(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 489 965 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
22.08.2012 Bulletin 2012/34

(21) Application number: **10823244.8**

(22) Date of filing: **11.08.2010**

(51) Int Cl.:
F25B 41/00 *(2006.01)* ***F25B 1/00*** *(2006.01)*
F25B 7/00 *(2006.01)*

(86) International application number:
PCT/JP2010/063638

(87) International publication number:
WO 2011/045976 (21.04.2011 Gazette 2011/16)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: **16.10.2009 JP 2009238938**

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(54) AIR-CONDITIONING HOT-WATER SUPPLY SYSTEM

(57) Problem to be Solved:

To provide an air-conditioning hot-water supply system in which the advantages of an ejector can be provided in both cooling operation and heating operation and which allows a reduction in power consumption of an air-conditioning refrigerant circuit.

Solution:

An air-conditioning refrigerant circuit (10) for selectively performing cooling operation and heating operation is composed of two circuits: a high-temperature-side refrigerant circuit constructed of a discharge portion (18c) of an ejector (18), a compressor (11), a four-way valve (12b), an intermediate heat exchanger (90), a second heat exchanger (17b), and a nozzle portion (18a) of the ejector; and a low-temperature-side refrigerant circuit constructed of the discharge portion (18c) of the ejector, the compressor (11), a four-way valve (12a), a heat exchanger (13a), an expansion valve (14), an expansion valve (16), a first heat exchanger (17a), and a suction portion (18b) of the ejector. A refrigerant pipe of the low-temperature-side refrigerant circuit for connecting between the expansion valve (14) and the expansion valve (16) is joined to a refrigerant pipe of the high-temperature-side refrigerant circuit for connecting between the intermediate heat exchanger (90) and the second heat exchanger (17b), to form a common refrigerant circuit into which a refrigerant flows from both of the high-temperature-side refrigerant circuit and the low-temperature-side refrigerant circuit. An air-conditioning expansion valve (15) is incorporated in the common refrigerant circuit.

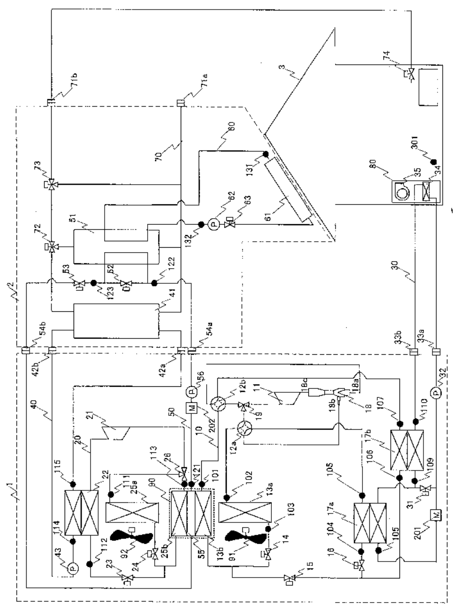

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an air-conditioning hot-water supply system, and particularly, is suitable for an air-conditioning hot-water supply system with a cascade refrigerating system in which an air-conditioning refrigerant circuit for selectively performing cooling and heating and a hot-water supply refrigerant circuit for storing hot water are connected to each other through an intermediate heat exchanger.

BACKGROUND ART

[0002] Techniques for driving an ejector by using the difference between two temperatures include a technique such as disclosed in Japanese Published Unexamined Patent Application No. 2001-147050 (Patent Literature 1).

[0003] The technique disclosed in Japanese Published Unexamined Patent Application No. 2001-147050 includes a compressor, a condenser, expansion valve for cold room means for decompressing a refrigerant to a first pressure, expansion valve for freezer means for decompressing the refrigerant to a second pressure, a cold room evaporator for cooling the air to be delivered to a cold room to a first temperature by evaporating the refrigerant expanded by the expansion valve for cold room means, and a freezer evaporator for cooling the air to be delivered to a freezer to a second temperature by evaporating the refrigerant expanded by the expansion valve for freezer means, wherein an ejector mixes the refrigerants passed through the cold room evaporator and the freezer evaporator, and increases the pressure, and then discharges the refrigerant to the compressor.

[0004] This technique is designed to allow the ejector to operate between the evaporators for two temperatures, namely, the cold room and the freezer of a refrigerator, and includes the expansion valve for cold room means for decompressing the refrigerant to the first pressure, the expansion valve for freezer means for decompressing the refrigerant to the second pressure, the cold room evaporator for cooling the air to the first temperature, and the freezer evaporator for cooling the air to the second temperature. Therefore, the temperature level relationship among the heat exchangers is the condenser > the cold room evaporator > the freezer evaporator, and consequently, even if the temperature of the cold room evaporator for driving the ejector is lower than the condenser temperature, the ejector can be driven.

CITATION LIST

PATENT LITERATURE

[0005]

Patent Literature 1: JP-A No. 2001-147050

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] By the way, because air conditioning systems need to perform both cooling operation and heating operation, even if a refrigerant flow direction is reversed, the ejector should offer similar advantages. However, there is a problem in the above-described related art in that, if a refrigerant flow direction is reversed, it becomes difficult to provide the advantages of the ejector.

[0007] Accordingly, the present invention has been made in view of such circumstances, and an object of the present invention is to provide an air-conditioning hot-water supply system in which the advantages of an ejector can be provided in both cooling operation and heating operation and which allows a reduction in power consumption of an air-conditioning refrigerant circuit.

SOLUTION TO PROBLEM

[0008] In order to accomplish the above-mentioned object, the present invention, according to a feature, provides an air-conditioning hot-water supply system including: an air-conditioning refrigerant circuit (10) for selectively performing cooling operation and heating operation; a hot-water supply refrigerant circuit (20) for supplying hot water; and an air-conditioning liquid circulation circuit (30) for performing indoor air conditioning. The air-conditioning hot-water supply system has: an intermediate heat exchanger (90) for performing heat exchange between the air-conditioning refrigerant

circuit (10) and the hot-water supply refrigerant circuit (20); and air-conditioning use-side first and second heat exchangers (17a) and (17b) for performing heat exchange between the air-conditioning refrigerant circuit (10) and the air-conditioning liquid circulation circuit (30). The air-conditioning refrigerant circuit (10) is composed of two circuits: an air-conditioning high-temperature-side refrigerant circuit constructed such that a discharge portion (18c) of an ejector (18), an air-conditioning compressor (11), a second four-way valve (12b) for changing a refrigerant flow direction, the intermediate heat exchanger (90), the air-conditioning use-side second heat exchanger (17b), and a nozzle portion (18a) of the ejector (18) are sequentially connected through a refrigerant pipe; and an air-conditioning low-temperature-side refrigerant circuit constructed such that the discharge portion (18c) of the ejector (18), the air-conditioning compressor (11), a first four-way valve (12a) for changing the refrigerant flow direction, an air-conditioning heat-source-side heat exchanger (13a) for performing heat exchange with outdoor air, an air-conditioning heat-source-side expansion valve (14), an air-conditioning use-side expansion valve (16), the air-conditioning use-side first heat exchanger (17a), and a suction portion (18b)
of the ejector (18) are sequentially connected through a refrigerant pipe. The refrigerant pipe of the air-conditioning low-temperature-side refrigerant circuit for connecting between the air-conditioning heat-source-side expansion valve (14) and the air-conditioning use-side expansion valve (16) is joined to the refrigerant pipe of the air-conditioning high-temperature-side refrigerant circuit for connecting between the intermediate heat exchanger (90) and the air-conditioning use-side second heat exchanger (17b), to form a common refrigerant circuit into which a refrigerant flows from both of the air-conditioning high-temperature-side refrigerant circuit and the air-conditioning low-temperature-side refrigerant circuit. Also, an air-conditioning expansion valve (15) for decompressing the refrigerant is incorporated in the common refrigerant circuit.

[0009] Furthermore, a feature of the air-conditioning hot-water supply system according to the present invention is that the above-described structure further includes a heat source liquid circulation circuit (50) for releasing heat or endothermic to or from the air-conditioning refrigerant circuit (10) and the hot-water supply refrigerant circuit (20) using hot and cold sources. The intermediate heat exchanger (90) performs heat exchange among the air-conditioning refrigerant circuit (10), the hot-water supply refrigerant circuit (20), and the heat source liquid circulation circuit (50).

[0010] Moreover, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the intermediate heat exchanger (90) is designed to perform heat exchange with a physical contact between a heat transfer pipe for absorbing and releasing heat of the refrigerant flowing through the hot-water supply refrigerant circuit (20) and a heat transfer pipe for endothermic and releasing heat of the refrigerant flowing through the air-conditioning refrigerant circuit (10).

[0011] Additionally, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the air-conditioning heat-source-side heat exchanger (13a) and the intermediate heat exchanger (90) are provided close to each other so as to allow heat exchange between the refrigerant flowing through the air-conditioning heat-source-side heat exchanger (13a) and the refrigerant flowing through the intermediate heat exchanger (90).

[0012] Furthermore, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, cooling and heating operation is performed by synchronizing opening and closing operation between the first four-way valve and the second four-way valve.

[0013] In addition, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, during heating operation, the opening position of the air-conditioning expansion valve (15) is controlled on the basis of liquid temperature of the heat source liquid circulation circuit (50), and the opening position of the air-conditioning heat-source-side expansion valve (14) is controlled on the basis of outdoor air temperature.

[0014] Moreover, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, during cooling operation, the opening position of the air-conditioning expansion valve (15) is controlled on the basis of an indoor-outdoor temperature differential, and the opening position of the air-conditioning use-side expansion valve (16) is controlled on the basis of a dew point temperature.

[0015] Additionally, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, an air-conditioning control valve (19) is incorporated in a branch portion at which the refrigerant circuit from an outlet of the air-conditioning compressor (11) branches into the air-conditioning high-temperature-side refrigerant circuit and the air-conditioning low-temperature-side refrigerant circuit. The air-conditioning control valve selectively changes a refrigerant flow path between the air-conditioning high-temperature-side refrigerant circuit and the air-conditioning low-temperature-side refrigerant circuit.

[0016] Furthermore, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the ejector (18) can be changed in flow resistance by changing a cross-sectional area of the nozzle portion (18a) of the ejector (changing the opening position of the nozzle portion).

[0017] Moreover, a feature of the air-conditioning hot-water supply system according to the present invention is that the above-described structure further includes a hot-water supply liquid circulation circuit (40) for releasing or endothermic...

to or from the hot-water supply refrigerant circuit (20) using hot and cold sources. The hot-water supply refrigerant circuit (20) has: a first hot-water supply refrigerant circuit constructed such that an outlet of a hot-water supply compressor (21), a hot-water supply use-side heat exchanger (22) for performing heat exchange with the hot-water supply liquid circulation circuit (40), a hot-water supply expansion valve (23) for decompressing the refrigerant, the intermediate heat exchanger (90), and an inlet of the hot-water supply compressor (21) are sequentially connected through a refrigerant pipe; and a second hot-water supply refrigerant circuit connected in parallel to the first hot-water supply refrigerant circuit in such a manner as to bypass the intermediate heat exchanger (90) from the first hot-water supply refrigerant circuit. A hot-water supply heat-source-side expansion valve (24) for decompressing the refrigerant is incorporated upstream of the second hot-water supply refrigerant circuit, and a hot-water supply heat-source-side heat exchanger (25a) for performing heat exchange with outdoor air is incorporated downstream of the second hot-water supply refrigerant circuit. A hot-water supply control valve (26) is provided at a downstream branch portion of branch portions at which the refrigerant circuit branches into the first hot-water supply refrigerant circuit and the second hot-water supply refrigerant circuit. The hot-water supply control valve selectively changes a refrigerant flow path between the first hot-water supply refrigerant circuit and the second hot-water supply refrigerant circuit.

[0018] In addition, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the hot-water supply heat-source-side heat exchanger (25a) and the intermediate heat exchanger (90) are provided close to each other so as to allow heat exchange between the refrigerant flowing through the hot-water supply heat-source-side heat exchanger (25a) and the refrigerant flowing through the intermediate heat exchanger (90).

[0019] Furthermore, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the lowermost portion of a heat transfer pipe constituting the hot-water supply heat-source-side heat exchanger (25a) is located above the uppermost portion of the hot-water supply heat-source-side heat transfer pipe constituting the intermediate heat exchanger (90).

[0020] Moreover, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the uppermost portion of a heat transfer pipe constituting the air-conditioning heat-source-side heat exchanger (13a) is located below the lowermost portion of the air-conditioning heat-source-side heat transfer pipe constituting the intermediate heat exchanger (90).

[0021] Additionally, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the hot-water supply refrigerant circuit (20) is provided above the air-conditioning refrigerant circuit (10) with the intermediate heat exchanger (90) there between.

[0022] Furthermore, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the refrigerants used are such that critical pressure of the refrigerant filled in the hot-water supply refrigerant circuit (20) is equal to or higher than that of the refrigerant filled in the air-conditioning refrigerant circuit (10).

[0023] Moreover, a feature of the air-conditioning hot-water supply system according to the present invention is that, in the above-described structure, the refrigerants used are such that a critical temperature of the refrigerant sealed in the hot-water supply refrigerant circuit (20) is equal to or higher than that of the refrigerant sealed in the air-conditioning refrigerant circuit (10).

[0024] With the air-conditioning refrigerant circuit constructed with the above structure, for example in the case of performing heating operation, the refrigerant discharged from the air-conditioning compressor is divided to flow into the first four-way valve and the second four-way valve. Thereafter, the respective refrigerants are subjected to heat exchange in the air-conditioning use-side first heat exchanger and the air-conditioning use-side second heat exchanger, and then, in the air-conditioning expansion valve, are decompressed to the pressure corresponding to the liquid temperature of the heat source liquid circulation circuit. The refrigerant passed through the air-conditioning expansion valve absorbs the heat carried by the heat source liquid circulation circuit in the intermediate heat exchanger. The refrigerant, after passing through the second four-way valve, flows into the nozzle portion of the ejector and drives the ejector. On the other hand, the refrigerant flowed into the air-conditioning heat-source-side expansion valve is decompressed by the expansion valve to the evaporating pressure corresponding to the temperature of the outdoor air carried by an outdoor air blower, and absorbs heat from the outdoor air in the air-conditioning heat-source-side heat exchanger. After passing through the first four-way valve, the refrigerant flows into the suction portion of the ejector. The refrigerant flowed into the ejector is subjected to mixing within the ejector and converted to a fixed pressure to be discharged to the air-conditioning compressor.

[0025] In this case, by the action of the ejector, the suction pressure of the air-conditioning compressor is set at a value between an upper limit of the refrigerant evaporating pressure of the intermediate heat exchanger and a lower limit of the evaporating pressure of the air-conditioning heat-source-side heat exchanger:

> an evaporating pressure of the air-conditioning heat-source-side heat exchanger ≤ a suction pressure of the air-conditioning compressor; and

an evaporating pressure of the intermediate heat exchanger ≥ a suction pressure of the air-conditioning compressor.

[0026] Therefore, since the suction pressure of the air-conditioning compressor can be made higher than the evaporating pressure of the air-conditioning heat-source-side heat exchanger, the air-conditioning refrigerant circuit can be efficiently operated. Also, even if the heat source of the heat source liquid circulation circuit is insufficient in heat quantity, and hence a required quantity of heat cannot be absorbed from the intermediate heat exchanger, blocking of the control valve connected to the intermediate heat exchanger and control of the flow resistance of the nozzle portion of the ejector allow the heating operation in which the air-conditioning heat-source-side heat exchanger is singly used. Therefore, even in the case of inability to use another heat source or increases or decreases in heat quantity of another heat source, follow-ups can be performed, thereby allowing optimum operational control of the air-conditioning refrigerant circuit.

[0027] The cooling operation includes two forms. One is a case (use of air-conditioning exhaust heat) where the heat exchange with the exhaust heat generated from the air-conditioning refrigerant circuit is performed for the hot-water supply refrigerant circuit and the heat source liquid circulation circuit through the intermediate heat exchanger. The other is a case where the heat exchange with the exhaust heat generated from the air-conditioning refrigerant circuit is not performed. In the case of using the intermediate heat exchanger, the refrigerant discharged from the air-conditioning compressor is divided to pass through the first four-way valve and the second four-way valve. Thereafter, the refrigerant flows into the intermediate heat exchanger and the air-conditioning heat-source-side heat exchanger. The refrigerants, flowed into the air-conditioning heat-source-side heat exchanger and the intermediate heat exchanger, are cooled by their respective heat exchangers and decompressed in the air-conditioning expansion valve to the evaporating pressure corresponding to indoor controlled temperature. The refrigerant, passed through the air-conditioning expansion valve, flows into the air-conditioning use-side second heat exchanger and the air-conditioning use-side expansion valve. The refrigerant, in the air-conditioning use-side second heat exchanger, absorbs the amount of heat corresponding to an indoor sensible heat load and flows into the nozzle portion of the ejector to drive the ejector. On the other hand, the refrigerant flowed into the air-conditioning use-side expansion valve is decompressed in the air-conditioning use-side expansion valve to the evaporating pressure to allow removal of indoor latent heat, and absorbs, in the air-conditioning use-side first heat exchanger, the amount of heat corresponding to an indoor latent heat load to flow into the ejector suction portion. The respective refrigerants flowed into the ejector are mixed within the ejector and converted to a fixed pressure to be discharged to the compressor.

[0028] In this case, the relationship between the suction pressure of the compressor and the evaporating pressure of each of the heat exchangers is:

an evaporating pressure of the air-conditioning use-side first heat exchanger ≤ a suction pressure of the air-conditioning compressor; and
an evaporating pressure of the air-conditioning use-side second heat exchanger ≥ a suction pressure of the air-conditioning compressor.

[0029] Therefore, since the inlet of the air-conditioning compressor can hold a pressure higher than the evaporating pressure of the air-conditioning use-side first heat exchanger, the air-conditioning refrigerant circuit can be efficiently operated. Also, if the latent heat load is small, the flow resistance of the air-conditioning use-side expansion valve and the ejector nozzle can be changed, so that the same advantage as the normal cooling operation can be obtained.

[0030] On the other hand, even when both the hot-water supply refrigerant circuit and the heat source liquid circulation circuit are in a nonoperating state and the heat generated in the air-conditioning refrigerant circuit cannot be used for other heat sources, the air-conditioning refrigerant circuit can be efficiently operated by constructing a natural circulation refrigerant circuit between the intermediate heat exchanger and the hot-water supply heat-source-side heat exchanger. It should be noted that the intermediate heat exchanger and the hot-water supply heat-source-side heat exchanger are connected to each other parallel to the refrigerant flow direction through the refrigerant circuit, and the control valves are provided upstream and downstream of the refrigerant circuit. Also, the lowermost portion of the hot-water supply heat-source-side heat exchanger is provided above the uppermost portion of the intermediate heat exchanger. The refrigerant circuit and the heat exchangers are positioned in this manner, thereby allowing construction of the natural circulation circuit using air-conditioning exhaust heat during cooling operation of the air-conditioning refrigerant circuit.

[0031] However, when the natural circulation circuit is constructed, in order to prevent leakage of heat to another heat source, the control valves provided on the heat source liquid circulation circuit is blocked. Also, the control valves connected to the upstream and downstream portions of the hot-water supply refrigerant circuit with respect to the intermediate heat exchanger and the hot-water supply use-side heat exchanger are blocked. Thus, the heat exchange between the heat transfer pipes within the intermediate heat exchanger is performed, so that the refrigerant of the air-conditioning refrigerant circuit is cooled and condensed, and the refrigerant of the hot-water supply refrigerant circuit is heated and evaporates. The refrigerant of the hot-water supply refrigerant circuit is discharged from the intermediate heat exchanger and then flowed into the hot-water supply heat-source-side heat exchanger by the saturated liquid-gas density difference. The refrigerant flowed into the hot-water supply heat-source-side heat exchanger is cooled by the outdoor air and condensed, and forms a flow flowing back to the intermediate heat exchanger by gravity. In this case, the refrigerant of the air-conditioning refrigerant circuit flowed into the intermediate heat exchanger can be subjected to heat exchange with the refrigerant in the hot-water supply refrigerant circuit, and outdoor air through the hot-water supply heat-source-side heat exchanger. Thus, the air-conditioning heat-source-side heat exchanger and the hot-water supply heat-source-side heat exchanger can be used for heat release of the air-conditioning refrigerant circuit, thereby allowing expansion of the apparent heat transfer area of the heat exchanger. Therefore, the air-conditioning refrigerant circuit can be efficiently operated.

ADVANTAGEOUS EFFECTS OF INVENTION

[0032] The present invention, with the above-described structure and operation, allows efficient operation of an air-conditioning refrigerant circuit of an air-conditioning hot-water supply system. In particular, the advantages of an ejector can be provided in both cooling operation and heating operation and the power consumption of the air-conditioning refrigerant circuit can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0033]

Fig. 1 is a schematic diagram of an air-conditioning hot-water supply system according to a first embodiment of the present invention.
Fig. 2 is a pressure-enthalpy chart of a refrigerant in the present invention.
Fig. 3 is a schematic diagram illustrating the refrigerant flow during cooling operation of the air-conditioning hot-water supply system according to the first embodiment of the present invention.
Fig. 4 is a schematic diagram illustrating the refrigerant flow during cooling operation of the air-conditioning hot-water supply system according to the first embodiment of the present invention.
Fig. 5 is a schematic diagram illustrating the refrigerant flow during cooling operation of the air-conditioning hot-water supply system according to the first embodiment of the present invention.
Fig. 6 is a schematic diagram illustrating the refrigerant flow during heating operation of the air-conditioning hot-water supply system according to the first embodiment of the present invention.
Fig. 7 is a schematic diagram illustrating the refrigerant flow during individual hot-water supply operation of the air-conditioning hot-water supply system according to the first embodiment of the present invention.
Fig. 8 is a schematic diagram of an air-conditioning hot-water supply system according to a second embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0034] Fig. 1 is a schematic diagram of an air-conditioning hot-water supply system 1. The air-conditioning hot-water supply system 1 is a system constructed of: an air-conditioning refrigerant circuit 10 for selectively performing cooling operation and heating operation; a hot-water supply refrigerant circuit 20; a heat source liquid circulation circuit 50 for releasing or absorbing heat to or from the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20 using hot and cold sources; and an intermediate heat exchanger 90 for performing heat exchange among the air-conditioning refrigerant circuit 10, the hot-water supply refrigerant circuit 20, and the heat source liquid circulation circuit 50. The air-conditioning hot-water supply system 1 is connected to an air-conditioning liquid circulation circuit 30, a hot-water supply use-side liquid circulation circuit 40, a solar collector liquid circulation circuit 60, and a hot-water supply circuit 70 so as to carry hot and cold heat to use-side equipment installed in a house 3, such as an air-conditioning unit 80, a storage tank 41, a heat storage tank 51, a solar collector 61, and a hot-water supply control valve 74 and provide the hot and cold heat to the inside of the house.

[0035] The air-conditioning refrigerant circuit 10 includes: an air-conditioning compressor 11 for compressing an air-conditioning refrigerant; a first four-way valve 12a and a second four-way valve 12b for changing air-conditioning refrigerant flow directions between cooling operation and heating operation; an air-conditioning heat-source-side heat exchanger 13a; the intermediate heat exchanger 90 for performing heat exchange with a hot-water supply refrigerant of the hot-water supply refrigerant circuit 20 and a heat carrier of the heat source liquid circulation circuit 50; an air-conditioning heat-source-side expansion valve 14; an air-conditioning expansion valve 15; an air-conditioning use-side expansion valve 16; an air-conditioning use-side first heat exchanger 17a; an air-conditioning use-side second heat exchanger 17b; an ejector 18; and an outdoor air blower 91 for carrying outdoor air to the air-conditioning heat-source-side heat exchanger 13a.

[0036] The intermediate heat exchanger 90 is constructed in such a manner that a heat transfer pipe 55 for absorbing and releasing heat of the heat source liquid circulation circuit 50, a heat transfer pipe 25b for absorbing and releasing heat of the refrigerant flowing through the hot-water supply refrigerant circuit 20, and a heat transfer pipe 13b for absorbing and releasing heat of the refrigerant flowing through the air-conditioning refrigerant circuit 10 are brought into thermal contact with one another, thereby allowing heat exchange among the three heat media. Further, a physical contact also exists between the heat transfer pipe 25b and the heat transfer pipe 13b. It should be noted that the air-conditioning heat-source-side heat exchanger 13a and the intermediate heat exchanger 90 are connected parallel to the flow direction through a refrigerant circuit.

[0037] The air-conditioning compressor 11 has refrigerant circuits that are connected to the first four-way valve 12a and the second four-way valve 12b, parallel to the refrigerant flow direction. Through the respective refrigerant circuits, the first four-way valve 12a is connected to the air-conditioning heat-source-side heat exchanger 13a and the second four-way valve 12b is connected to the heat transfer pipe 13b of the intermediate heat exchanger 90. It should be noted that, while not shown in the drawing, the four-way valves 12a and 12b are provided with a control mechanism that controls the opening and closing movements of the valves 12a and 12b in a manner so as to cause the valves 12a and 12b to open and close synchronously. The air-conditioning heat-source-side expansion valve 14 is connected to the air-conditioning heat-source-side heat exchanger 13a in series in the refrigerant flow direction. The refrigerant circuits from the air-conditioning heat-source-side expansion valve 14 and the heat transfer pipe 13b of the intermediate heat exchanger 90 are joined again together to be connected to a refrigerant circuit connected to the air-conditioning expansion valve 15. The refrigerant circuit connected to the air-conditioning expansion valve 15 branches to be connected to the air-conditioning use-side expansion valve 16 and the air-conditioning use-side second heat exchanger 17b. The air-conditioning use-side expansion valve 16 and the air-conditioning use-side first heat exchanger 17a are connected in series in the refrigerant flow direction. The first four-way valve 12a and the second four-way valve 12b are connected to a suction portion 18b and a nozzle portion 18a of the ejector, respectively. A discharge portion 18c of the ejector is connected to the air-conditioning compressor 11.

[0038] In this manner, the air-conditioning refrigerant circuit 10 according to this embodiment is composed of two refrigerant circuits, namely, an air-conditioning high-temperature-side refrigerant circuit and an air-conditioning low-temperature-side refrigerant circuit. The air-conditioning high-temperature-side refrigerant circuit is constructed such that the ejector discharge portion 18c, the air-conditioning compressor 11, the second four-way valve 12b, the intermediate heat exchanger 90, the air-conditioning use-side second heat exchanger 17b, and the ejector nozzle portion 18a are sequentially connected through a refrigerant pipe. The air-conditioning low-temperature-side refrigerant circuit is constructed such that the ejector discharge portion 18c, the air-conditioning compressor 11, the first four-way valve 12a, the air-conditioning heat-source-side heat exchanger 13a, the air-conditioning heat-source-side expansion valve 14, the air-conditioning use-side expansion valve 16, the air-conditioning use-side first heat exchanger 17a, and the ejector suction portion 18b are sequentially connected through a refrigerant pipe. Also, the air-conditioning expansion valve 15 is incorporated in the common refrigerant circuit into which the refrigerant flows from both of these two refrigerant circuits.

[0039] The hot-water supply refrigerant circuit 20 includes a hot-water supply compressor 21 for compressing the hot-water supply refrigerant; a hot-water supply use-side heat exchanger 22; a hot-water supply expansion valve 23; a hot-water supply heat-source-side expansion valve 24; an hot-water supply heat-source-side heat exchanger 25a; the intermediate heat exchanger 90; a three-way valve (a hot-water supply control valve) 26; and an outdoor air blower 92 for carrying outdoor air to the hot-water supply heat-source-side heat exchanger 25a. It should be noted that a check valve may be used in place of the three-way valve 26.

[0040] The hot-water supply refrigerant circuit 20 is composed of two refrigerant circuits, namely, a first hot-water supply refrigerant circuit and a second hot-water supply refrigerant circuit. The first hot-water supply refrigerant circuit is constructed such that the hot-water supply compressor 21, the hot-water supply use-side heat exchanger 22, the hot-water supply expansion valve 23, and the intermediate heat exchanger 90 are sequentially connected through a refrigerant pipe. On the other hand, the second hot-water supply refrigerant circuit is formed so as to bypass the intermediate heat exchanger 90 from the first hot-water supply refrigerant circuit and be connected in parallel to the first hot-water supply refrigerant circuit. The second hot-water supply refrigerant circuit is designed to connect, sequentially from a branch portion located upstream of the intermediate heat exchanger 90, the hot-water supply heat-source-side expansion valve 24 and the hot-water supply heat-source-side heat exchanger 25a through a refrigerant pipe and then to be joined to the first hot-water supply refrigerant circuit at a branch portion located downstream of the intermediate heat exchanger 90. In addition, the three-way valve 26 is provided at the branch portion located downstream of the intermediate heat exchanger 90.

[0041] Note that, in this embodiment, the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20 are arranged in such a manner as to be vertically separated by the intermediate heat exchanger 90, the hot-water supply refrigerant circuit 20 being disposed above the air-conditioning refrigerant circuit 10. Also, the lowermost portion of a heat transfer pipe of the hot-water supply heat-source-side heat exchanger 25a is located above the uppermost portion of the heat transfer pipe 25b of the intermediate heat exchanger 90. The uppermost portion of a heat transfer pipe of the air-conditioning heat-source-side heat exchanger 13a is located below the lowermost portion of the heat transfer pipe 13b of the intermediate heat exchanger 90.

[0042] The heat source liquid circulation circuit 50 includes: the heat storage tank 51; a control valve 52 for controlling the circulating volume of the heat carrier to be returned to the heat storage tank 51; a control valve 53 for controlling the total circulating volume of the heat carrier; the heat transfer pipe 55 of the intermediate heat exchanger 90 to be used by the heat source liquid circulation circuit; and a liquid circulating pump 56.

[0043] There is a head difference between the intermediate heat exchanger 90 and the hot-water supply heat-source-side heat exchanger 25a so that the refrigerant circulates naturally between the intermediate heat exchanger 90 and the hot-water supply heat-source-side heat exchanger 25a by using a density difference between saturated liquid and saturated gas of the refrigerant sealed in the hot-water supply refrigerant circuit 20. It should be noted that the intermediate heat exchanger 90 and the hot-water supply heat-source-side heat exchanger 25a are provided close to each other so as to allow efficient heat exchange.

[0044] In the same manner, there is also a head difference between the intermediate heat exchanger 90 and the air-conditioning heat-source-side heat exchanger 13a so that the refrigerant circulates naturally between the intermediate heat exchanger 90 and the air-conditioning heat-source-side heat exchanger 13a by using a density difference between saturated liquid and saturated gas of the refrigerant sealed in the air-conditioning refrigerant circuit 10. It should be noted that the intermediate heat exchanger 90 and the air-conditioning heat-source-side heat exchanger 13a are provided close to each other so as to allow efficient heat exchange.

[0045] Note that, in the present invention, there are provided temperature detecting means 100, 101, 132, etc., flow detecting means 201 and 202, humidity detecting means 301 and the like, however, their respective installation positions or the like are not limited to this embodiment.

[0046] Operation in each operation mode of the air-conditioning hot-water supply system constructed of the above-described devices will be described hereinafter with reference to FIGS. 2 to 8.

[0047] Fig. 3 illustrates a refrigerant circulation path during cooling operation of the air-conditioning refrigerant circuit 10 of the air-conditioning hot-water supply system described in the present invention. Fig. 2 shows operating points of the air-conditioning refrigerant circuit of FIG. 3 as a pressure-enthalpy curve, wherein the solid line represents the operation of a cycle of the present invention, and the dashed line represents the operation of a normal refrigeration cycle. FIG. 3 illustrates a mode in which the air-conditioning refrigerant circuit 10 is operated by compression and the hot-water supply refrigerant circuit 20 is operated by natural circulation. In this case, the degree of opening of the hot-water supply expansion valve 23 of the hot-water supply refrigerant circuit 20 is in a full-closed state, and the hot-water supply heat-source-side expansion valve 24 is fully open. Also, in this embodiment, the heat source liquid circulation circuit 50 is in a resting state. The heat source liquid circulation control valves 52 and 53 are fully closed. Thus, the solar collector liquid circulation circuit 60 can be operated thermally independent from the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20. Consequently, the solar collector liquid circulation circuit 60 can be operated until the heat storage tank 51 reaches a predetermined temperature, regardless of operation of the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20.

[0048] A refrigerant (P2) discharged from the air-conditioning compressor 11 passes through the four-way valves 12a and 12b, and flows into the air-conditioning heat-source-side heat exchanger 13a, and the heat transfer pipe 13b constituting the intermediate heat exchanger 90. The refrigerant flowed into the air-conditioning heat-source-side heat exchanger 13a is cooled and condensed by heat exchange with outdoor air. In the same manner, the refrigerant flowed into the heat transfer pipe 13b of the intermediate heat exchanger 90 is cooled and condensed by heat exchange with a refrigerant in the heat transfer pipe 25b constituting the intermediate heat exchanger 90.

[0049] The refrigerant in the heat transfer pipe 25b absorbs heat from the heat transfer pipe 13b and evaporates. Therefore, the refrigerant is flowed into the hot-water supply heat-source-side heat exchanger 25a by opening the three-way valve 26 of the hot-water supply refrigerant circuit 20 toward the hot-water supply heat-source-side heat exchanger 25a. The refrigerant, in the hot-water supply heat-source-side heat exchanger 25a, is subjected to heat exchange with the outdoor air carried by the outdoor air blower 92, and consequently cooled and condensed. The refrigerant converted into a liquid forms a natural circulation circuit in which a saturated gas-liquid density difference causes the refrigerant to flow naturally back to the intermediate heat exchanger 90. It should be noted that, when the outside air temperature is low and the air-conditioning load is small, the three-way valve 26 is closed so as to close the natural circulation circuit, thereby allowing control of the heat transfer area of the heat exchanger. Therefore, the control of the heat transfer area of the heat exchanger and the air volume control by activation/deactivation of the outdoor air blowers 91 and 92 can be performed depending on the state of the refrigerant discharged from the air-conditioning compressor 11, thereby allowing optimum control of the operation of the air-conditioning refrigerant circuit 10.

[0050] A refrigerant (P3), passed through the air-conditioning heat-source-side heat exchanger 13a and the heat transfer pipe 13b of the intermediate heat exchanger 90, is decompressed and expanded to the evaporating pressure corresponding to a preset indoor temperature in the house 3 by the air-conditioning expansion valve 15. In this case, the air-conditioning heat-source-side expansion valve 14 is fully open. A refrigerant (P4b) passed through the air-conditioning expansion valve 15 flows into the air-conditioning use-side expansion valve 16 and the air-conditioning use-side second heat exchanger 17b. The refrigerant flowed into the air-conditioning use-side expansion valve 16 is further expanded and decompressed, in the air-conditioning use-side expansion valve 16, to the evaporating pressure corresponding to a dehumidification load in the house 3, and flows into the air-conditioning use-side first heat exchanger 17a (P4a).

[0051] In this case, the following relationship is established: an evaporating pressure of the air-conditioning use-side first heat exchanger 17a ≤ an evaporating pressure of the air-conditioning use-side second heat exchanger 17b.

[0052] The refrigerants flowed into the air-conditioning use-side first and second heat exchangers 17a and 17b are subjected to heat exchange with a heat carrier circulating through the air-conditioning liquid circulation circuit 30, and consequently absorb heat and evaporate. As a result of this, the heat carrier circulating through the air-conditioning liquid circulation circuit 30 is cooled. The cooled heat carrier can be carried by a pump 32 to an indoor heat exchanger 34 installed in the house 3, thereby allowing cooling and dehumidification of indoor air.

[0053] A refrigerant (P5b) passed through the air-conditioning use-side second heat exchanger 17b flows into the ejector nozzle portion 18a to drive the ejector 18. On the other hand, a refrigerant (P5a) passed through the air-conditioning use-side first heat exchanger 17a is sucked into the ejector 18 through the ejector suction portion 18b and mixed with the refrigerant flowed into the ejector 18 through the ejector nozzle portion 18a, and then subjected to pressure rising in the ejector discharge portion 18c to flow back to the air-conditioning compressor 11 (P1).

[0054] In this case, because the refrigerant is subjected to pressure rising by the ejector 18, the pressure in an inlet of the air-conditioning compressor 11 is:

an evaporating pressure (P4a, P5a) of the air-conditioning use-side first heat exchanger 17a ≤ a suction pressure (P1) of the compressor 11; and
an evaporating pressure (P4b, P5b) of the air-conditioning use-side second heat exchanger 17b ≥ a suction pressure (P1) of the compressor 11,

and consequently the suction pressure (P1) of the air-conditioning compressor 11 can be increased.

[0055] The normal refrigeration cycle operates in a circulation path of P1', P2', P3, P4a, and P5a. Thus, an enthalpy difference (ΔH) consumed during compression process in the ejector refrigeration cycle can be made smaller than an enthalpy difference (ΔH') consumed during compression process in the normal refrigeration cycle. Therefore, the air-conditioning refrigerant circuit 10 can be efficiently operated.

[0056] In the case of a relatively small amount of dehumidification, the air-conditioning use-side expansion valve 16 is fully opened and the ejector nozzle portion 18a is fully opened so that the air-conditioning use-side first and second heat exchangers 17a and 17b can be operated under the same conditions. This can cause expansion of the apparent heat transfer areas of the heat exchangers, thereby allowing an increase in the refrigerant evaporating pressure. Thus, also in the case where the dehumidification load is small, the air-conditioning refrigerant circuit 10 can be efficiently operated.

[0057] On the other hand, if the water temperature of the heat storage tank 51 is lower than outdoor air temperature, the heat wasted in the air-conditioning refrigerant circuit 10 is carried to the heat storage tank 51 so that the hot-water supply refrigerant circuit 20 can be efficiently operated. FIG. 4 illustrates the refrigerant flow in the above-described state. It should be noted that the flow of the air-conditioning refrigerant circuit 10 has been described in the embodiment of FIG. 3 and the details will not be repeated. FIG. 4 illustrates a mode in which the air-conditioning refrigerant circuit 10 is operated by compression and the hot-water supply refrigerant circuit 20 is in a resting state. At this time, the degree of opening of each of the hot-water supply expansion valve 23 and the hot-water supply heat-source-side expansion valve 24 is in a full-closed state.

[0058] In FIG. 4, the refrigerant of the air-conditioning refrigerant circuit 10 is discharged from the air-conditioning compressor 11 and flows into the air-conditioning heat-source-side heat exchanger 13a, and the heat transfer pipe 13b of the intermediate heat exchanger 90. The refrigerant flowed into the heat transfer pipe 13b of the intermediate heat exchanger 90 is subjected to heat exchange with a heat carrier flowing through the heat transfer pipe 55 in the intermediate heat exchanger 90. Consequently, the heat carrier circulating through the heat source liquid circulation circuit 50 is heated by the refrigerant of the air-conditioning refrigerant circuit 10. The heated heat carrier is flowed back to the heat storage tank 51 by the heat source liquid circulating pump 56. On the other hand, the solar collector liquid circulation circuit 60 is connected to the inside of the heat storage tank 51, and thus the heat collected by the solar collector 61 can be stored at the same time.

[0059] According to the present invention, the exhaust heat generated from the air-conditioning heat source, and the heat generated from another heat source, such as solar heat, can be recovered at the same time.

[0060] Also, the direct heat exchange between the hot-water supply refrigerant circuit 20 and the air-conditioning refrigerant circuit 10 can be performed. FIG. 5 illustrates the refrigerant flow in the case where the hot-water supply refrigerant circuit 20 directly uses the heat from the air-conditioning refrigerant circuit 10. It should be noted that the flows of the air-conditioning refrigerant circuit 10 and the solar collector liquid circulation circuit 60 have been described in the embodiment of FIGS. 3 and 4 and the details will not be repeated. FIG. 5 illustrates an operation mode of the air-conditioning hot-water supply system in which the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20 are operated by compression and the heat source liquid circulation circuit 50 is in an operating state.

[0061] In FIG. 5, the refrigerant of the air-conditioning refrigerant circuit 10 is discharged from the air-conditioning compressor 11 and flows into the air-conditioning heat-source-side heat exchanger 13a, and the heat transfer pipe 13b of the intermediate heat exchanger 90. The refrigerant flowed into the heat transfer pipe 13b of the intermediate heat exchanger 90 is subjected to heat exchange with the refrigerant flowing through the heat transfer pipe 25b in the intermediate heat exchanger 90.

[0062] The refrigerant of the hot-water supply refrigerant circuit 20 is discharged from the hot-water supply compressor 21 and heats a heat carrier flowing through the hot-water supply liquid circulation circuit 40 in the hot-water supply use-side heat exchanger 22. The heated heat carrier is flowed back to the storage tank 41 by a hot-water supply liquid circulating pump 43. The refrigerant passed through the hot-water supply use-side heat exchanger 22 flows into the hot-water supply expansion valve 23. The degree of opening of the hot-water supply expansion valve 23 is controlled so that the hot-water supply refrigerant flowed into the hot-water supply expansion valve 23 is set at the evaporating pressure corresponding to the lower of the temperatures of the refrigerant flowing through the heat transfer pipe 13b of the intermediate heat exchanger and the heat carrier flowing through the heat transfer pipe 55. The hot-water supply refrigerant decompressed and expanded in the hot-water supply expansion valve 23 flows into the hot-water supply heat-source-side expansion valve 24 and the heat transfer pipe 25b of the intermediate heat exchanger 90. The refrigerant flowed into the heat transfer pipe 25b of the intermediate heat exchanger 90 is heated and evaporates by heat exchange with the refrigerant and the heat carrier flowing through the heat transfer pipe 13b and the heat transfer pipe 55, respectively. On the other hand, the refrigerant flowed into the hot-water supply heat-source-side expansion valve 24 is decompressed and expanded to the evaporating pressure corresponding to outdoor air temperature in the hot-water supply heat-source-side expansion valve 24, and then heated and evaporates by heat exchange with outdoor air in the hot-water supply heat-source-side heat exchanger 25a.

[0063] At this time, the relationship between the refrigerant and the heat carrier flowing through the respective heat transfer pipes is:

heat carrier temperature in the heat transfer pipe 55 ≈ air-conditioning exhaust heat temperature; and
heat carrier temperature in the heat transfer pipe 55 ≥ outdoor air temperature.

[0064] Therefore, when the exhaust heat from the air-conditioning refrigerant circuit 10 is used for the hot-water supply refrigerant circuit 20, the hot-water supply heat-source-side expansion valve 24 is fully closed so as to block the flow of the hot-water supply refrigerant into the hot-water supply heat-source-side heat exchanger 25a. Thus, an imbalance in evaporating temperature due to different heat sources is prevented. In the same manner, when the air-conditioning exhaust heat is not used, the flow toward the intermediate heat exchanger 90 with respect to the three-way valve (the hot-water supply control valve) 26 is blocked. Thus, all refrigerants circulating through the hot-water supply refrigerant circuit 20 flow into the hot-water supply heat-source-side heat exchanger 25a and are subjected to heat exchange with outdoor air. In this manner, since the intermediate heat exchanger 90 and the hot-water supply heat-source-side heat exchanger 25a can be selectively used depending upon the use or nonuse of the air-conditioning exhaust heat, the refrigerant can be maintained at an optimum evaporation pressure. This prevents a reduction in operational efficiency of the hot-water supply refrigerant circuit.

[0065] FIG. 6 illustrates the refrigerant flow during heating operation of the air-conditioning refrigerant circuit 10 of the present invention. FIG. 6 illustrates an operation mode of the air-conditioning hot-water supply system in which the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20 are operated by compression and the heat source liquid circulation circuit 50 is in an operating state.

[0066] The refrigerant discharged from the air-conditioning compressor 11 passes through the first and second four-way valves 12a and 12b and the respective refrigerants are subjected to heat exchange in the air-conditioning use-side first and second heat exchangers 17a and 17b, and is consequently cooled and condensed. The refrigerants passed through the air-conditioning use-side first and second heat exchangers 17a and 17b are expanded and decompressed, by the air-conditioning expansion valve 15, to the evaporating pressure corresponding to the temperature of the heat carrier flowing through the hot-water supply use-side liquid circulation circuit 40. In this case, the air-conditioning use-side expansion valve 16 is fully open. The refrigerant passed through the air-conditioning expansion valve 15 flows into the air-conditioning heat-source-side expansion valve 14 and the heat transfer pipe 13b of the intermediate heat exchanger 90. The refrigerant flowed into the air-conditioning heat-source-side expansion valve 14 is expanded and decompressed to the evaporating pressure corresponding to outdoor air temperature and then flows into the air-conditioning heat-source-side heat exchanger 13a.

[0067] The refrigerant flowed into the air-conditioning heat-source-side heat exchanger 13a is subjected to heat exchange with the outdoor air carried by the outdoor air blower 91, and consequently absorbs heat and evaporates. The refrigerant flowed into the heat transfer pipe 13b of the intermediate heat exchanger 90 is subjected to heat exchange with the heat transfer pipe 25b and the heat transfer pipe 55, and consequently absorbs heat and evaporates. Since the heat carrier flowed into the heat transfer pipe 55 of the intermediate heat exchanger 90 absorbs the heat of the solar collector 61, the temperature of the heat carrier is not less than 10°C above outdoor air temperature.

[0068] Therefore, the relationship between the evaporating pressures of the refrigerant flowing through the heat transfer pipe 13b of the intermediate heat exchanger 90 and the refrigerant flowing through the air-conditioning heat-source-side heat exchanger 13a is:

evaporating pressure of the heat transfer pipe 13b of the intermediate heat exchanger 90 ≥ evaporating pressure of the air-conditioning heat-source-side heat exchanger 13a.

[0069] The refrigerant passed through the intermediate heat exchanger 90 flows into the ejector nozzle portion 18a to drive the ejector 18. On the other hand, the refrigerant passed through the air-conditioning heat-source-side heat exchanger 13a is sucked into the ejector 18 through the ejector suction portion 18b and mixed with the refrigerant flowed into the ejector 18 through the ejector nozzle portion 18a, and then subjected to pressure rising in the ejector discharge portion 18c to flow back to the air-conditioning compressor 11. In this case, the refrigerant is subjected to pressure rising by the ejector 18.

[0070] Therefore, the relationship between the suction pressure of the air-conditioning compressor 11 and the evaporating pressure of each of the heat exchangers is:

an evaporating pressure of the air-conditioning heat-source-side heat exchanger 13a ≤ a suction pressure of the air-conditioning compressor 11; and

an evaporating pressure of the heat transfer pipe 13b of the intermediate heat exchanger 90 ≥ a suction pressure of the air-conditioning compressor 11.

Thus, the suction pressure of the air-conditioning compressor 11 can be kept high. Therefore, the air-conditioning refrigerant circuit 10 can be efficiently operated.

[0071] When the temperature of the heat carrier flowed into the heat source liquid circulation circuit 50 is low, the degree of opening of the ejector nozzle portion 18a is fully closed so as to prevent the flow of the refrigerant into the intermediate heat exchanger 90. Thus, also in the case where another heat source is not used, the air-conditioning refrigerant circuit 10 can be efficiently operated.

[0072] Also, FIG. 7 illustrates the refrigerant flow during individual operation of the hot-water supply refrigerant circuit 20 in a nonoperating state of the air-conditioning refrigerant circuit 10. FIG. 7 illustrates a mode in which: the air-conditioning refrigerant circuit 10 is operated by natural circulation; the hot-water supply refrigerant circuit 20 is operated by compression; and the heat source liquid circulation circuit 50 is in a resting state.

[0073] The refrigerant discharged from the hot-water supply compressor 21 is cooled and condensed in the hot-water supply use-side heat exchanger 22 and flows into the hot-water supply expansion valve 23. The refrigerant flowed into the hot-water supply expansion valve 23 is expanded and decompressed to the evaporating pressure corresponding to outdoor air temperature in the hot-water supply expansion valve 23, and flows into the hot-water supply heat-source-side expansion valve 24 and the intermediate heat exchanger 90. In this case, the hot-water supply heat-source-side expansion valve 24 is in a full-open state. The refrigerant flowed into the heat transfer pipe 25b of the intermediate heat exchanger 90 and the refrigerant flowed into the hot-water supply heat-source-side heat exchanger 25a are subjected to heat exchange with the heat transfer pipe 13b of the air-conditioning refrigerant circuit 10 and outdoor air, respectively, and consequently evaporates.

[0074] Here, the relationship between outdoor air temperature and the evaporating temperature of the hot-water supply heat-source-side heat exchanger 25a is:

refrigerant temperature of the hot-water supply heat-source-side heat exchanger 25a ≤ outdoor air temperature.

[0075] Therefore, if a predetermined head difference is provided between the heat transfer pipe 13b of the intermediate heat exchanger 90 and the air-conditioning heat-source-side heat exchanger 13a, a natural circulation circuit caused by temperature difference can be formed in the circuit formed therebetween. At this time, an air-conditioning control valve 19 is opened in a direction to allow the first and second four-way valves 12a and 12b to communicate with each other, and the air-conditioning expansion valve 15 is in a full-closed state. The heat subjected to heat exchange between the heat transfer pipe 25b of the intermediate heat exchanger 90 and the air-conditioning heat-source-side heat exchanger 13a is carried to the air-conditioning heat-source-side heat exchanger 13a by using the natural circulation circuit constructed in the air-conditioning refrigerant circuit 10, and subjected to heat exchange with outdoor air in the air-conditioning heat-source-side heat exchanger 13a, thereby allowing increases in the heat transfer area and blast volume of the hot-water supply heat-source-side heat exchanger 25a. Consequently, also in the case of individual operation of the hot-water supply refrigerant circuit 20, efficient operation can be performed.

[0076] Additionally, FIG. 8 illustrates an embodiment in which the ejector circuit of the present invention is applied to the hot-water supply refrigerant circuit 20. Also in the hot-water supply refrigerant circuit, an ejector 27 can offer advantages similar to those in the air-conditioning refrigerant circuit 10.

[0077] Furthermore, in the present invention, as for the critical point (critical temperature and pressure) of the refrigerant in each of the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20, the refrigerant used in the hot-water supply refrigerant circuit 20 may have a critical point equal to or higher than that in the air-conditioning refrigerant circuit 10. Even in the hot-water supply refrigerant circuit 20 having a required condensation temperature higher than that in the air-conditioning refrigerant circuit 10, therefore, a two-phase region with high heat transfer efficiency can be used. It is therefore possible to select refrigerants which allow optimal maintenance of the temperature control areas of the air-conditioning refrigerant circuit 10 and the hot-water supply refrigerant circuit 20.

[0078] As described in the above embodiment, according to the present invention, it is possible to reduce power consumption at the time of operation in the air-conditioning hot-water supply system that combines air-conditioning hot-water supply system.

[0079] It should be noted that, in the above description of the present invention, solar heat is mainly used as a heat source other than air, however, the present invention, of course, has similar advantages even if other heat sources (renewable energy sources), such as earth thermal and biomass, are used.

[0080] In the same manner, although forms of the compressor, the pump, and the air blower have not been described in the present invention, even if a variable displacement compressor or pump using an inverter or the like is used, similar advantages can, of course, be obtained.

REFERENCE SIGNS LIST

[0081]

1...	Air-conditioning hot-water supply system
3...	House
10...	Air-conditioning refrigerant circuit
11...	Air-conditioning compressor
12a...	First four-way valve
12b...	Second four-way valve
13a...	Air-conditioning heat-source-side heat exchanger
13b...	Air-conditioning heat-source-side heat transfer pipe of intermediate heat exchanger
14...	Air-conditioning heat-source-side expansion valve
15...	Air-conditioning expansion valve
16...	Air-conditioning use-side expansion valve
17a...	Air-conditioning use-side first heat exchanger
17b...	Air-conditioning use-side second heat exchanger
18...	Ejector
18a...	Ejector nozzle portion
18b...	Ejector suction portion
18c...	Ejector discharge portion
19...	Air-conditioning control valve
20...	Hot-water supply refrigerant circuit
21...	Hot-water supply compressor
22...	Hot-water supply use-side heat exchanger
23...	Hot-water supply expansion valve
24...	Hot-water supply heat-source-side expansion valve
25a...	Hot-water supply heat-source-side heat exchanger
25b...	Hot-water supply heat-source-side heat transfer pipe of intermediate heat exchanger
26...	Three-way valve (hot-water supply control valve)
27...	Ejector
30...	Air-conditioning liquid circulation circuit
31...	Control valve
32...	Pump
34...	Indoor heat exchanger

35...	Indoor air blower
40...	Hot-water supply liquid circulation circuit
41...	Storage tank for hot-water supply system
43...	Liquid circulating pump
50...	Heat source liquid circulation circuit
51...	Storage tank for solar collector
52, 53...	Heat source liquid circulation flow control valve
55...	Heat transfer pipe of heat source liquid circulation circuit of intermediate heat exchanger
56...	Liquid circulating pump
60...	Solar collector liquid circulation circuit
61...	Solar collector
62...	Liquid circulating pump
63...	Control valve
70...	Hot-water supply circuit
72, 73, 74...	Hot-water supply control valve
80...	Air-conditioning unit
90...	Intermediate heat exchanger
91, 92...	Outdoor air blower
101, 102, ... 132...	Thermal sensor
201, 202...	Flowmeter
301...	hygrometer

Claims

1. An air-conditioning hot-water supply system comprising: an air-conditioning refrigerant circuit for selectively performing cooling operation and heating operation; a hot-water supply refrigerant circuit for supplying hot water; and an air-conditioning liquid circulation circuit for performing indoor air conditioning, the air-conditioning hot-water supply system having: an intermediate heat exchanger for performing heat exchange between the air-conditioning refrigerant circuit and the hot-water supply refrigerant circuit; and air-conditioning use-side first and second heat exchangers for performing heat exchange between the air-conditioning refrigerant circuit and the air-conditioning liquid circulation circuit,
wherein: the air-conditioning refrigerant circuit is composed of two circuits:

an air-conditioning high-temperature-side refrigerant circuit constructed such that a discharge portion of an ejector, an air-conditioning compressor, a second four-way valve for changing a refrigerant flow direction, the intermediate heat exchanger, the air-conditioning use-side second heat exchanger, and a nozzle portion of the ejector are sequentially connected through a refrigerant pipe; and
an air-conditioning low-temperature-side refrigerant circuit constructed such that the discharge portion of the ejector, the air-conditioning compressor, a first four-way valve for changing the refrigerant flow direction, an air-conditioning heat-source-side heat exchanger for performing heat exchange with outdoor air, an air-conditioning heat-source-side expansion valve, an air-conditioning use-side expansion valve, the air-conditioning use-side first heat exchanger, and a suction portion of the ejector are sequentially connected through a refrigerant pipe, and
wherein: the refrigerant pipe of the air-conditioning low-temperature-side refrigerant circuit for connecting between the air-conditioning heat-source-side expansion valve and the air-conditioning use-side expansion valve is joined to the refrigerant pipe of the air-conditioning high-temperature-side refrigerant circuit for connecting between the intermediate heat exchanger and the air-conditioning use-side second heat exchanger, to form a common refrigerant circuit into which a refrigerant flows from both of the air-conditioning high-temperature-side refrigerant circuit and the air-conditioning low-temperature-side refrigerant circuit; and
an air-conditioning expansion valve for decompressing the refrigerant is incorporated in the common refrigerant circuit.

2. The air-conditioning hot-water supply system according to Claim 1, further comprising a heat source liquid circulation circuit for releasing or absorbing heat to or from the air-conditioning refrigerant circuit and the hot-water supply refrigerant circuit using hot and cold sources, wherein the intermediate heat exchanger performs heat exchange among the air-conditioning refrigerant circuit, the hot-water supply refrigerant circuit, and the heat source liquid circulation circuit.

3. The air-conditioning hot-water supply system according to Claim 2, wherein the intermediate heat exchanger is designed to perform heat exchange with a physical contact between a heat transfer pipe for absorbing and releasing heat of the refrigerant flowing through the hot-water supply refrigerant circuit and a heat transfer pipe for absorbing and releasing heat of the refrigerant flowing through the air-conditioning refrigerant circuit.

4. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, wherein the air-conditioning heat-source-side heat exchanger and the intermediate heat exchanger are provided close to each other so as to allow heat exchange between the refrigerant flowing through the air-conditioning heat-source-side heat exchanger and the refrigerant flowing through the intermediate heat exchanger.

5. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, wherein cooling and heating operation is performed by synchronizing opening and closing movements between the first four-way valve and the second four-way valve.

6. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, wherein, during heating operation, the degree of opening of the air-conditioning expansion valve is controlled on the basis of liquid temperature of the heat source liquid circulation circuit, and the degree of opening of the air-conditioning heat-source-side expansion valve is controlled on the basis of outdoor air temperature.

7. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, wherein, during cooling operation, the degree of opening of the air-conditioning expansion valve is controlled on the basis of an indoor-outdoor temperature differential, and the degree of opening of the air-conditioning use-side expansion valve is controlled on the basis of a dehumidification amount.

8. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, wherein an air-conditioning control valve is incorporated in a branch portion at which the refrigerant circuit from an outlet of the air-conditioning compressor branches into the air-conditioning high-temperature-side refrigerant circuit and the air-conditioning low-temperature-side refrigerant circuit, the air-conditioning control valve selectively changing a refrigerant flow path between the air-conditioning high-temperature-side refrigerant circuit and the air-conditioning low-temperature-side refrigerant circuit.

9. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, wherein the ejector can be changed in flow resistance by changing a cross-sectional area of the nozzle portion of the ejector.

10. The air-conditioning hot-water supply system according to any one of Claims 1 to 3, further comprising a hot-water supply liquid circulation circuit for releasing or absorbing heat to or from the hot-water supply refrigerant circuit using hot and cold sources,
wherein: the hot-water supply refrigerant circuit has:

a first hot-water supply refrigerant circuit constructed such that an outlet of a hot-water supply compressor, a hot-water supply use-side heat exchanger for performing heat exchange with the hot-water supply liquid circulation circuit, a hot-water supply expansion valve for decompressing the refrigerant, the intermediate heat exchanger, and an inlet of the hot-water supply compressor are sequentially connected through a refrigerant pipe; and
a second hot-water supply refrigerant circuit connected in parallel to the first hot-water supply refrigerant circuit in such a manner as to bypass the intermediate heat exchanger from the first hot-water supply refrigerant circuit, wherein: a hot-water supply heat-source-side expansion valve for decompressing the refrigerant is incorporated upstream of the second hot-water supply refrigerant circuit, and a hot-water supply heat-source-side heat exchanger for performing heat exchange with outdoor air is incorporated downstream of the second hot-water supply refrigerant circuit; and
wherein: a hot-water supply control valve is provided at a downstream branch portion of branch portions at which the refrigerant circuit branches into the first hot-water supply refrigerant circuit and the second hot-water supply refrigerant circuit, the hot-water supply control valve selectively changing a refrigerant flow path between the first hot-water supply refrigerant circuit and the second hot-water supply refrigerant circuit.

11. The air-conditioning hot-water supply system according to Claim 10, wherein the hot-water supply heat-source-side heat exchanger and the intermediate heat exchanger are provided close to each other so as to allow heat exchange between the refrigerant flowing through the hot-water supply heat-source-side heat exchanger and the refrigerant flowing through the intermediate heat exchanger.

12. The air-conditioning hot-water supply system according to any one of Claims 1 to 11, wherein the lowermost portion of a heat transfer pipe constituting the hot-water supply heat-source-side heat exchanger is located above the uppermost portion of the hot-water supply heat-source-side heat transfer pipe constituting the intermediate heat exchanger.

13. The air-conditioning hot-water supply system according to any one of Claims 1 to 11, wherein the uppermost portion of a heat transfer pipe constituting the air-conditioning heat-source-side heat exchanger is located below the lowermost portion of the air-conditioning heat-source-side heat transfer pipe constituting the intermediate heat exchanger.

14. The air-conditioning hot-water supply system according to any one of Claims 1 to 11, wherein the hot-water supply refrigerant circuit is provided above the air-conditioning refrigerant circuit with the intermediate heat exchanger therebetween.

15. The air-conditioning hot-water supply system according to any one of Claims 1 to 11, wherein the refrigerants used are such that critical pressure of the refrigerant sealed in the hot-water supply refrigerant circuit is equal to or higher than that of the refrigerant sealed in the air-conditioning refrigerant circuit.

16. The air-conditioning hot-water supply system according to any one of Claims 1 to 11, wherein the refrigerants used are such that critical temperature of the refrigerant sealed in the hot-water supply refrigerant circuit is equal to or higher than that of the refrigerant sealed in the air-conditioning refrigerant circuit.

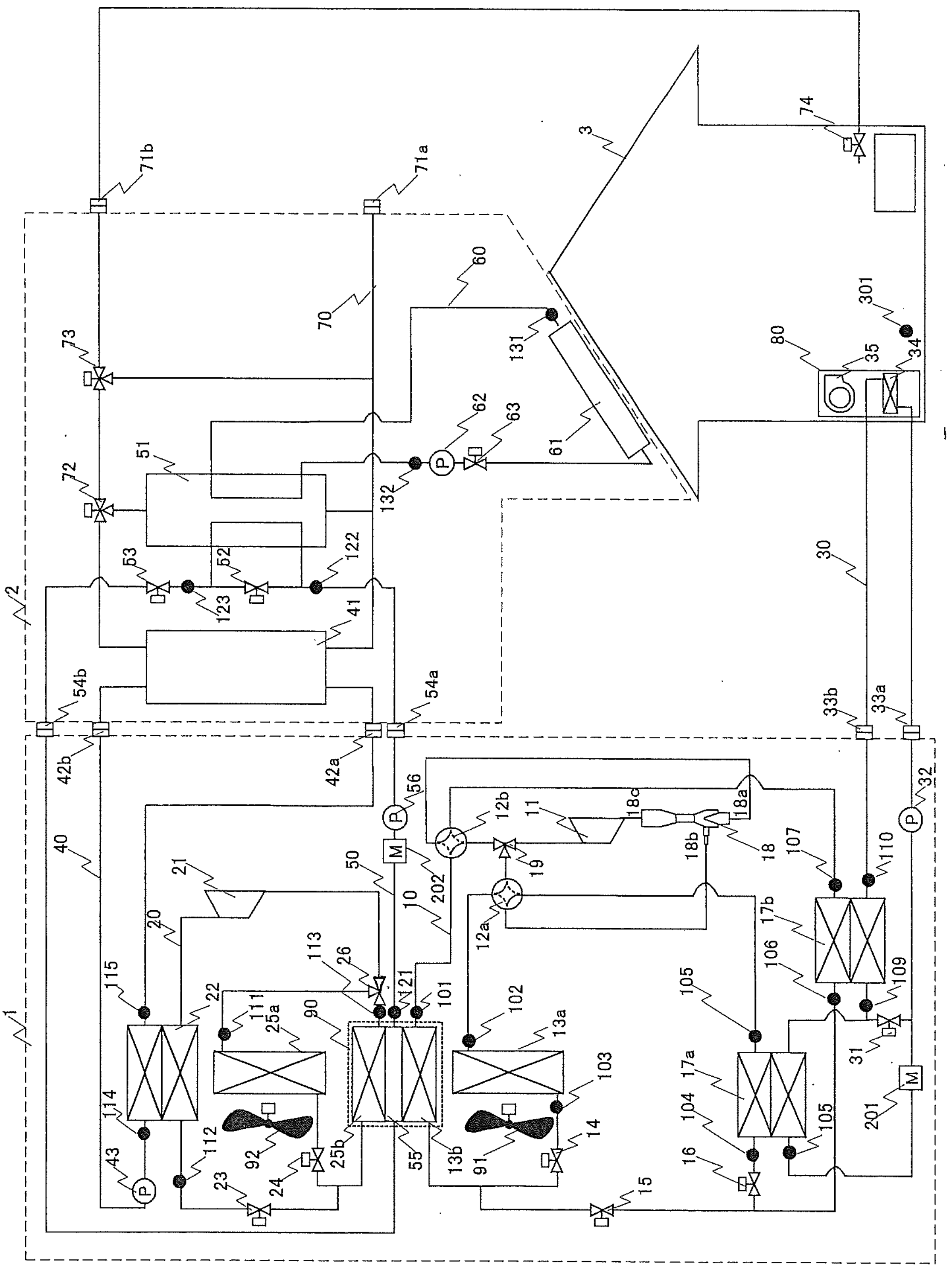

FIG. 1

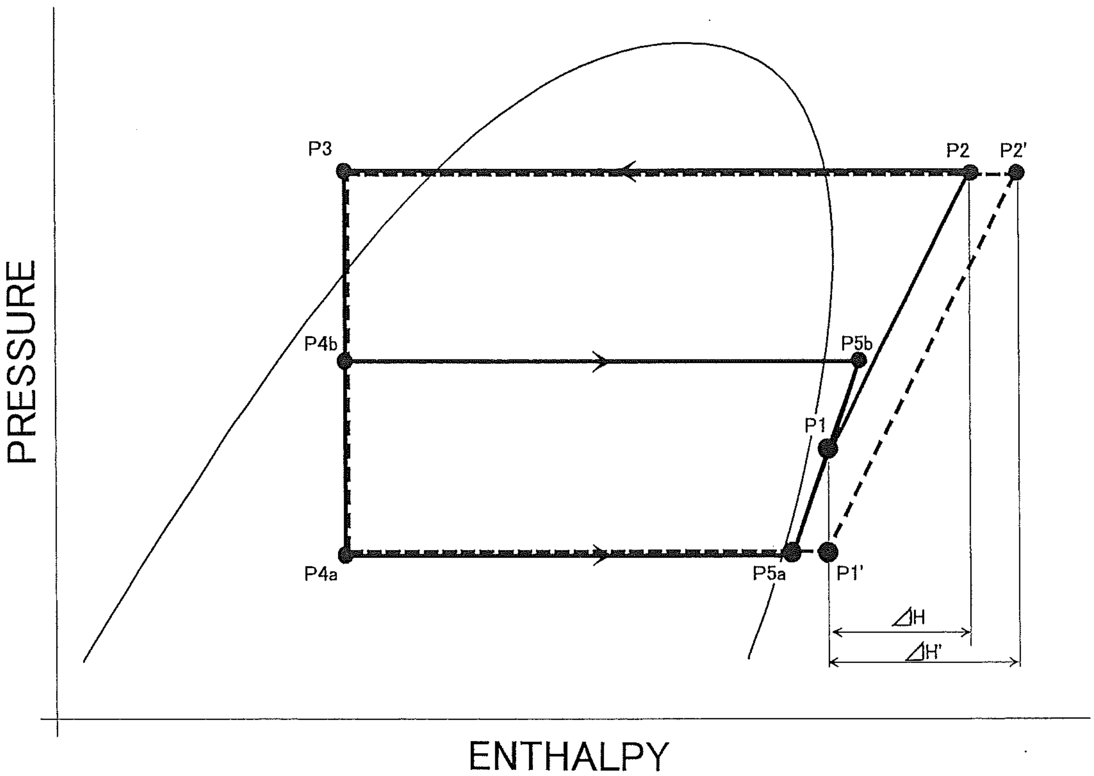

FIG. 2

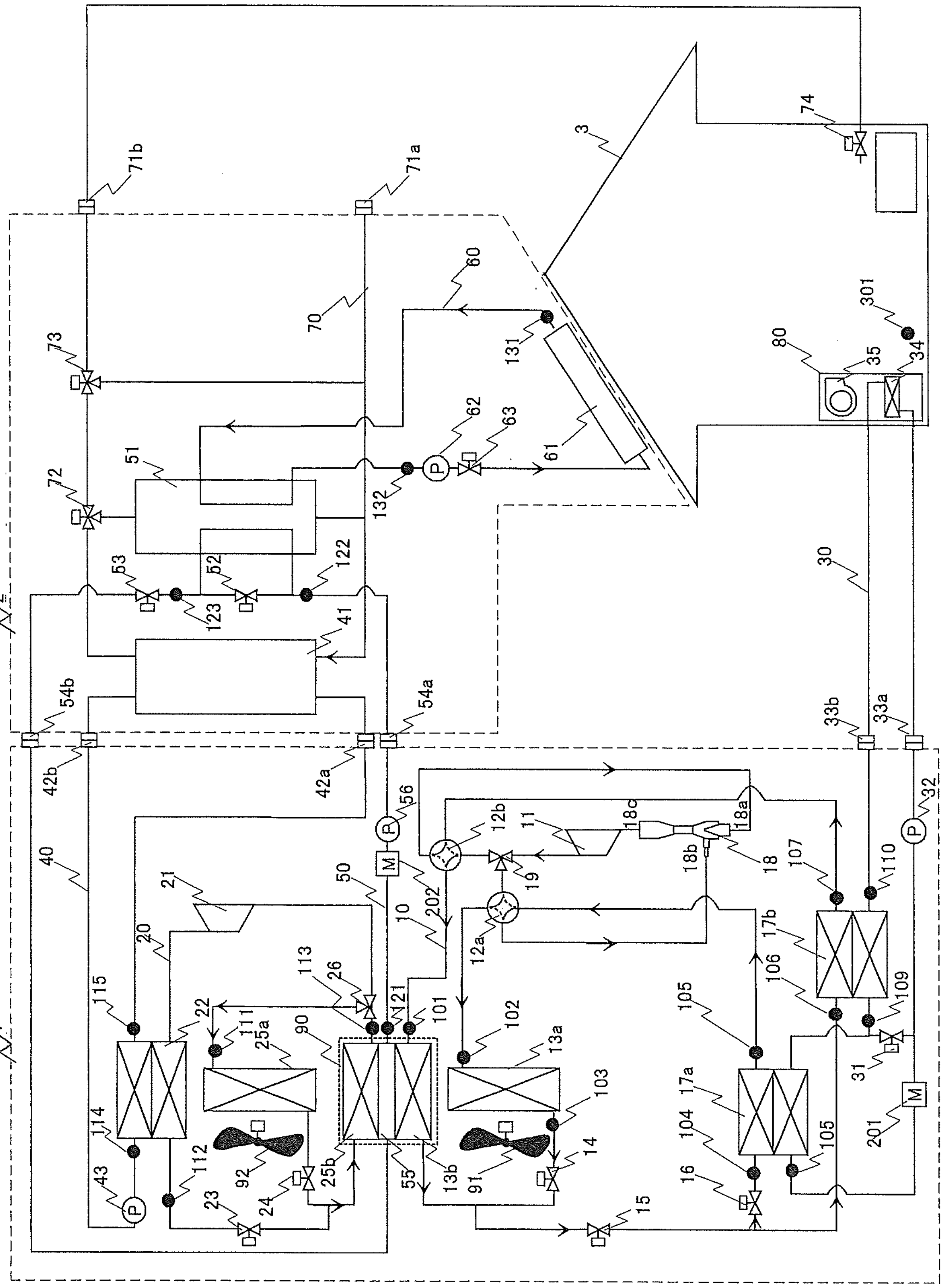

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FIG. 3

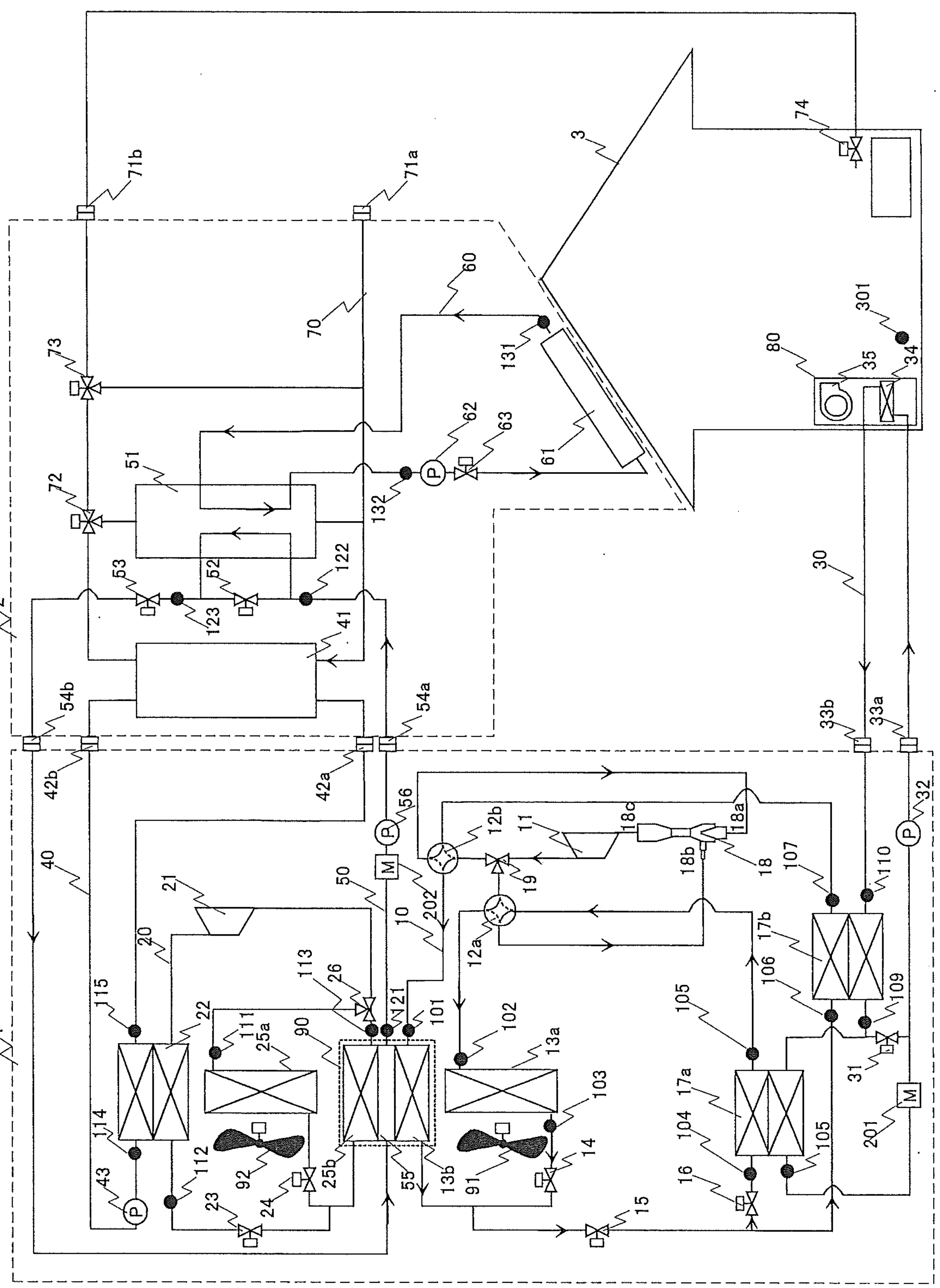
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FIG. 4

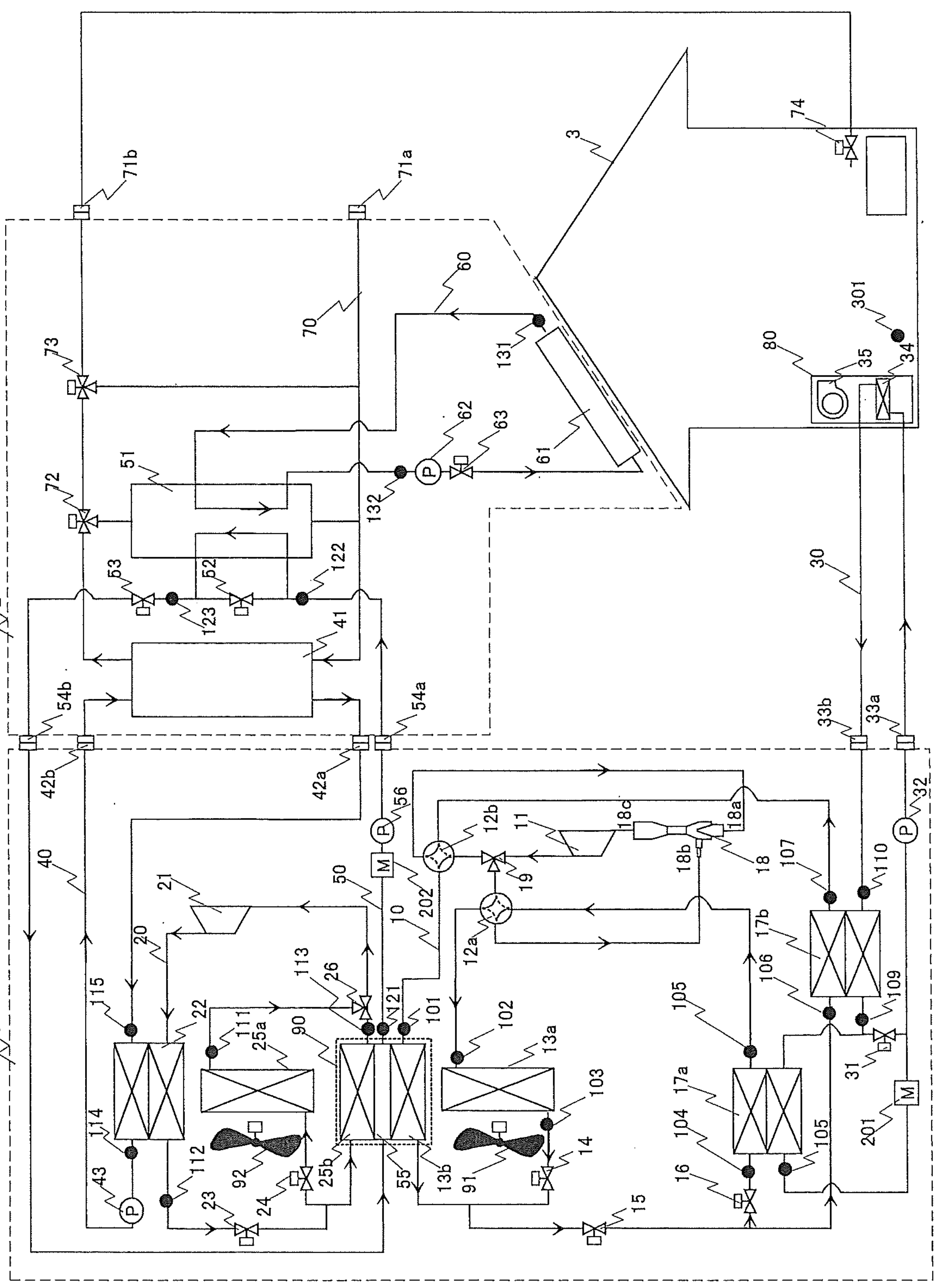
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FIG. 5

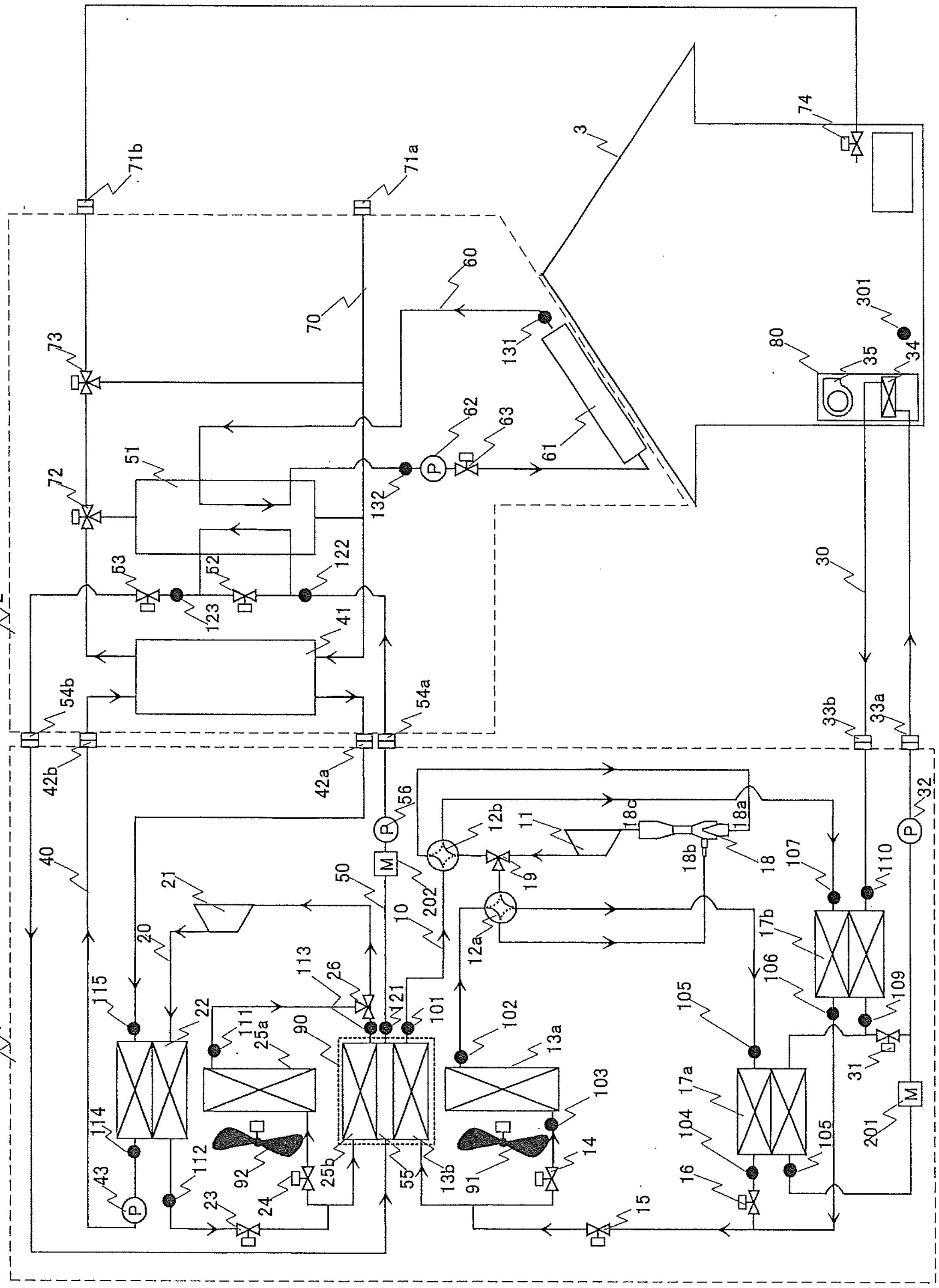
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FIG.6

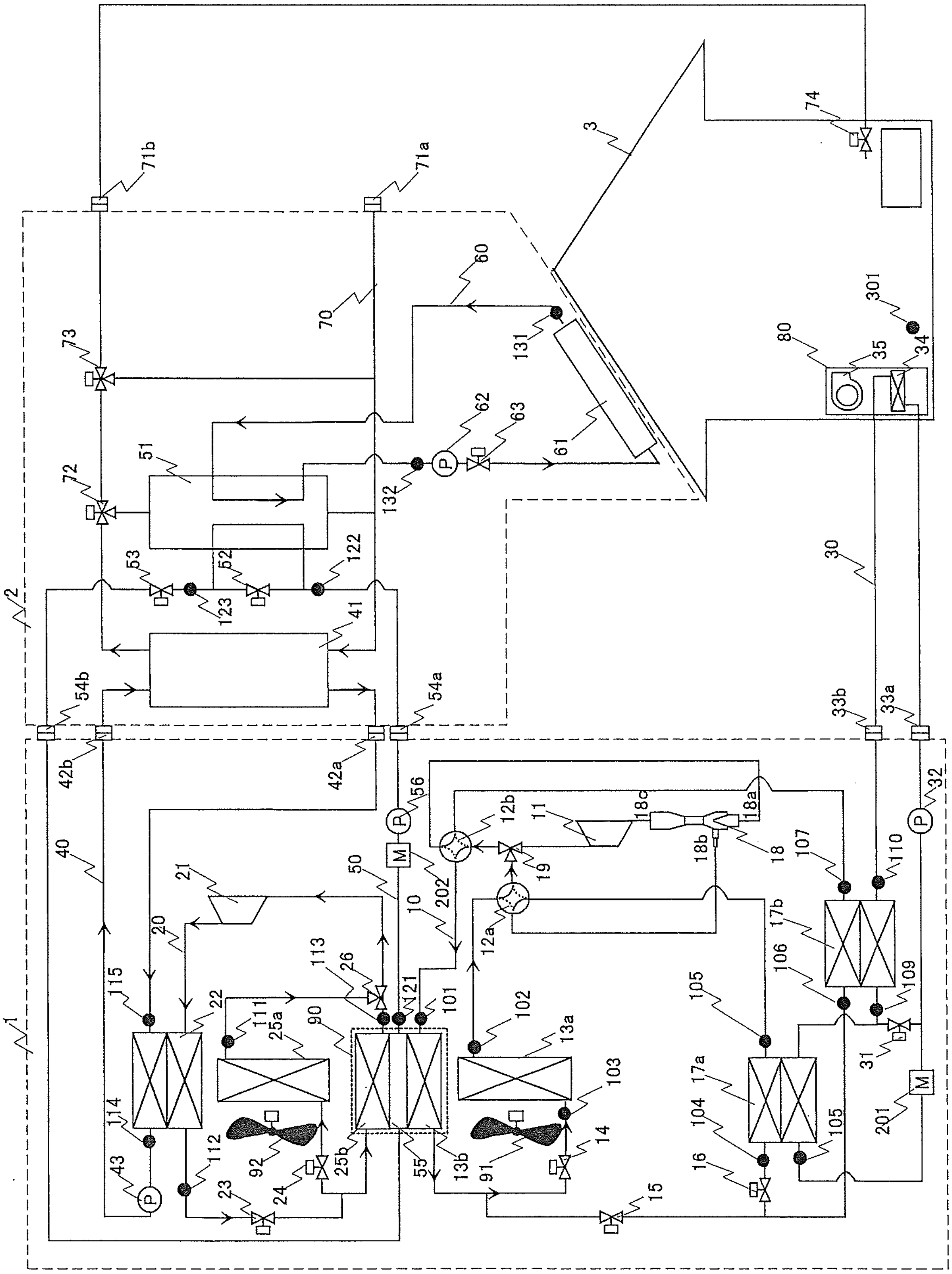
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FIG.7

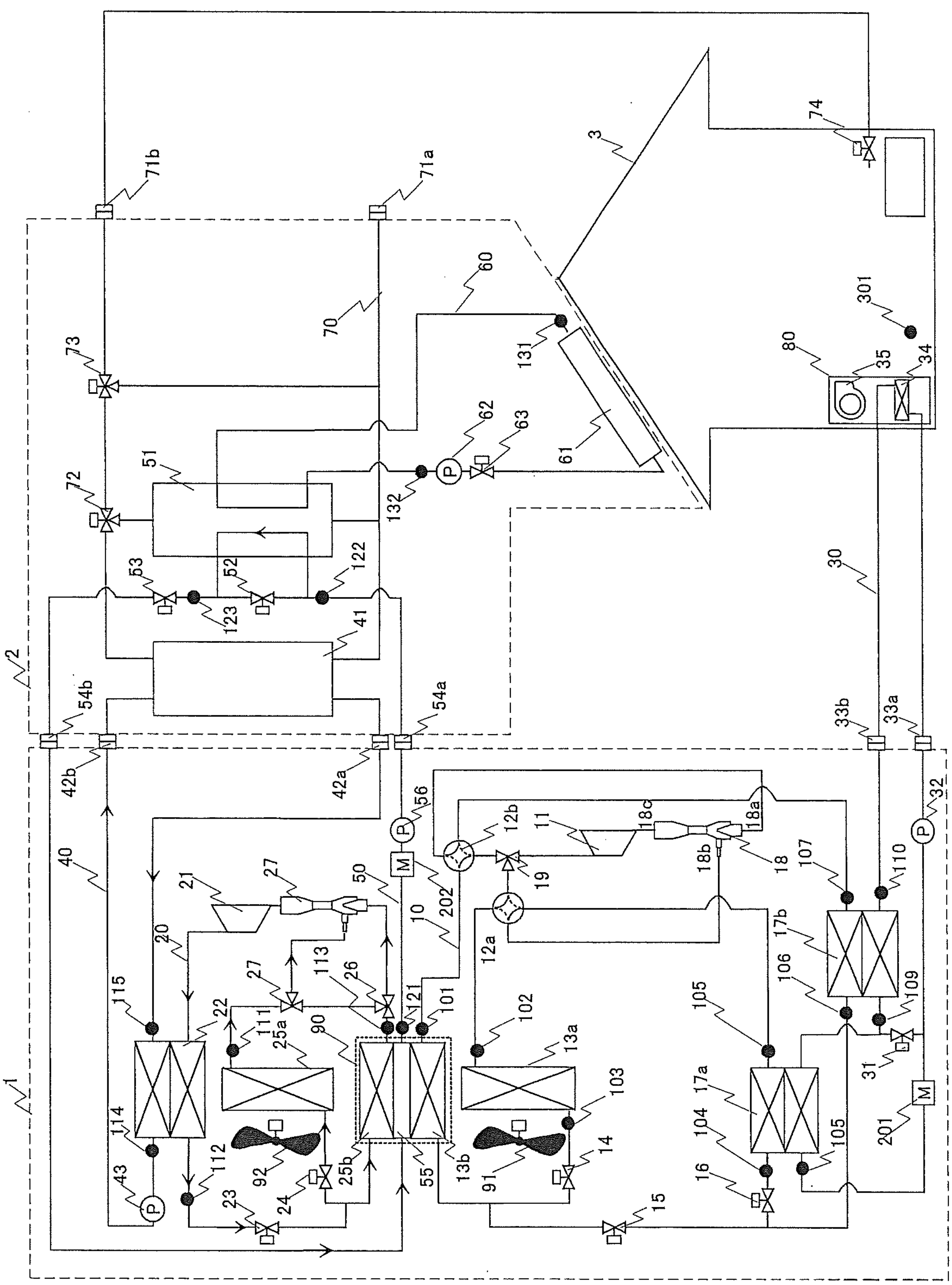

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FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/063638

A. CLASSIFICATION OF SUBJECT MATTER
F25B41/00(2006.01)i, *F25B1/00*(2006.01)i, *F25B7/00*(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)
F25B41/00, F25B1/00, F25B7/00

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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.
A	JP 2004-309093 A (Denso Corp.), 04 November 2004 (04.11.2004), fig. 3 to 7; paragraphs [0050] to [0063] & DE 102004007932 A & CN 1523301 A	1-16
A	JP 4-32669 A (Matsushita Electric Industrial Co., Ltd.), 04 February 1992 (04.02.1992), fig. 1; entire text & JP 61-502172 A & US 4560358 A & EP 181394 A & WO 1985/005283 A1 & DE 3572309 D & AU 4438985 A & CA 1219296 A & IE 56593 B & AT 45507 T & AU 569012 B & AT 45507 E & IE 851165 L	1-16

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 September, 2010 (08.09.10)	21 September, 2010 (21.09.10)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/063638

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 4-260759 A (Hitachi, Ltd.), 16 September 1992 (16.09.1992), entire text; all drawings & US 5285645 A	1-16
A	JP 61-101771 A (Mitsubishi Electric Corp.), 20 May 1986 (20.05.1986), entire text; fig. 1 (Family: none)	1-16

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Patent documents cited in the description

- JP 2001147050 A **[0002] [0003] [0005]**