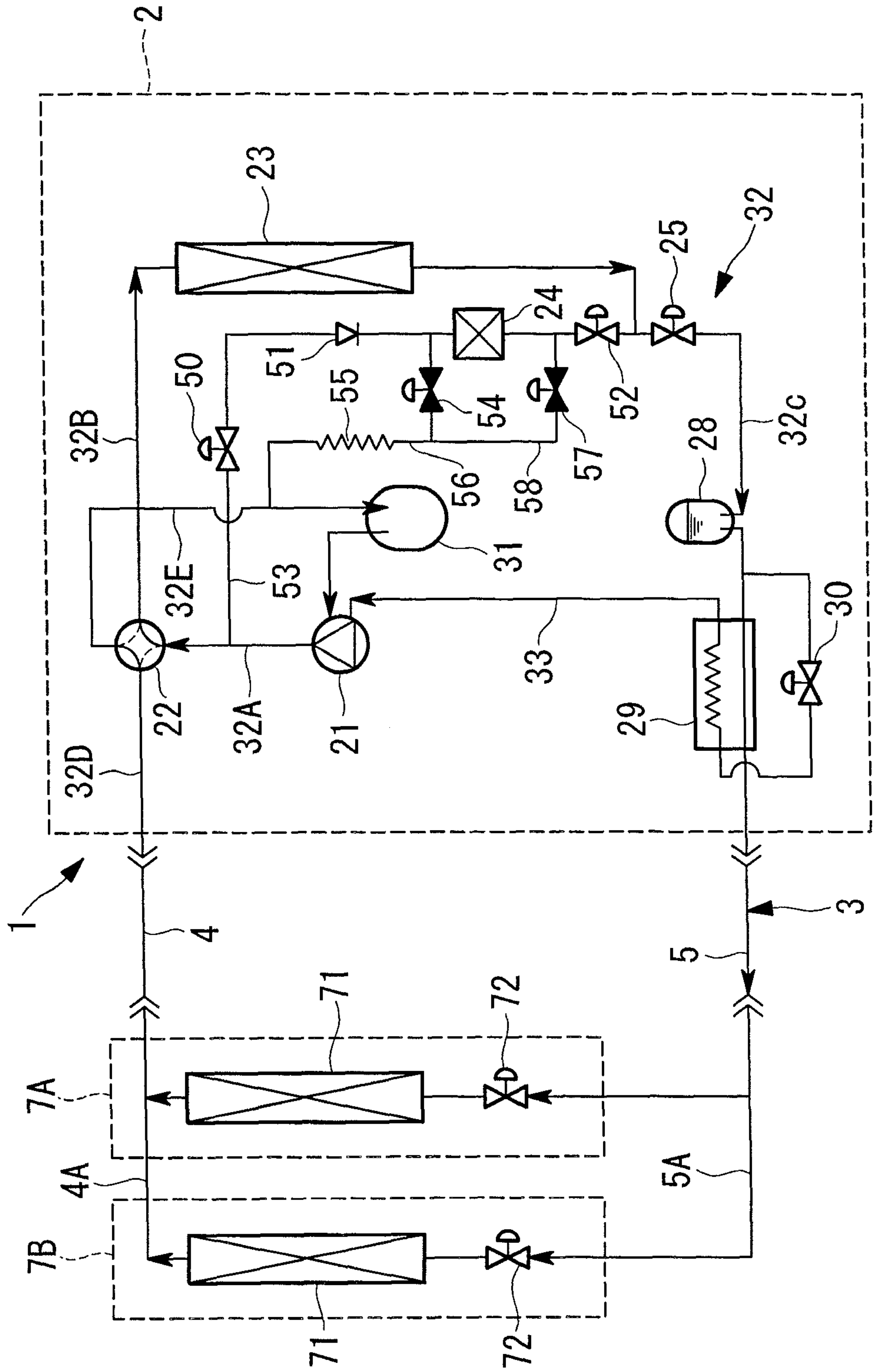
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FIG. 8

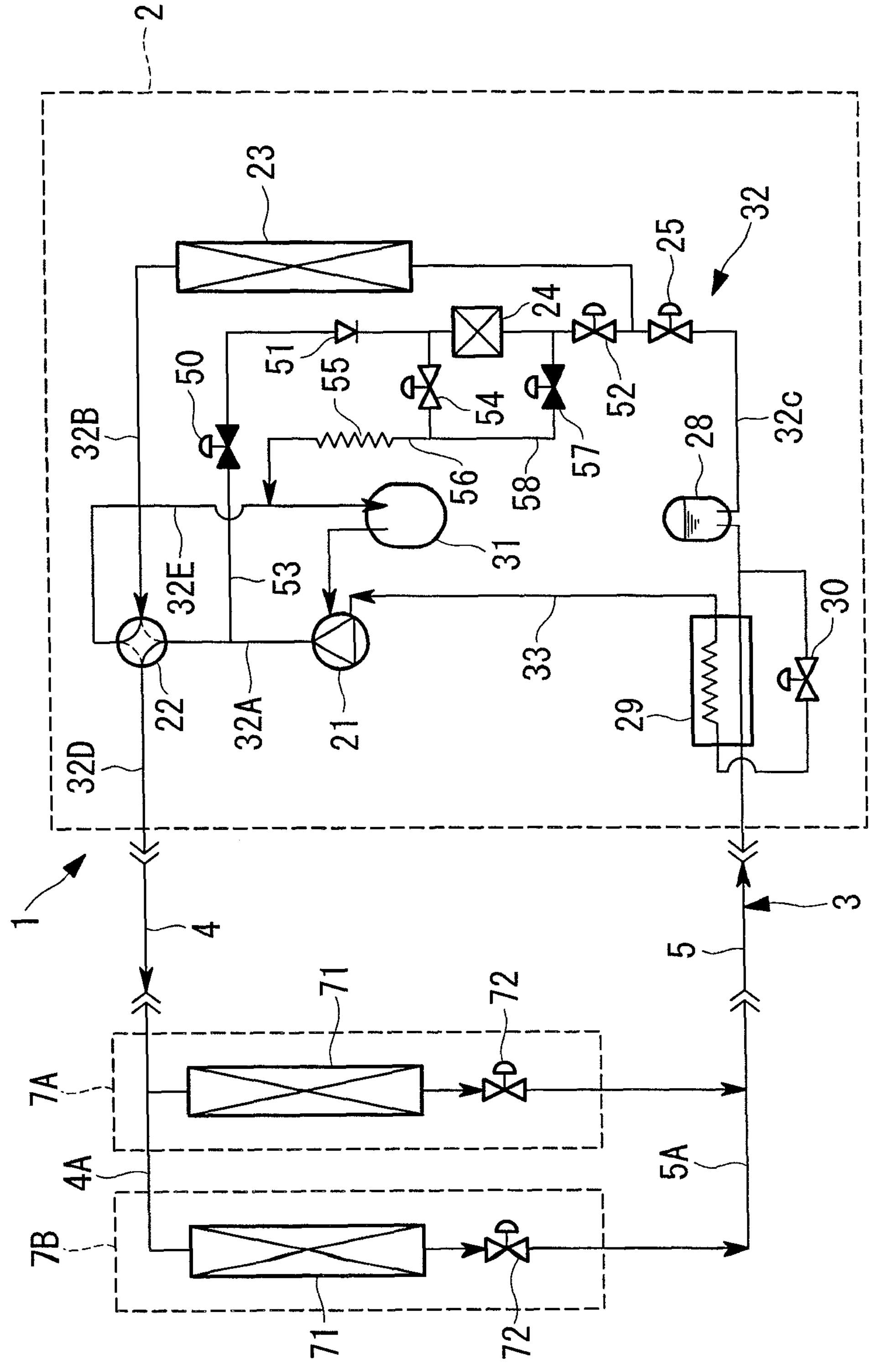
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FIG. 9

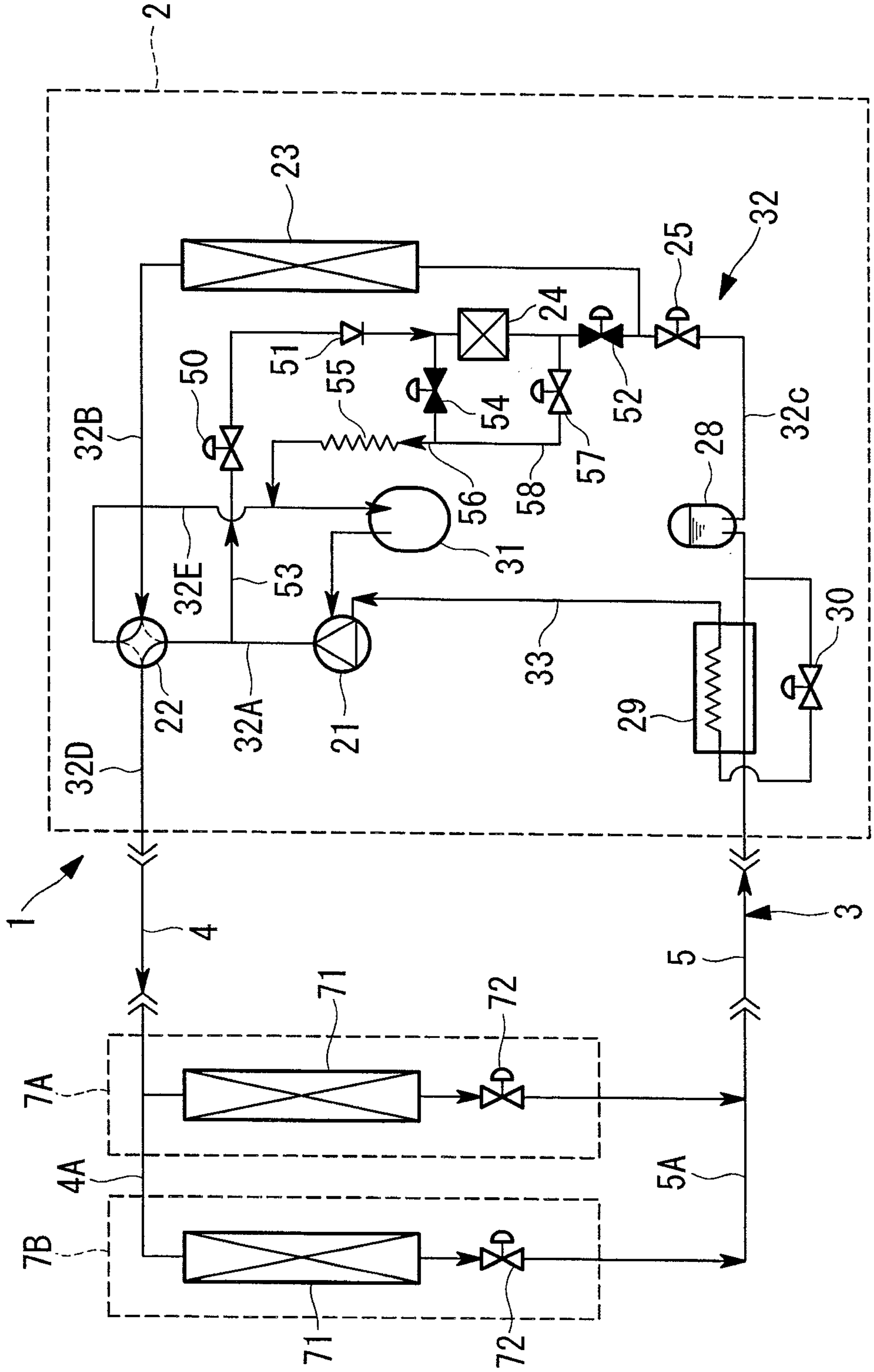
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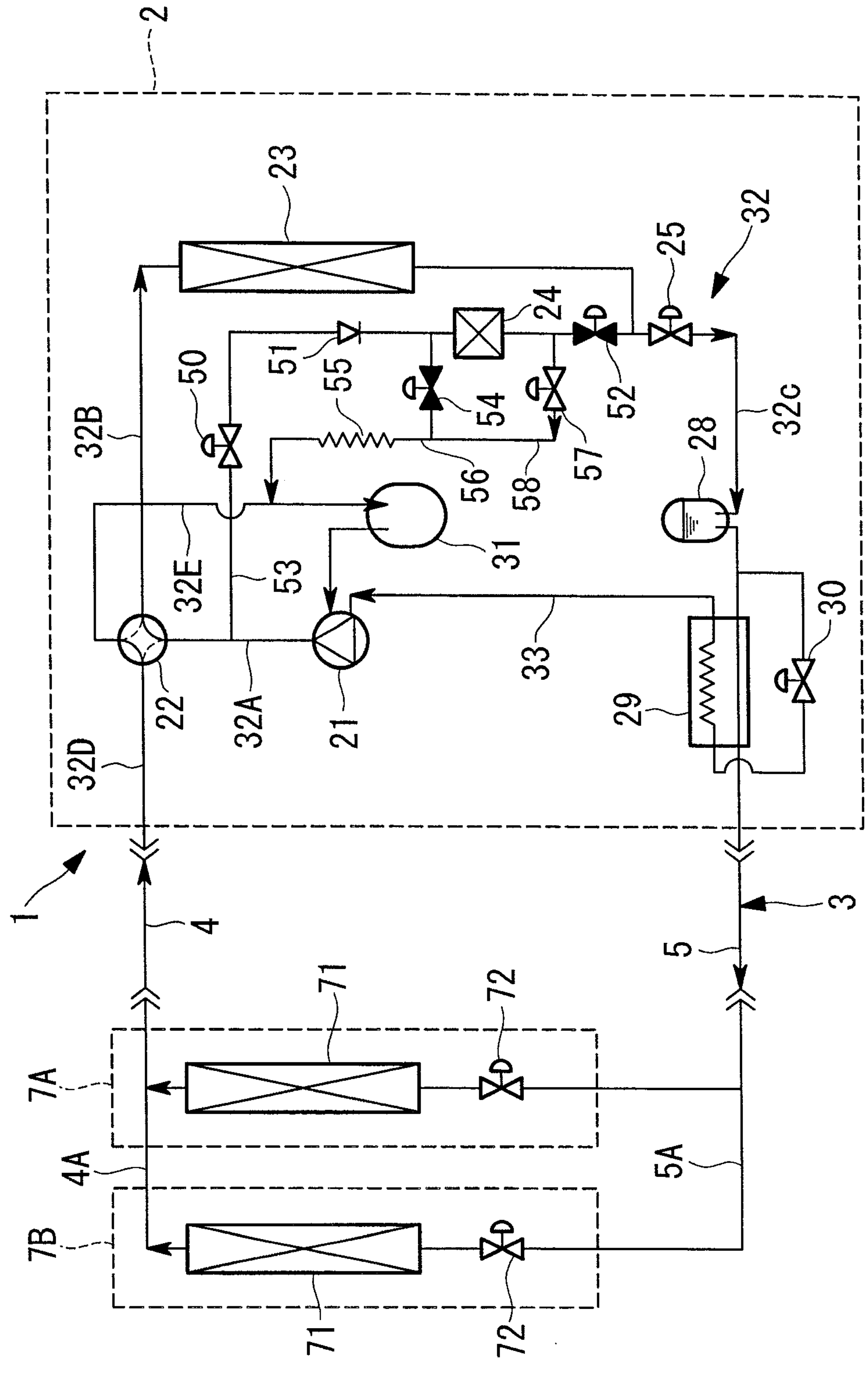
FIG. 10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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070471

A. CLASSIFICATION OF SUBJECT MATTER
F25B47/02(2006.01)i, *F25B1/00*(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)
F25B47/02, F25B1/00

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	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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 A	JP 2007-132628 A (Sanyo Electric Co., Ltd.), 31 May, 2007 (31.05.07), Par. Nos. [0010] to [0013]; Fig. 1 (Family: none)	1 2-6
Y A	JP 6-180164 A (Mitsubishi Heavy Industries, Ltd.), 28 June, 1994 (28.06.94), Par. Nos. [0011], [0019] to [0026]; Figs. 1 to 3, 5 (Family: none)	1 2-6
Y A	JP 2006-258343 A (Mitsubishi Electric Corp.), 28 September, 2006 (28.09.06), Par. No. [0009]; Fig. 1 (Family: none)	1 2-6

☒ 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	Date of mailing of the international search report
06 February, 2009 (06.02.09)	17 February, 2009 (17.02.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070471

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-263440 A (Mitsubishi Electric Corp.), 11 October, 2007 (11.10.07), Full text; Figs. 1 to 10 (Family: none)	1-6
A	JP 7-280378 A (Mitsubishi Heavy Industries, Ltd.), 27 October, 1995 (27.10.95), Full text; Figs. 1 to 6 (Family: none)	1-6
A	JP 2001-330332 A (Daikin Industries, Ltd.), 30 November, 2001 (30.11.01), Par. No. [0022]; Fig. 3 (Family: none)	1-6
A	JP 8-193771 A (Hitachi, Ltd.), 30 July, 1996 (30.07.96), Par. Nos. [0009] to [0023]; Figs. 1 to 3 (Family: none)	1,5,6
A	JP 61-101762 A (Matsushita Electric Industrial Co., Ltd.), 20 May, 1986 (20.05.86), Page 2, lower left column, line 8 to lower right column, line 14; Figs. 1 to 3 (Family: none)	2
A	JP 4-186074 A (Matsushita Seiko Co., Ltd.), 02 July, 1992 (02.07.92), Page 2, lower right column, lines 1 to 13; Fig. 1 (Family: none)	5,6

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070471

Comment on the invention of claim 6:

Claim 6 states that it cites claim 6; however, because of the terms "the first bypass circuit" etc., the international search was performed based on the estimation that what is cited in claim 6 is claim 5.

Form PCT/ISA/210 (extra sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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- JP HEI7280378 B **[0005]**
- JP 2006097992 A **[0005]**