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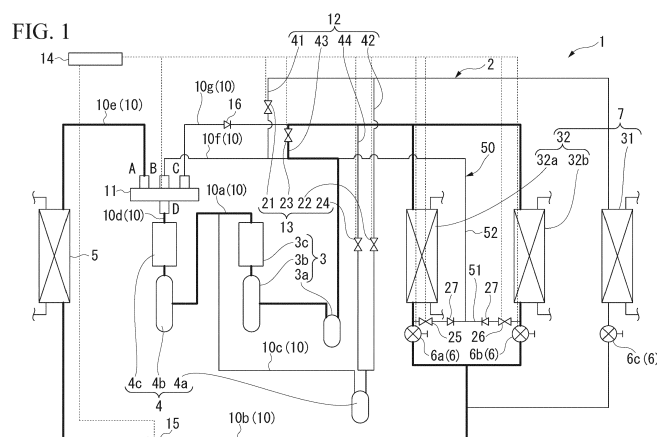
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(54) **HEAT PUMP AND METHOD OF CONTROLLING HEAT PUMP**

(57) A heat pump (1) includes a four-way valve (11) which is configured to select a first channel through which a refrigerant discharged from a high-stage compressor (4) is introduced into the condenser (5) and a refrigerant supplied from an evaporator (7) is introduced into a low-stage compressor (3) and a second channel through which the refrigerant discharged from the high-stage compressor (4) is introduced into the evaporator (7) and the refrigerant supplied from the condenser (5) is intro-

duced into the low-stage compressor (3), and a bypass flow path (12) through which the refrigerant supplied from the evaporator (7) is introduced into the low-stage compressor (3) without passing through the four-way valve or through which the refrigerant supplied from the evaporator (7) is introduced into the high-stage compressor (4) without passing through the four-way valve (11) and the low-stage compressor (3).



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a heat pump which is provided in a refrigerant circuit and a method of controlling a heat pump.

Description of Related Art

[0002] In the related art, a refrigeration cycle, that is, a heat pump is known, in which a refrigerant circuit through which a refrigerant is repeatedly compressed and expanded and circulates is provided. In such a heat pump, for example, as disclosed in Japanese Unexamined Patent Application, First Publication No. 2016-90102, a refrigerant may be compressed in two stages by a low-stage compressor which compresses the refrigerant and a high-stage compressor further compresses the refrigerant discharged from the low-stage compressor.

[0003] In addition, in such a heat pump, an evaporator which evaporates the refrigerant on an upstream side of the low-stage compressor is provided. For example, the evaporator is a heat exchanger which performs heat exchange between the refrigerant and a heat medium such as water or air.

SUMMARY OF THE INVENTION

[0004] Here, in the heat pump of Japanese Unexamined Patent Application, First Publication No. 2016-90102, the refrigerant supplied from the evaporator is introduced into the low-stage compressor, and thereafter, is introduced into the high-stage compressor.

[0005] However, the amount of heat exchange in the evaporator is not always constant, and may fluctuate due to environmental factors or the like. Accordingly, the temperature of the refrigerant which is introduced from the heat exchanger into the low-stage compressor is not constant, the refrigerant introduced into the low-stage compressor is not optimal for compression in the low-stage compressor, and thus, an efficient operation of the heat pump as a whole cannot be performed.

[0006] Therefore, the present invention provides a heat pump and a method of controlling a heat pump capable of being effectively operated by introducing a refrigerant optimal for compression into a low-stage compressor and a high-stage compressor.

[0007] According to a first aspect of the present invention, there is provided heat pump including: a low-stage compressor which is configured to compress a refrigerant; a high-stage compressor which is configured to compress the refrigerant discharged from the low-stage compressor; a condenser which is configured to condense the refrigerant discharged from the high-stage compres-

sor; an expansion unit which is configured to depressurize the refrigerant supplied from the condenser; an evaporator which is connected to the expansion unit and evaporates the refrigerant supplied from the expansion unit; a four-way valve which is configured to select a first channel through which the refrigerant discharged from the high-stage compressor is introduced into the condenser and the refrigerant supplied from the evaporator is introduced into the low-stage compressor and a second channel through which the refrigerant discharged from the high-stage compressor is introduced into the evaporator and the refrigerant supplied from the condenser is introduced into the low-stage compressor; and a bypass flow path through which the refrigerant supplied from the evaporator is introduced into the low-stage compressor without passing through the four-way valve or through which the refrigerant supplied from the evaporator is introduced into the high-stage compressor without passing through the four-way valve and the low-stage compressor.

[0008] The amount of heat exchange in the evaporator fluctuates and the temperature of the refrigerant is changed, and thus, a state of the refrigerant toward the low-stage compressor and the high-stage compressor may not be optimal for compression in the low-stage compressor and the high-stage compressor. Here, in the present aspect, since the bypass flow path is provided, not only the refrigerant supplied from the evaporator can be introduced into the low-stage compressor, but also the refrigerant supplied from the evaporator can bypass the low-stage compressor and can be directly introduced into the high-stage compressor. Therefore, according to a state of the refrigerant flowing out from the evaporator, the channel of the refrigerant can be switched to a compressor capable of performing optimal compression.

[0009] In addition, the refrigerant which is supplied from the evaporator without passing through the four-way valve can be introduced into the low-stage compressor, or can be directly introduced into the high-stage compressor. Accordingly, even in the heat pump which has the four-way valve and in which the distribution channel of the refrigerant can be changed, an additional installation of the bypass flow path is easily performed such that the refrigerant supplied from the evaporator can be introduced into the compressor capable of performing optimum.

[0010] In addition, the heat pump may further include an on-off valve which is provided in the bypass flow path and opens or closes the bypass flow path; and a controller which is configured to operate the on-off valve and the four-way valve.

[0011] In addition, since the controller is provided, the channel of the refrigerant can be automatically switched such that the refrigerant is introduced into the compressor capable of performing the optimal compression according to the state of the refrigerant flowing out from the evaporator.

[0012] Moreover, in the heat pump, the evaporator may

include a first heat exchanger which is configured to perform heat exchange between the refrigerant and a first heat medium, and a second heat exchanger which is provided in parallel with the first heat exchanger and is configured to perform heat exchange between the refrigerant and a second heat medium, the bypass flow path may include a first low-side bypass section which connects the first heat exchanger and the low-stage compressor to each other, a first high-side bypass section which connects the first heat exchanger and the high-stage compressor to each other without passing through the low-stage compressor, a second low-side bypass section which connects the second heat exchanger and the low-side section to each other, and a second high-side bypass section which connects the second heat exchanger and the high-stage compressor to each other without passing through the low-stage compressor, and the on-off valve may include a first valve which is provided in the first low-side bypass section, a second valve which is provided in the first high-side bypass section, a third valve which is provided in the second low-side bypass section, and a fourth valve which is provided in the second high-side bypass section.

[0013] The bypass flow path has each bypass section which connects each of the first heat exchanger and the second heat exchanger and each compressor, and thus, the refrigerant can be directly introduced into any compressor from the first heat exchanger and the second heat exchanger. Therefore, optimal compression of the refrigerant can be performed according to various states of the refrigerant.

[0014] In addition, the heat pump may further include a flow path through which the second heat exchanger and the four-way valve are connected to each other, the second low-side bypass section and the second high-side bypass section may be provided to branch off from the flow path, and the heat pump may further include a check valve which is provided to be closer to the four-way valve side in the flow path than to a position at which the second low-side bypass section and the second high-side bypass section branch off from the flow path and allows only a flow of the refrigerant from the four-way valve toward the second heat exchanger.

[0015] By such a check valve, when the refrigerant passes through the bypass flow path without passing through the four-way valve from the second heat exchanger and is introduced into each compressor, the entire refrigerant supplied from the second heat exchanger can flow to the bypass flow path. Accordingly, the bypass flow path can be fully functional.

[0016] In addition, in the heat pump, the controller may select the second channel in the four-way valve and may operate the first valve, the second valve, the third valve, and the fourth valve to close the bypass flow path, and may introduce the refrigerant discharged from the high-stage compressor into the second heat exchanger via the check valve.

[0017] In such a heat pump, by introducing the refrigerant

discharged from the high-stage compressor into the second heat exchanger, a defrost operation for removing frost attached to the second heat exchanger can be performed. Moreover, in this defrost operation, after heat is absorbed to the refrigerant by the condenser to evaporate the refrigerant, the refrigerant is compressed by the low-stage compressor and the high-stage compressor, and thereafter, the high-temperature and high-pressure refrigerant can be introduced into the second heat exchanger. Accordingly, the defrosting can be effectively performed at a short time in the second heat exchanger. As a result, it is possible to use the second heat exchanger in a wide operation range.

[0018] Moreover, the heat pump may further include a valve device which is provided between the condenser and the expansion unit, and the controller may operate the valve device to stop a flow of the refrigerant from the condenser to the expansion unit, may select the second channel in the four-way valve, thereafter, may operate the first valve to open the first low-side bypass section, and may operate the second valve, the third valve, and the fourth valve to close the first high-side bypass section, the second low-side bypass section, and the second high-side bypass section.

[0019] In such a heat pump, the refrigerant discharged from the high-stage compressor is introduced into the second heat exchanger, and thus, the defrost operation for removing frost attached to the second heat exchanger can be performed. Moreover, in this defrost operation, the first low-side bypass section is opened by the first valve, and thus, after heat is absorbed to the refrigerant by the first heat exchanger to evaporate the refrigerant, the refrigerant is compressed by the low-stage compressor and the high-stage compressor, and thereafter, the high-temperature and high-pressure refrigerant can be introduced into the second heat exchanger. Accordingly, the defrosting can be effectively performed at a short time in the second heat exchanger. As a result, it is possible to use the second heat exchanger in a wide operation range.

[0020] Moreover, in the heat pump, the expansion unit may include a first expansion valve which is provided in an inlet of the first heat exchanger between the condenser and the first heat exchanger, and a second expansion valve which is disposed in parallel with the first expansion valve and is provided in an inlet of the second heat exchanger between the condenser and the second heat exchanger, the heat pump may further include: a hot gas circuit which is provided to allow a portion between the second heat exchanger and the second expansion valve to communicate with an inlet of the low-stage compressor; a fifth valve which is provided in the hot gas circuit; and a check valve which is provided in the hot gas circuit and allows only a flow of the refrigerant from the inlet of the second heat exchanger toward the inlet of the low-stage compressor, the controller may operate the second expansion valve to stop a flow of the refrigerant from the condenser to the second expansion valve and operate

the fifth valve to open the hot gas circuit so as to introduce the refrigerant supplied from the second heat exchanger into the low-stage compressor via the check valve.

[0021] According to such a configuration, it is possible to a so-called hot gas operation by the controller. By performing the hot gas operation, the refrigerant can circulate between the second heat exchanger, the low-stage compressor, and the high-stage compressor without passing through the condenser.

[0022] Moreover, in the heat pump, the controller may select the first channel in the four-way valve, in a case where a temperature of the refrigerant flowing out from the first heat exchanger is lower than a temperature of the refrigerant flowing out from the second heat exchanger, the controller may open the first low-side bypass section by the first valve, close the first high-side bypass section by the second valve, close the second low-side bypass section by the third valve, and open the second high-side bypass section by the fourth valve, and in a case where the temperature of the refrigerant flowing out from the first heat exchanger is higher than the temperature of the refrigerant flowing out from the second heat exchanger, the controller may close the first low-side bypass section by the first valve, open the first high-side bypass section by the second valve, open the second low-side bypass section by the third valve, and close the second high-side bypass section by the fourth valve.

[0023] According to such a configuration, in the case where the temperature of the refrigerator flowing out from the first heat exchanger is lower than the temperature of the refrigerant flowing out from the second heat exchanger, the refrigerant supplied from the first heat exchanger can be introduced into the low-stage compressor, and the refrigerant supplied from the second heat exchanger can be directly introduced into the high-stage compressor. Moreover, in the case where the temperature of the refrigerator flowing out from the first heat exchanger is higher than the temperature of the refrigerant flowing out from the second heat exchanger, the refrigerant supplied from the first heat exchanger can be directly introduced into the high-stage compressor, and the refrigerant supplied from the second heat exchanger can be introduced into the low-stage compressor. That is, each of the refrigerant supplied from the first heat exchanger and the refrigerant supplied from the second heat exchanger can be introduced into a compressor suitable for compression of the low-stage compressor and the high-stage compressor.

[0024] Moreover, in the heat pump, the controller may select the first channel in the four-way valve, in a case where a temperature of the refrigerant flowing out from the condenser, a temperature of the refrigerant flowing out from the first heat exchanger, and a temperature of the refrigerant flowing out from the second heat exchanger are equal to each other, the controller may close the first low-side bypass section by the first valve, open the first high-side bypass section by the second valve, close the second low-side bypass section by the third valve,

and open the second high-side bypass section by the fourth valve.

[0025] According to such a configuration, in the case where the temperature of the refrigerant flowing out from the condenser, the temperature of the refrigerant flowing out from the first heat exchanger, and the temperature of the refrigerant flowing out from the second heat exchanger are equal to each other, the refrigerant supplied from the first heat exchanger can be directly introduced into the high-stage compressor and the refrigerant supplied from the second heat exchanger can be directly introduced into the high-stage compressor. That is, each of the refrigerant supplied from the first heat exchanger and the refrigerant supplied from the second heat exchanger can be introduced into a compressor suitable for compression of the low-stage compressor and the high-stage compressor.

[0026] Moreover, in the heat pump, the controller may select the first channel in the four-way valve, in a case where a temperature of the refrigerant flowing out from the first heat exchanger and a temperature of the refrigerant flowing out from the second heat exchanger are equal to each other and there is a temperature difference between the temperature of the refrigerant flowing out from the first heat exchanger and the temperature of the refrigerant flowing out from the second heat exchanger, and a temperature of the refrigerant flowing out from the condenser, the controller may open the first low-side bypass section by the first valve, close the first high-side bypass section by the second valve, open the second low-side bypass section by the third valve, and close the second high-side bypass section by the fourth valve.

[0027] According to such a configuration, in the case where the temperature of the refrigerant flowing out from the first heat exchanger and the temperature of the refrigerant flowing out from the second heat exchanger are equal to each other and there is a temperature difference between the temperature of the refrigerant flowing out from the first heat exchanger and the temperature of the refrigerant flowing out from the second heat exchanger, and a temperature of the refrigerant flowing out from the condenser, the refrigerant supplied from the first heat exchanger can be introduced into the low-stage compressor and the refrigerant supplied from the second heat exchanger can be introduced into the low-stage compressor. That is, each of the refrigerant supplied from the first heat exchanger and the refrigerant supplied from the second heat exchanger can be introduced into a compressor suitable for compression of the low-stage compressor and the high-stage compressor.

[0028] In a method of controlling a heat pump according to a second aspect of the present invention, the first channel is selected in the four-way valve, and thereafter, in a case where a temperature of the refrigerant flowing out from the first heat exchanger is lower than a temperature of the refrigerant flowing out from the second heat exchanger, the first low-side bypass section is opened by the first valve, the first high-side bypass section is

closed by the second valve, the second low-side bypass section is closed by the third valve, and the second high-side bypass section is opened by the fourth valve, and in a case where the temperature of the refrigerant flowing out from the first heat exchanger is higher than the temperature of the refrigerant flowing out from the second heat exchanger, the first low-side bypass section is closed by the first valve, the first high-side bypass section is opened by the second valve, the second low-side bypass section is opened by the third valve, and the second high-side bypass section is closed by the fourth valve.

[0029] In addition, in a method of controlling a heat pump according to a third aspect of the present invention, the first channel is selected in the four-way valve, and thereafter, in a case where a temperature of the refrigerant flowing out from the condenser, a temperature of the refrigerant flowing out from the first heat exchanger, and a temperature of the refrigerant flowing out from the second heat exchanger are equal to each other, the first low-side bypass section is closed by the first valve, the first high-side bypass section is opened by the second valve, the second low-side bypass section is closed by the third valve, and the second high-side bypass section is opened by the fourth valve.

[0030] Moreover, in a method of controlling a heat pump according to a third aspect of the present invention, the first channel is selected in the four-way valve, and thereafter, in a case where a temperature of the refrigerant flowing out from the first heat exchanger and a temperature flowing out from the second heat exchanger are equal to each other and there is a temperature difference between the temperature of the refrigerant flowing out from the first heat exchanger and the temperature of the refrigerant flowing out from the second heat exchanger, and a temperature of the refrigerant flowing out from the condenser, the first low-side bypass section is opened by the first valve, the first high-side bypass section is closed by the second valve, the second low-side bypass section is opened by the third valve, and the second high-side bypass section is closed by the fourth valve.

[0031] According to the above-described heat pump and the above-described method of controlling a heat pump, it is possible to perform an operation effectively by introducing a refrigerant optimal for compression into a low-stage compressor and a high-stage compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is an entire configuration diagram of a heat pump of an embodiment of the present invention, shows an operation pattern 1, and shows locations where a refrigerant flows by thick lines.

FIG. 2 is the entire configuration diagram of the heat pump of the embodiment of the present invention, shows an operation pattern 2, and shows locations where the refrigerant flows by thick lines.

FIG. 3 is the entire configuration diagram of the heat pump of the embodiment of the present invention, shows an operation pattern 3, and shows locations where the refrigerant flows by thick lines.

FIG. 4 is the entire configuration diagram of the heat pump of the embodiment of the present invention, shows an operation pattern 4, and shows locations where the refrigerant flows by thick lines.

FIG. 5 is the entire configuration diagram of the heat pump of the embodiment of the present invention, shows an operation pattern 5, and shows locations where the refrigerant flows by thick lines.

FIG. 6 is the entire configuration diagram of the heat pump of the present invention, shows a defrost operation pattern 1, and shows locations where the refrigerant flows by thick lines.

FIG. 7 is the entire configuration diagram of the heat pump of the present invention, shows a defrost operation pattern 2, and shows locations where the refrigerant flows by thick lines.

FIG. 8 is the entire configuration diagram of the heat pump of the present invention, shows a hot gas operation pattern, and shows locations where the refrigerant flows by thick lines.

DETAILED DESCRIPTION OF THE INVENTION

[0033] Hereinafter, a heat pump 1 of an embodiment of the present invention will be described.

[0034] As shown in FIG. 1, a heat pump 1 according to the present embodiment includes a refrigerant circuit 2 which is operated in a two-stage compression cycle. The refrigerant circuit 2 has a low-stage compressor 3, a high-stage compressor 4, a condenser 5, an expansion unit 6, and an evaporator 7, and these components are connected to each other in this order by a pipe 10 (flow path). In addition, for example, a refrigerant such as carbon dioxide circulates through the refrigerant circuit 2. Here, the refrigerant is not particularly limited to the carbon dioxide.

[0035] In addition, the refrigerant circuit 2 has a four-way valve 11 which is provided between the high-stage compressor 4 and the condenser 5. Moreover, the refrigerant circuit 2 has a bypass flow path 12 through which the refrigerant supplied from the evaporator 7 can be introduced into the low-stage compressor 3 without passing through the four-way valve 11 or through which the refrigerant supplied from the evaporator 7 can be introduced into the high-stage compressor 4 without passing through the low-stage compressor 3. Moreover, the refrigerant circuit 2 has an on-off valve 13 which is provided in the bypass flow path 12 and opens and closes the bypass flow path 12 and a controller 14 which is configured to operate the on-off valve 13 and the four-way valve 11.

[0036] The low-stage compressor 3 sucks the refrigerant and compresses the refrigerant. In the present embodiment, the low-stage compressor 3 has a low-stage

side accumulator 3a which is configured to perform gas-liquid separation of the refrigerant, a low-stage compressor body 3b which is configured to compress a gas-phase refrigerant supplied from the low-stage side accumulator 3a, and a low-stage side oil separator 3c which removes lubricating oil in the refrigerant discharged from the low-stage compressor body 3b.

[0037] The high-stage compressor 4 is connected to the low-stage compressor 3 in series and further compresses the refrigerant discharged from the low-stage compressor 3 such that a pressure of the refrigerant increases. More specifically, in the present embodiment, the high-stage compressor 4 has a high-stage compressor body 4b which is configured to compress the refrigerant passing through the low-stage side oil separator 3c and a high-stage side oil separator 4c which removes the lubricating oil in the refrigerant discharged from the high-stage compressor body 4b.

[0038] The high-stage compressor body 4b is connected to the low-stage side oil separator 3c by an inter-stage pipe 10a. In addition, the high-stage compressor body 4b further has a high-stage side accumulator 4a which is connected to an accumulator pipe 10c joining to a middle of the inter-stage pipe 10a and performs gas-liquid separation of the refrigerant flowing in from an upstream side. The high-stage compressor body 4b compresses a gas-phase refrigerant supplied from the high-stage side accumulator 4a in addition to a gas-phase refrigerant supplied from the low-stage side oil separator 3c.

[0039] The condenser 5 performs heat exchange between a high-temperature and high-pressure refrigerant discharged from the high-stage compressor body 4b of the high-stage compressor 4 and a heat medium such as air or water, and thus, cools and condenses the refrigerant. The condenser 5 is an indoor heat exchanger which is installed in a room.

[0040] The expansion unit 6 adiabatically expands the refrigerant supplied from the condenser 5 and depressurizes the refrigerant. The expansion unit 6 has a plurality of (three in the present embodiment) expansion valves 6a, 6b, and 6c, corresponds to three heat exchangers of the evaporator 7 described later, and is provided on an upstream side (inlet side) of the evaporator 7. A valve device 15 is provided in a connection pipe 10b between the expansion unit 6 and the condenser 5. The valve device 15 opens and closes a flow path of the connection pipe 10b. A capillary tube or the like may be used instead of the expansion unit 6.

[0041] In the present embodiment, the evaporator 7 has a water heat exchanger (first heat exchanger) 31 and an air heat exchanger (second heat exchanger) 32 which is provided in parallel with the water heat exchanger 31. The evaporator 7 is an outdoor heat exchanger which is installed outside a room.

[0042] The refrigerant which flows out from the condenser 5 and passes through the expansion valve (first expansion valve) 6c is introduced into the water heat exchanger 31, and heat exchange between the refrigerant

and the water (first heat medium) is performed by the water heat exchanger 31.

[0043] The refrigerant which flows out from the condenser 5 and passes through the expansion valves (second expansion valve) 6a and 6b is introduced into the air heat exchanger 32, and heat exchange between the refrigerant and the air (second heat medium) is performed by the air heat exchanger 32. In addition, in the present embodiment, the air heat exchanger 32 has a first air heat exchange unit 32a and a second air heat exchange unit 32b which are provided in parallel with each other.

[0044] The four-way valve 11 is a valve which has four ports A, B, C, and D. The port D is connected to the high-stage side oil separator 4c by a discharge pipe 10d. In addition, the port A and the condenser 5 are connected to each other by a condenser connection pipe 10e. The port B is connected to the low-stage side accumulator 3a by an introduction pipe 10f. The port C is connected to the first air heat exchange unit 32a and the second air heat exchange unit 32b of the air heat exchanger 32 by a heat exchange connection pipe 10g. In the heat exchange connection pipe 10g, a check valve 16 which allows only a flow of the refrigerant from the four-way valve 11 toward the air heat exchanger 32 is provided.

[0045] The bypass flow path 12 has a water low-side bypass section (first low-side bypass section) 41 which connects the water heat exchanger 31 and the low-stage compressor 3 to each other, a water high-side bypass section (first high-side bypass section) 42 which connects the water heat exchanger 31 and the high-stage compressor 4 to each other without passing through the low-stage compressor 3, an air low-side bypass section (second low-side bypass section) 43 which connects the air heat exchanger 32 and the low-stage compressor 3 to each other, and an air high-side bypass section (second high-side bypass section) 44 which connects the air heat exchanger 32 and the high-stage compressor 4 to each other without passing through the low-stage compressor 3.

[0046] The water low-side bypass section 41 is a pipe which connects the water heat exchanger 31 and a middle of the introduction pipe 10f extending from the port B of the four-way valve 11 to each other. The refrigerant can be introduced from the water heat exchanger 31 into the low-stage side accumulator 3a of the low-stage compressor 3 through the water low-side bypass section 41.

[0047] The water high-side bypass section 42 is a pipe 10 which is branched off from a middle of the water low-side bypass section 41 and connects the water heat exchanger 31 and the high-stage side accumulator 4a of the high-stage compressor 4. The refrigerant can be directly introduced from the water heat exchanger 31 to the high-stage side accumulator 4a through the water high-side bypass section 42.

[0048] The air low-side bypass section 43 is a pipe which is branched off from a middle of the heat exchange connection pipe 10g and connects the air heat exchanger 32 and the low-stage side accumulator 3a to each other.

Accordingly, the refrigerant can be introduced from the air heat exchanger 32 into the low-stage side accumulator 3a through the air low-side bypass section 43. Accordingly, the check valve 16 is provided to be closer to the four-way valve 11 side than to a position at which the air low-side bypass section 43 branches off from the heat exchange connection pipe 10g, that is, a connection location between the air low-side bypass section 43 and the heat exchange connection pipe 10g.

[0049] The air high-side bypass section 44 is a pipe which branches off from a middle of the heat exchange connection pipe 10g and connects the air heat exchanger 32 and the high-stage side accumulator 4a to each other. Accordingly, the refrigerant can be directly introduced from the air heat exchanger 32 into the high-stage side accumulator 4a through the air high-side bypass section 44. In the present embodiment, the air high-side bypass section 44 branches off from the heat exchange connection pipe 10g on a side closer to the air heat exchanger 32 than to the air low-side bypass section 43. Accordingly, the check valve 16 is provided to be closer to the four-way valve 11 side than to a position at which the air high-side bypass section 44 branches off from the heat exchange connection pipe 10g, that is, a connection location between the air high-side bypass section 44 and the heat exchange connection pipe 10g.

[0050] The on-off valve 13 has a first valve 21 which is provided in the water low-side bypass section 41, a second valve 22 which is provided in the water high-side bypass section 42, a third valve 23 which is provided in the air low-side bypass section 43, and a fourth valve 24 which is provided in the air high-side bypass section 44. Each of the valves 21, 22, 23, and 24 is a two-way valve, and opens and close of a flow path of each of the bypass sections 41, 42, 43, and 44.

[0051] The controller 14 operates the expansion unit 6, the on-off valve 13, the four-way valve 11, and the valve device 15, and thus, changes a flow direction of the refrigerant in the refrigerant circuit 2.

[0052] Here, the heat pump 1 of the present embodiment further includes a hot gas circuit 50. The hot gas circuit 50 has an inter-heat exchanger pipe 51 which connects a portion between the first air heat exchange unit 32a and an expansion valve 6a and a portion between the second air heat exchange unit 32b and the expansion valve 6b to each other, and a hot gas pipe 52 which branches off from the inter-heat exchanger pipe 51 and is connected to the accumulator pipe 10c between the low-stage side accumulator 3a and the four-way valve 11. That is, the hot gas circuit 50 is provided such that the portion between the first air heat exchange unit 32a and the expansion valve 6a (and the portion between the second air heat exchange unit 32b and the expansion valve 6b) and an inlet of the low-stage compressor 3 can communicate with each other.

[0053] In the inter-heat exchanger pipe 51, a fifth valve 25 and a check valve 27 are provided between a position at which the hot gas pipe 52 branches off from the inter-

heat exchanger pipe 51 and the first air heat exchange unit 32a, and a sixth valve 26 and a check valve 27 are provided between a position at which the hot gas pipe 52 branches off from the inter-heat exchanger pipe 51 and the second air heat exchanger 32b. The fifth valve 25 and the sixth valve 26 are operated by the controller 14 and thus, opens or closes the flow path of the inter-heat exchanger pipe 51. The check valve 27 causes the refrigerant to flow from the first air heat exchange unit 32a and the second air heat exchange unit 32b to the hot gas pipe 52 through the inter-heat exchanger pipe 51, and conversely, the check valve 27 prevents the refrigerant from flowing from the hot gas pipe 52 to the first air heat exchange unit 32a and the second air heat exchange unit 32b. The sixth valve 26 may be substantially the same as the fifth valve 25.

[0054] Next, in a case where the heat pump 1 is operated according to operation patterns 1 to 5 shown in FIGS. 1 to 5, a procedure of switching of each valve by the controller 14 will be described.

(Operation Pattern 1)

[0055] As shown in FIG. 1, in the operation pattern 1, the controller 14 operates the four-way valve 11 such that the port D and the port A communicate with each other. In addition, the port B and the port C communicate with each other. Accordingly, the refrigerant discharged from the high-stage compressor 4 is introduced into the condenser 5, and the refrigerant supplied from the evaporator 7 is introduced into the low-stage compressor 3. In this state, a distribution channel of the refrigerant is referred to as a first channel.

[0056] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to close the water low-side bypass section 41, close the water high-side bypass section 42, open the air low-side bypass section 43, and close the air high-side bypass section 44. Accordingly, the refrigerant supplied from the air heat exchanger 32 does not pass through the four-way valve 11, and the entire refrigerant is introduced into the low-stage side accumulator 3a of the low-stage compressor 3. In addition, the refrigerant supplied from the air heat exchanger 32 is compressed by the low-stage compressor body 3b, and thereafter, the refrigerant is further compressed by the high-stage compressor body 4b, passes through the four-way valve 11, and is introduced into the condenser 5. In the operation pattern 1, the water heat exchanger 31 is not used.

(Operation Pattern 2)

[0057] As shown in FIG. 2, in the operation pattern 2, the controller 14 operates the four-way valve 11 to set the distribution channel of the refrigerant to the first channel.

[0058] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to open the water low-side

bypass section 41, close the water high-side bypass section 42, open the air low-side bypass section 43, and close the air high-side bypass section 44. Accordingly, the refrigerant supplied from the water heat exchanger 31 and the air heat exchanger 32 does not pass through the four-way valve 11, and the entire refrigerant is introduced into the low-stage side accumulator 3a of the low-stage compressor 3. In addition, the refrigerant is compressed by the low-stage compressor body 3b, and thereafter, the refrigerant is further compressed by the high-stage compressor body 4b, passes through the four-way valve 11, and is introduced into the condenser 5. The operation pattern 2 is performed in a case where a temperature of the refrigerant which flows out from the water heat exchanger 31 and a temperature of the refrigerant which flows out from the air heat exchanger 32 are equal to each other and there is a temperature difference equal to or more than a predetermined value between the temperature of the refrigerant which flows out from the water heat exchanger 31 and the temperature of the refrigerant which flows out from the air heat exchanger 32, and a temperature of the refrigerant which flows out from the condenser 5. Here, the "temperature of the refrigerant which flows out from the water heat exchanger 31" means a temperature of a refrigerant after the refrigerant flowing out from the first air heat exchange unit 32a and the refrigerant flowing out of the second air heat exchange unit 32b join each other.

(Operation Pattern 3)

[0059] As shown in FIG. 3, in the operation pattern 3, the controller 14 operates the four-way valve 11 to set the distribution channel of the refrigerant to the first channel.

[0060] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to close the water low-side bypass section 41, open the water high-side bypass section 42, open the air low-side bypass section 43, and close the air high-side bypass section 44. Accordingly, the refrigerant supplied from the water heat exchanger 31 does not pass through the four-way valve 11 and the low-stage compressor 3, and the refrigerant is introduced into the high-stage side accumulator 4a of the high-stage compressor 4. In addition, the refrigerant supplied from the water heat exchanger 31 is compressed by the high-stage compressor body 4b, and thereafter, the refrigerant passes through the four-way valve 11 and is introduced into the condenser 5. In addition, the refrigerant supplied from the air heat exchanger 32 does not pass through the four-way valve 11, and the entire refrigerant is introduced into the low-stage side accumulator 3a of the low-stage compressor 3. In addition, the refrigerant supplied from the air heat exchanger 32 is compressed by the low-stage compressor body 3b, and thereafter, the refrigerant is further compressed by the high-stage compressor body 4b, passes through the four-way valve 11, and is introduced into the condenser 5.

[0061] The operation pattern 3 is performed in a case where the temperature of the refrigerant which flows out from the water heat exchanger 31 is higher than the temperature of the refrigerant which flows out from the air heat exchanger 32.

(Operation Pattern 4)

[0062] As shown in FIG. 4, in the operation pattern 4, the controller 14 operates the four-way valve 11 to set the distribution channel of the refrigerant to the first channel.

[0063] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to open the water low-side bypass section 41, close the water high-side bypass section 42, close the air low-side bypass section 43, and close the air high-side bypass section 44. Accordingly, the refrigerant supplied from the water heat exchanger 31 does not pass through the four-way valve 11, and the entire refrigerant is introduced into the low-stage side accumulator 3a of the low-stage compressor 3. In addition, the refrigerant supplied from the water heat exchanger 31 is compressed by the low-stage compressor body 3b, and thereafter, the refrigerant is further compressed by the high-stage compressor body 4b, passes through the four-way valve 11, and is introduced into the condenser 5. In the operation pattern 4, the air heat exchanger 32 is not used.

(Operation Pattern 5)

[0064] As shown in FIG. 5, in the operation pattern 5, the controller 14 operates the four-way valve 11 to set the distribution channel of the refrigerant to the first channel.

[0065] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to open the water low-side bypass section 41, close the water high-side bypass section 42, close the air low-side bypass section 43, and open the air high-side bypass section 44. Accordingly, the refrigerant supplied from the water heat exchanger 31 does not pass through the four-way valve 11, and the entire refrigerant is introduced into the low-stage side accumulator 3a of the low-stage compressor 3. In addition, the refrigerant supplied from the water heat exchanger 31 is compressed by the low-stage compressor body 3b, and thereafter, the refrigerant is further compressed by the high-stage compressor body 4b, passes through the four-way valve 11, and is introduced into the condenser 5. In addition, the refrigerant supplied from the air heat exchanger 32 does not pass through the four-way valve 11 and the low-stage compressor 3, and the refrigerant is introduced into the high-stage side accumulator 4a. In addition, the refrigerant supplied from the air heat exchanger 32 is compressed by the high-stage compressor body 4b, and thereafter, the refrigerant passes through the four-way valve 11 and is introduced into the condenser 5.

[0066] The operation pattern 5 is performed in a case where the temperature of the refrigerant which flows out from the water heat exchanger 31 is lower than the temperature of the refrigerant which flows out from the air heat exchanger 32.

[0067] Next, in a case where the heat pump 1 is operated in defrost operation patterns 1 and 2 shown in FIGS. 6 and 7, a procedure of switching of each valve by the controller 14 will be described.

(Defrost Operation Pattern 1)

[0068] As shown in FIG. 6, in the defrost operation pattern 1, the controller 14 operates the four-way valve 11 such that the port D and the port C communicate with each other. In addition, the port B and the port A communicate with each other. Accordingly, the refrigerant discharged from the high-stage compressor 4 is introduced into the evaporator 7, and the refrigerant supplied from the condenser 5 is introduced into the low-stage compressor 3. In this state, a distribution channel of the refrigerant is referred to as a second channel.

[0069] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to close the water low-side bypass section 41, close the water high-side bypass section 42, close the air low-side bypass section 43, and close the air high-side bypass section 44. Accordingly, a high-temperature and high pressure refrigerant supplied from the high-stage compressor 4 passes through the four-way valve 11, and is introduced into the air heat exchanger 32 through the heat exchange connection pipe 10g and the check valve 16. In addition, the refrigerant passes through the air heat exchanger 32, and thus, defrosting of the air heat exchanger 32 is performed, and thus, the refrigerant flows into the expansion valves 6a and 6b which are provided in the first air heat exchange unit 32a and the second air heat exchange unit 32b. Thereafter, the refrigerant is introduced into the condenser 5, passes through the four-way valve 11, and is introduced into the low-stage side accumulator 3a of the low-stage compressor 3. In this case, the water heat exchanger 31 is not used.

(Defrost Operation Pattern 2)

[0070] As shown in FIG. 7, in the defrost operation pattern 2, the controller 14 operates the four-way valve 11 to set the distribution channel of the refrigerant to the second channel. In addition, the controller 14 operates the valve device 15 to close the connection pipe 10b.

[0071] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to open the water low-side bypass section 41, close the water high-side bypass section 42, close the air low-side bypass section 43, and close the air high-side bypass section 44. Accordingly, the high-temperature and high pressure refrigerant supplied from the high-stage compressor 4 passes through the four-way valve 11, and is introduced into the air heat

exchanger 32 through the heat exchange connection pipe 10g. In addition, the refrigerant passes through the air heat exchanger 32, and thus, defrosting of the air heat exchanger 32 is performed, and thus, the refrigerant flows into the expansion valves 6a and 6b which are provided in the first air heat exchange unit 32a and the second air heat exchange unit 32b. Thereafter, the refrigerant is introduced into the water heat exchanger 31 and is introduced into the low-stage side accumulator 3a of the low-stage compressor 3 through the water low-side bypass section 41. In this case, the condenser 5 is not used.

(Hot Gas Operation Pattern)

[0072] As shown in FIG. 8, in a hot gas operation pattern, the controller 14 operates the four-way valve 11 to set the distribution channel of the refrigerant to the second channel. In addition, the controller 14 operates the expansion valves 6a and 6b to close the connection pipe 10b.

[0073] In addition, the controller 14 operates the first valve 21 to the fourth valve 24 to close the water low-side bypass section 41, close the water high-side bypass section 42, close the air low-side bypass section 43, and close the air high-side bypass section 44. In addition, the controller 14 operates the fifth valve 25 and the sixth valve 26 to open the inter-heat exchanger pipe 51. Accordingly, the high-temperature and high pressure refrigerant supplied from the high-stage compressor 4 passes through the four-way valve 11, and is introduced into the air heat exchanger 32 through the heat exchange connection pipe 10g. In addition, the refrigerant passes through the air heat exchanger 32, and thus, defrosting of the air heat exchanger 32 is performed, and thus, the refrigerant flows into the inter-heat exchanger pipe 51. Thereafter, the refrigerant is introduced into the low-stage side accumulator 3a of the low-stage compressor 3 through the hot gas pipe 52. In this case, the air heat exchanger 32 and the water heat exchanger 31 are not used.

[0074] In the heat pump 1 of the above-described present embodiment, an amount of heat exchange in the evaporator 7 fluctuates and the temperature of the refrigerant is changed, and thus, a state of the refrigerant toward the low-stage compressor 3 and the high-stage compressor 4 may not be optimal for compression in the low-stage compressor 3 and the high-stage compressor 4. Particularly, the evaporator 7 has the air heat exchanger 32 including the first air heat exchange unit 32a and the second air heat exchange unit 32b, and the water heat exchanger 31. Accordingly, in each case, the temperature of air or water, which is a medium for performing the heat exchange, fluctuates due to a change of an environment, and thus, the amount of heat exchange of the refrigerant is likely to fluctuate largely.

[0075] Here, since the bypass flow path 12 is provided, not only the refrigerant supplied from the evaporator 7 can be introduced into the low-stage compressor 3, but

also the refrigerant supplied from the evaporator 7 can bypass the low-stage compressor 3 and can be directly introduced into the high-stage compressor 4. Therefore, according to a state of the refrigerant flowing out from the evaporator 7, the channel of the refrigerant can be switched to a compressor capable of performing optimal compression. Accordingly, it is possible to improve the operation efficiency of the heat pump 1.

[0076] In addition, since the bypass flow path 12 is provided, the refrigerant which is supplied from the evaporator 7 without passing through the four-way valve 11 can be introduced into the low-stage compressor 3, or can be directly introduced into the high-stage compressor 4. Accordingly, even in the heat pump which has the four-way valve 11 and in which the distribution channel of the refrigerant can be changed, an additional installation of the bypass flow path 12 is easily performed such that the refrigerant supplied from the evaporator 7 can be introduced into the compressor capable of performing optimum.

[0077] In addition, since the controller 14 is provided, the channel of the refrigerant can be automatically switched such that the refrigerant is introduced into the compressor capable of performing the optimal compression according to the state of the refrigerant flowing out from the evaporator 7.

[0078] In addition, since the check valve 16 is provided in the heat exchange connection pipe 10g, when the refrigerant passes through the bypass flow path 12 without passing through the four-way valve 11 from the air heat exchanger 32 and is introduced into each of the compressors 3 and 4, the entire refrigerant supplied from the air heat exchanger 32 can flow to the bypass flow path 12 (the air low-side bypass section 43 and the air high-side bypass section 44). Accordingly, the bypass flow path 12 can be fully functional.

[0079] In addition, in the configuration of the present embodiment, the defrost operation pattern 1 and the defrost operation pattern 2 can be selected by the controller 14. In addition, in the defrost operation patterns 1 and 2, the defrosting can be effectively performed at a short time in the air heat exchanger 32. In addition, the hot gas operation pattern can be also selected by the controller 14. By performing the hot gas operation, the refrigerant can circulate between the air heat exchanger 32, the low-stage compressor 3, and the high-stage compressor 4 without passing through the condenser 5.

[0080] While preferred embodiments of the invention have been described and illustrated above, it should be understood that these are exemplary examples of the invention and are not to be considered as limiting. Additions, omissions, substitutions, and other modifications can be made without departing from the spirit or scope of the present invention. Accordingly, the invention is not to be considered as being limited by the foregoing description, and is only limited by the scope of the appended claims. For example, in a case where the temperature of the refrigerant flowing out from the condenser 5, the tem-

perature of the refrigerant flowing out from the water heat exchanger 31, and the temperature of the refrigerant flowing out from the air heat exchanger 32 are equal to each other, after the controller 14 selects the first channel in the four-way valve 11, the water low-side bypass section 41 may be closed by the first valve 21, the water high-side bypass section 42 may be opened by the second valve 22, the air low-side bypass section 43 may be closed by the third valve 23, and the air high-side bypass section 44 may be opened by the fourth valve 24. By performing this operation, in the case where the temperature of the refrigerant flowing out from the condenser 5, the temperature of the refrigerant flowing out from the water heat exchanger 31, and the temperature of the refrigerant flowing out from the air heat exchanger 32 are equal to each other, the refrigerant supplied from the water heat exchanger 31 can be directly introduced into the high-stage compressor 4 and the refrigerant supplied from the air heat exchanger 32 can be directly introduced into the high-stage compressor 4. That is, each of the refrigerant supplied from the water heat exchanger 31 and the refrigerant supplied from the air heat exchanger 32 can be introduced into a compressor suitable for compression of the low-stage compressor 3 and the high-stage compressor 4.

[0081] For example, the controller 14 may not necessarily be provided. In this case, each valve may be operated manually.

[0082] In addition, the evaporator 7 is not limited to the combination of the water heat exchanger 31 and the air heat exchanger 32 described above, and the number of heat exchangers is not limited to the above-described case. For example, the evaporator 7 may not have the air heat exchanger 32 and may have two water heat exchangers in parallel.

[0083] In addition, in the above-described refrigerant circuit 2, various valves may be provided in addition to the above-described various valves.

EXPLANATION OF REFERENCES

[0084]

- 1: heat pump
- 2: refrigerant circuit
- 3: low-stage compressor
- 3a: low-stage side accumulator
- 3b: low-stage compressor body
- 3c: low-stage side oil separator
- 4: high-stage compressor
- 4a: high-stage side accumulator
- 4b: high-stage compressor body
- 4c: high-stage side oil separator
- 5: condenser
- 6: expansion unit
- 6a, 6b: expansion valve (second expansion valve)
- 6c: expansion valve (first expansion valve)
- 7: evaporator

10: pipe (flow path)
 10a: inter-stage pipe
 10b: connection pipe
 10c: accumulator pipe
 10d: discharge pipe 5
 10e: condenser connection pipe
 10f: introduction pipe
 10g: heat exchange connection pipe
 11: four-way valve
 12: bypass flow path 10
 13: on-off valve
 14: controller
 15: valve device
 16: check valve
 21: first valve 15
 22: second valve
 23: third valve
 24: fourth valve
 25: fifth valve
 26: sixth valve 20
 27: check valve
 31: water heat exchanger (first heat exchanger)
 32: air heat exchanger (second heat exchanger)
 32a: first air heat exchange unit
 32b: second air heat exchange unit 25
 41: water low-side bypass section (first low-side bypass section)
 42: water high-side bypass section (first high-side bypass section)
 43: air low-side bypass section (second low-side bypass section) 30
 44: air high-side bypass section (second high-side bypass section)
 50: hot gas circuit
 51: inter-heat exchanger pipe 35
 52: hot gas pipe

Claims

1. A heat pump (1) comprising:

a low-stage compressor (3) which is configured to compress a refrigerant;
 a high-stage compressor (4) which is configured to compress the refrigerant discharged from the low-stage compressor (3);
 a condenser (5) which is configured to condense the refrigerant discharged from the high-stage compressor (4); 50
 an expansion unit (6) which is configured to depressurize the refrigerant supplied from the condenser (5);
 an evaporator (7) which is connected to the expansion unit (6) and configured to evaporate the refrigerant supplied from the expansion unit (6);
 a four-way valve (11) which is configured to select a first channel through which the refrigerant

discharged from the high-stage compressor (4) is introduced into the condenser (5) and the refrigerant supplied from the evaporator (7) is introduced into the low-stage compressor (3) and a second channel through which the refrigerant discharged from the high-stage compressor (4) is introduced into the evaporator (7) and the refrigerant supplied from the condenser (5) is introduced into the low-stage compressor (3); and a bypass flow path (12) through which the refrigerant supplied from the evaporator (7) is introduced into the low-stage compressor (3) without passing through the four-way valve (11) or through which the refrigerant supplied from the evaporator (7) is introduced into the high-stage compressor (4) without passing through the four-way valve (11) and the low-stage compressor (3).

2. The heat pump according to claim 1, further comprising:

an on-off valve (13) which is provided in the bypass flow path (12) and opens or closes the bypass flow path (12); and
 a controller (14) which is configured to operate the on-off valve (13) and the four-way valve (11).

3. The heat pump according to claim 2, wherein the evaporator (7) includes a first heat exchanger (31) which is configured to perform heat exchange between the refrigerant and a first heat medium, and a second heat exchanger (32) which is provided in parallel with the first heat exchanger (31) and is configured to perform heat exchange between the refrigerant and a second heat medium, wherein the bypass flow path (12) includes a first low-side bypass section (41) which connects the first heat exchanger (31) and the low-stage compressor (3) to each other, a first high-side bypass section (42) which connects the first heat exchanger (31) and the high-stage compressor (4) to each other without passing through the low-stage compressor (3), a second low-side bypass section (43) which connects the second heat exchanger (32) and the low-stage compressor (3) to each other, and a second high-side bypass section (44) which connects the second heat exchanger (32) and the high-stage compressor (4) to each other without passing through the low-stage compressor (3), wherein the on-off valve (13) includes a first valve (21) which is provided in the first low-side bypass section (41), a second valve (22) which is provided in the first high-side bypass section (42), a third valve (23) which is provided in the second

low-side bypass section (43), and
a fourth valve (24) which is provided in the second
high-side bypass section (44).

4. The heat pump according to claim 3, further comprising: 5

a flow path (10) through which the second heat
exchanger (32) and the four-way valve (11) are
connected to each other, 10
wherein the second low-side bypass section
(43) and the second high-side bypass section
(44) are provided to branch off from the flow path
(10),
the heat pump further comprising: 15
a check valve (16) which is provided to be closer
to the four-way valve (11) side in the flow path
(10) than to a position at which the second low-
side bypass section (43) and the second high-
side bypass section (44) branch off from the flow 20
path (10) and is configured to allow only a flow
of the refrigerant from the four-way valve (11)
toward the second heat exchanger (32).

5. The heat pump according to claim 4, 25
wherein after the controller (14) selects the second
channel in the four-way valve (11), the controller (14)
operates the first valve (21), the second valve (22),
the third valve (23), and the fourth valve (24) to close
the bypass flow path, and introduces the refrigerant 30
discharged from the high-stage compressor (4) into
the second heat exchanger (32) via the check valve
(16).

6. The heat pump according to claim 4, further comprising: 35

a valve device (15) which is provided between
the condenser and the expansion unit,
wherein the controller (14) operates the valve
device (15) to stop a flow of the refrigerant from
the condenser (5) to the expansion unit (6), se- 40
lects the second channel in the four-way valve
(11), thereafter, operates the first valve (21) to
open the first low-side bypass section (41), and
operates the second valve (22), the third valve
(23), and the fourth valve (24) to close the first
high-side bypass section (42), the second low- 45
side bypass section (43), and the second high-
side bypass section (44). 50

7. The heat pump according to claim 5,
wherein the expansion unit (6) includes
a first expansion valve (6c) which is provided in an
inlet of the first heat exchanger (31) between the
condenser (5) and the first heat exchanger (31), and
a second expansion valve (6a, 6b) which is disposed
in parallel with the first expansion valve (6c) and is 55

provided in an inlet of the second heat exchanger
(32) between the condenser (5) and the second heat
exchanger (32),
the heat pump further comprising:

a hot gas circuit (50) which is provided to allow
a portion between the second heat exchanger
(32) to communicate with the second expansion
valve (6a, 6b) and an inlet of the low-stage com-
pressor (3);
a fifth valve (25) which is provided in the hot gas
circuit (50); and
a check valve (27) which is provided in the hot
gas circuit (50) and is configured to allow only a
flow of the refrigerant from the inlet of the second
heat exchanger (32) toward the inlet of the low-
stage compressor (3),
wherein the controller (14) is configured to op-
erate the second expansion valve (6a, 6b) to
stop a flow of the refrigerant from the condenser
(5) to the second expansion valve (6a, 6b) and
operate the fifth valve (25) to open the hot gas
circuit (50) so as to introduce the refrigerant sup-
plied from the second heat exchanger (32) into
the low-stage compressor (3) via the check
valve (27).

8. The heat pump according to any one of claims 4 to 7,
wherein the controller (14) is configured to select the
first channel in the four-way valve (11),
in a case where a temperature of the refrigerant flow-
ing out from the first heat exchanger (31) is lower
than a temperature of the refrigerant flowing out from
the second heat exchanger (32), the controller is
configured to open the first low-side bypass section
(41) by the first valve (21), close the first high-side
bypass section (42) by the second valve (22), closes
the second low-side bypass section (43) by the third
valve (23), and opens the second high-side bypass
section (44) by the fourth valve (24), and
in a case where the temperature of the refrigerant
flowing out from the first heat exchanger (31) is high-
er than the temperature of the refrigerant flowing out
from the second heat exchanger (32), the controller
is configured to close the first low-side bypass sec-
tion (41) by the first valve (21), open the first high-
side bypass section (42) by the second valve (22),
open the second low-side bypass section (43) by the
third valve (23), and close the second high-side by-
pass section (44) by the fourth valve (24).

9. The heat pump according to any one of claims 4 to 8,
wherein the controller selects the first channel in the
four-way valve (11),
in a case where a temperature of the refrigerant flow-
ing out from the condenser (5), a temperature of the
refrigerant flowing out from the first heat exchanger
(31), and a temperature of the refrigerant flowing out

from the second heat exchanger (32) are equal to each other, the controller is configured to close the first low-side bypass section (41) by the first valve (21), open the first high-side bypass section (42) by the second valve (22), close the second low-side bypass section (43) by the third valve (23), and open the second high-side bypass section (44) by the fourth valve (24).

10. The heat pump according to any one of claims 4 to 9, wherein the controller selects the first channel in the four-way valve (11),
 in a case where a temperature of the refrigerant flowing out from the first heat exchanger (31) and a temperature of the refrigerant flowing out from the second heat exchanger (32) are equal to each other and there is a temperature difference between the temperature of the refrigerant flowing out from the first heat exchanger (31) and the temperature of the refrigerant flowing out from the second heat exchanger (32), and a temperature of the refrigerant flowing out from the condenser (5), the controller is configured to open the first low-side bypass section (41) by the first valve (21), close the first high-side bypass section (42) by the second valve (22), open the second low-side bypass section (43) by the third valve (23), and close the second high-side bypass section (44) by the fourth valve (24).
11. A method of controlling a heat pump (1),
 the heat pump (1) including
 a low-stage compressor (3) which is configured to compress a refrigerant,
 a high-stage compressor (4) which is configured to compress the refrigerant discharged from the low-stage compressor (3),
 a condenser (5) which is configured to condense the refrigerant discharged from the high-stage compressor (4),
 an expansion unit (6) which is configured to depressurize the refrigerant supplied from the condenser (5),
 an evaporator (7) which is connected to the expansion unit (6) and is configured to evaporate the refrigerant supplied from the expansion unit (6),
 a four-way valve (11) which is configured to select a first channel through which the refrigerant discharged from the high-stage compressor (4) is introduced into the condenser (5) and the refrigerant supplied from the evaporator (7) is introduced into the low-stage compressor (3) and a second channel through which the refrigerant discharged from the high-stage compressor (4) is introduced into the evaporator (7) and the refrigerant supplied from the condenser (5) is introduced into the low-stage compressor (3),
 a bypass flow path (12) through which the refrigerant supplied from the evaporator (7) is introduced into

the low-stage compressor (3) without passing through the four-way valve (11) or through which the refrigerant supplied from the evaporator (7) is introduced into the high-stage compressor (4) without passing through the four-way valve (11) and the low-stage compressor (3), and
 an on-off valve (13) which is provided in the bypass flow path (12) and is configured to open or close the bypass flow path (12),
 the evaporator (7) including

a first heat exchanger (31) which is configured to perform heat exchange between the refrigerant and a first heat medium, and
 a second heat exchanger (32) which is provided in parallel with the first heat exchanger (31) and is configured to perform heat exchange between the refrigerant and a second heat medium,

the bypass flow path (12) including

a first low-side bypass section (41) which connects the first heat exchanger (31) and the low-stage compressor (3) to each other,
 a first high-side bypass section (42) which connects the first heat exchanger (31) and the high-stage compressor (4) to each other without passing through the low-stage compressor (3),
 a second low-side bypass section (43) which connects the second heat exchanger (32) and the low-stage compressor (3) to each other, and
 a second high-side bypass section (44) which connects the second heat exchanger (32) and the high-stage compressor (4) to each other without passing through the low-stage compressor (3),

the on-off valve (13) including

a first valve (21) which is provided in the first low-side bypass section (41),
 a second valve (22) which is provided in the first high-side bypass section (42),
 a third valve (23) which is provided in the second low-side bypass section (43), and
 a fourth valve (24) which is provided in the second high-side bypass section (44),

the heat pump (1) further including
 a flow path (10) through which the second heat exchanger (32) and the four-way valve (11) are connected to each other,
 the second low-side bypass section (43) and the second high-side bypass section (44) being provided to branch off from the flow path (10),
 the heat pump further including
 a check valve (16) which is provided to be closer to the four-way valve (11) side in the flow path (10) than

to a position at which the second low-side bypass section (43) and the second high-side bypass section (44) branch off from the flow path (10) and allows only a flow of the refrigerant from the four-way valve (11) toward the second heat exchanger (32), the method comprising:

selecting the first channel in the four-way valve (11);

thereafter, in a case where a temperature of the refrigerant flowing out from the first heat exchanger (31) is lower than a temperature of the refrigerant flowing out from the second heat exchanger (32), opening the first low-side bypass section (41) by the first valve (21), closing the first high-side bypass section (42) by the second valve (22), closing the second low-side bypass section (43) by the third valve (23), and opening the second high-side bypass section (44) by the fourth valve (24); and

in a case where the temperature of the refrigerant flowing out from the first heat exchanger (31) is higher than the temperature of the refrigerant flowing out from the second heat exchanger (32), closing the first low-side bypass section (41) by the first valve (21), opening the first high-side bypass section (42) by the second valve (22), opening the second low-side bypass section (43) by the third valve (23), and closing the second high-side bypass section (44) by the fourth valve (24).

12. A method of controlling a heat pump (1),

the heat pump (1) including

a low-stage compressor (3) which is configured to compress a refrigerant,

a high-stage compressor (4) which is configured to compress the refrigerant discharged from the low-stage compressor (3),

a condenser (5) which is configured to condense the refrigerant discharged from the high-stage compressor (4),

an expansion unit (6) which is configured to depressurize the refrigerant supplied from the condenser (5),

an evaporator (7) which is connected to the expansion unit (6) and is configured to evaporate the refrigerant supplied from the expansion unit (6),

a four-way valve (11) which is configured to select a first channel through which the refrigerant discharged from the high-stage compressor (4) is introduced into the condenser (5) and the refrigerant supplied from the evaporator (7) is introduced into the low-stage compressor (3) and a second channel through which the refrigerant discharged from the high-stage compressor (4) is introduced into the evaporator (7) and the refrigerant supplied from the condenser (5) is introduced into the low-stage com-

pressor (3),

a bypass flow path (12) through which the refrigerant supplied from the evaporator (7) is introduced into the low-stage compressor (3) without passing through the four-way valve (11) or through which the refrigerant supplied from the evaporator (7) is introduced into the high-stage compressor (4) without passing through the four-way valve (11) and the low-stage compressor (3), and

an on-off valve (13) which is provided in the bypass flow path (12) and is configured to open or close the bypass flow path (12),

the evaporator (7) including

a first heat exchanger (31) which is configured to perform heat exchange between the refrigerant and a first heat medium, and

a second heat exchanger (32) which is provided in parallel with the first heat exchanger (31) and is configured to perform heat exchange between the refrigerant and a second heat medium,

the bypass flow path (12) including

a first low-side bypass section (41) which connects the first heat exchanger (31) and the low-stage compressor (3) to each other,

a first high-side bypass section (42) which connects the first heat exchanger (31) and the high-stage compressor (4) to each other without passing through the low-stage compressor (3), a second low-side bypass section (43) which connects the second heat exchanger (32) and the low-stage compressor (3) to each other, and a second high-side bypass section (44) which connects the second heat exchanger (32) and the high-stage compressor (4) to each other without passing through the low-stage compressor (3),

the on-off valve (13) including

a first valve (21) which is provided in the first low-side bypass section (41),

a second valve (22) which is provided in the first high-side bypass section (42),

a third valve (23) which is provided in the second low-side bypass section (43), and

a fourth valve (24) which is provided in the second high-side bypass section (44),

the heat pump (1) further including

a flow path (10) through which the second heat exchanger (32) and the four-way valve (11) are connected to each other,

the second low-side bypass section (43) and the second high-side bypass section (44) being provided to branch off from the flow path (10),

the heat pump further including
 a check valve (16) which is provided to be closer to
 the four-way valve (11) side in the flow path (10) than
 to a position at which the second low-side bypass
 section (43) and the second high-side bypass sec-
 tion (44) branch off from the flow path (10) and allows
 only a flow of the refrigerant from the four-way valve
 (11) toward the second heat exchanger (32),
 the method comprising:

selecting the first channel in the four-way valve
 (11); and
 thereafter, in a case where a temperature of the
 refrigerant flowing out from the condenser (5),
 a temperature of the refrigerant flowing out from
 the first heat exchanger (31), and a temperature
 of the refrigerant flowing out from the second
 heat exchanger (32) are equal to each other,
 closing the first low-side bypass section (41) by
 the first valve (21), opening the first high-side
 bypass section (42) by the second valve (22),
 closing the second low-side bypass section (43)
 by the third valve (23), and opening the second
 high-side bypass section (44) by the fourth valve
 (24).

13. A method of controlling a heat pump (1),

the heat pump (1) including
 a low-stage compressor (3) which is configured to
 compress a refrigerant,
 a high-stage compressor (4) which is configured to
 compress the refrigerant discharged from the low-
 stage compressor (3),
 a condenser (5) which is configured to condense the
 refrigerant discharged from the high-stage compres-
 sor (4),
 an expansion unit (6) which is configured to depres-
 surize the refrigerant supplied from the condenser
 (5),
 an evaporator (7) which is connected to the expan-
 sion unit (6) and is configured to evaporate the re-
 frigerant supplied from the expansion unit (6),
 a four-way valve (11) which is configured to select a
 first channel through which the refrigerant dis-
 charged from the high-stage compressor (4) is intro-
 duced into the condenser (5) and the refrigerant sup-
 plied from the evaporator (7) is introduced into the
 low-stage compressor (3) and a second channel
 through which the refrigerant discharged from the
 high-stage compressor (4) is introduced into the
 evaporator (7) and the refrigerant supplied from the
 condenser (5) is introduced into the low-stage com-
 pressor (3),
 a bypass flow path (12) through which the refrigerant
 supplied from the evaporator (7) is introduced into
 the low-stage compressor (3) without passing
 through the four-way valve (11) or through which the
 refrigerant supplied from the evaporator (7) is intro-

duced into the high-stage compressor (4) without
 passing through the four-way valve (11) and the low-
 stage compressor (3), and
 an on-off valve (13) which is provided in the bypass
 flow path (12) and is configured to open or close the
 bypass flow path (12),
 the evaporator (7) including

a first heat exchanger (31) which is configured
 to perform heat exchange between the refriger-
 ant and a first heat medium, and
 a second heat exchanger (32) which is provided
 in parallel with the first heat exchanger (31) and
 is configured to perform heat exchange between
 the refrigerant and a second heat medium,

the bypass flow path (12) including

a first low-side bypass section (41) which con-
 nects the first heat exchanger (31) and the low-
 stage compressor (3) to each other,
 a first high-side bypass section (42) which con-
 nects the first heat exchanger (31) and the high-
 stage compressor (4) to each other without
 passing through the low-stage compressor (3),
 a second low-side bypass section (43) which
 connects the second heat exchanger (32) and
 the low-stage compressor (3) to each other, and
 a second high-side bypass section (44) which
 connects the second heat exchanger (32) and
 the high-stage compressor (4) to each other
 without passing through the low-stage compres-
 sor (3),

the on-off valve (13) including

a first valve (21) which is provided in the first
 low-side bypass section (41),
 a second valve (22) which is provided in the first
 high-side bypass section (42),
 a third valve (23) which is provided in the second
 low-side bypass section (43), and
 a fourth valve (24) which is provided in the sec-
 ond high-side bypass section (44),

the heat pump (1) further including

a flow path (10) through which the second heat ex-
 changer (32) and the four-way valve (11) are con-
 nected to each other,
 the second low-side bypass section (43) and the sec-
 ond high-side bypass section (44) being provided to
 branch off from the flow path (10),
 the heat pump further including
 a check valve (16) which is provided to be closer to
 the four-way valve (11) side in the flow path (10) than
 to a position at which the second low-side bypass
 section (43) and the second high-side bypass sec-
 tion (44) branch off from the flow path (10) and is

configured to allow only a flow of the refrigerant from the four-way valve (11) toward the second heat exchanger (32),
the method comprising:

selecting the first channel in the four-way valve (11); and

thereafter, in a case where a temperature of the refrigerant flowing out from the first heat exchanger (31) and a temperature of the refrigerant flowing out from the second heat exchanger (32) are equal to each other and there is a temperature difference between the temperature of the refrigerant flowing out from the first heat exchanger (31) and the temperature of the refrigerant flowing out from the second heat exchanger (32), and a temperature of the refrigerant flowing out from the condenser (5), opening the first low-side bypass section (41) by the first valve (21), closing the first high-side bypass section (42) by the second valve (22), opening the second low-side bypass section (43) by the third valve (23), and closing the second high-side bypass section (44) by the fourth valve (24).

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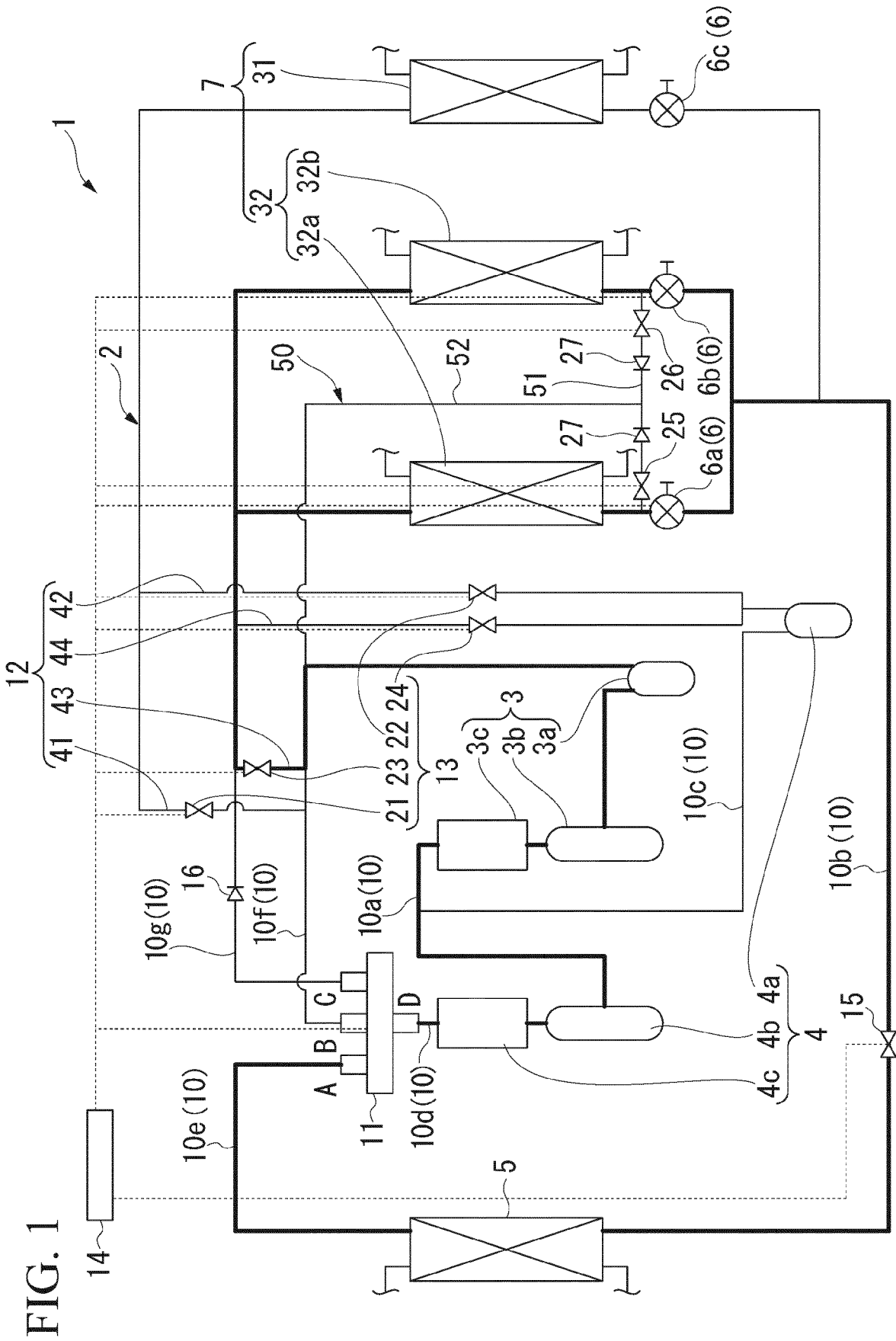
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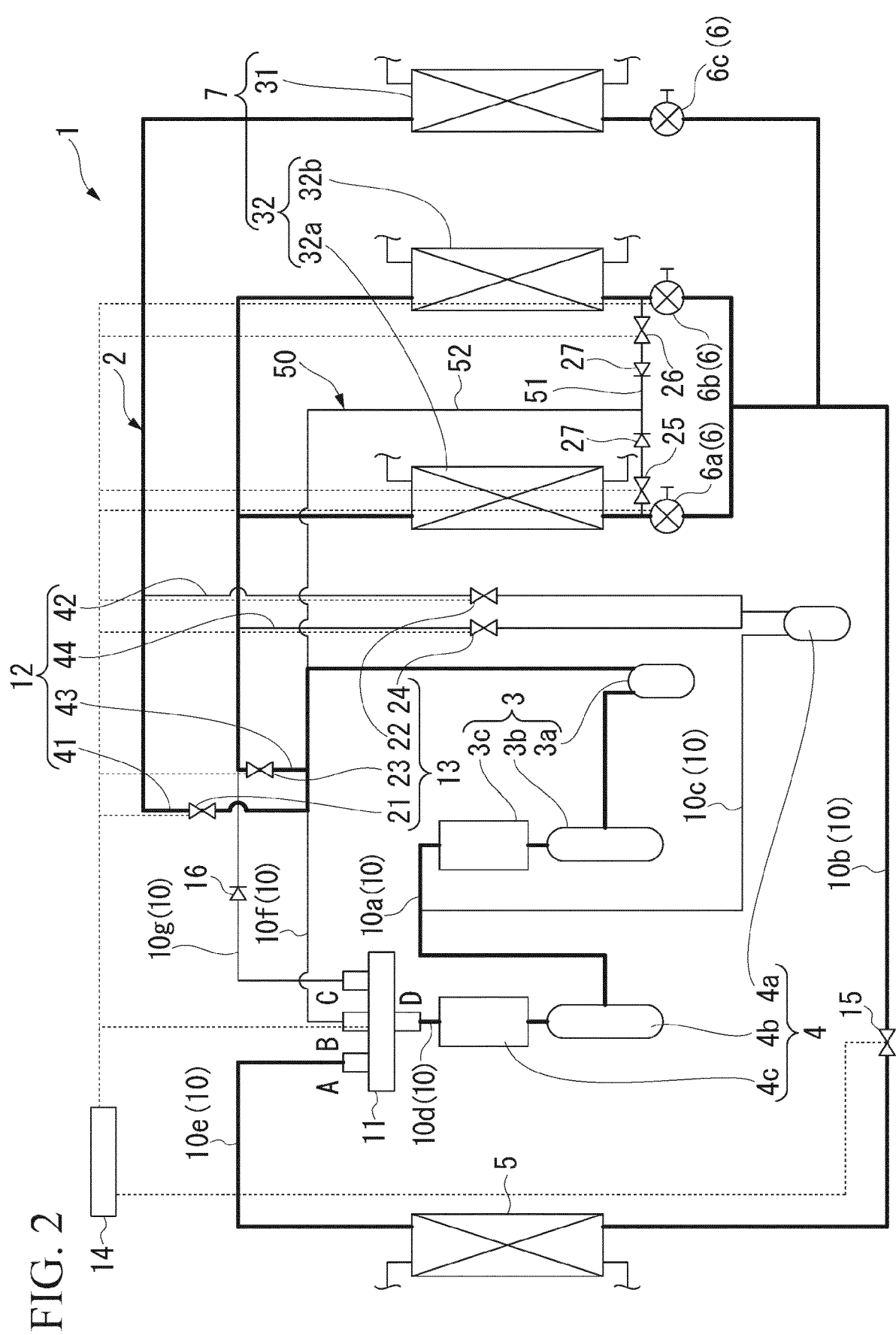
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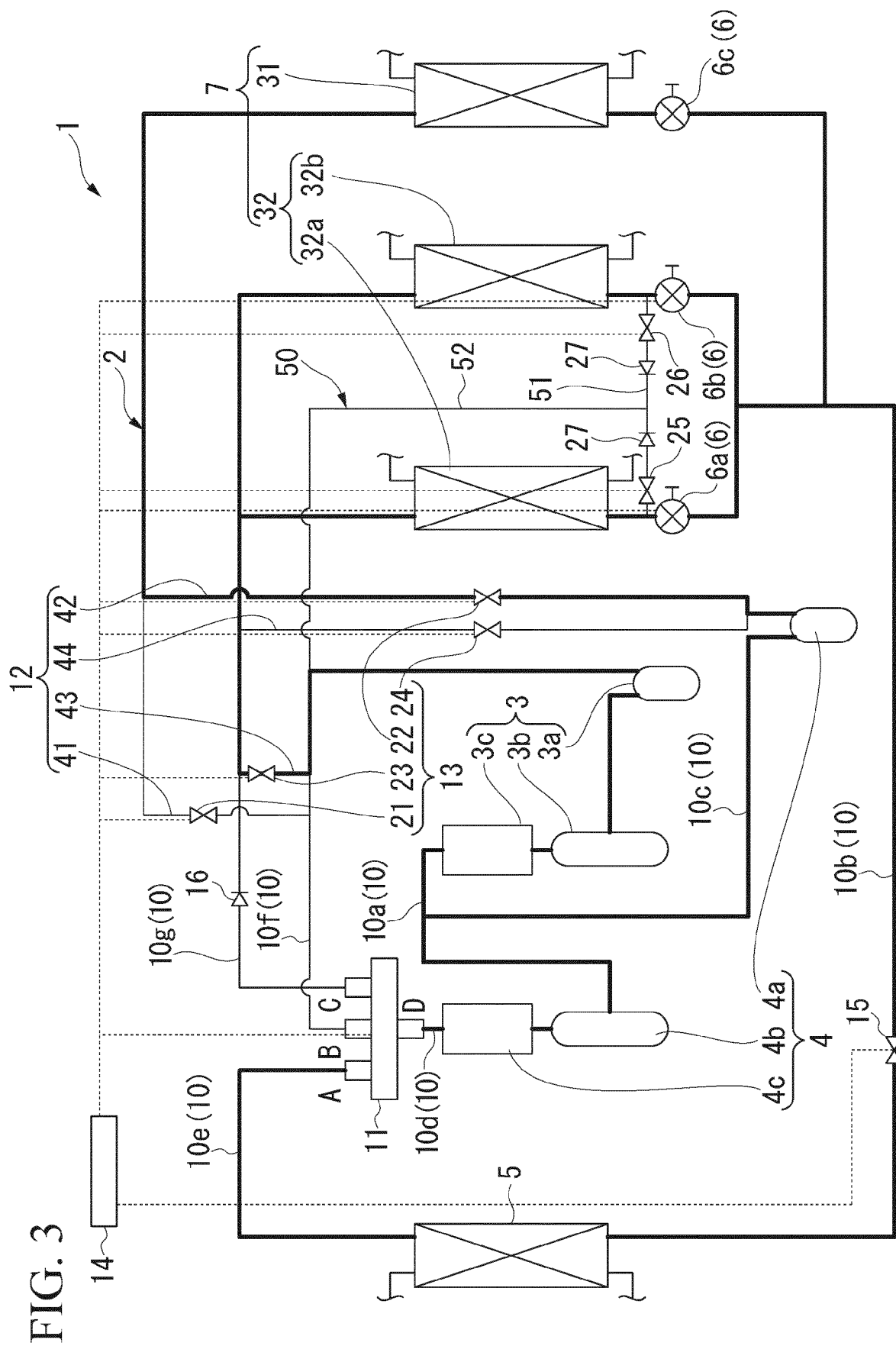
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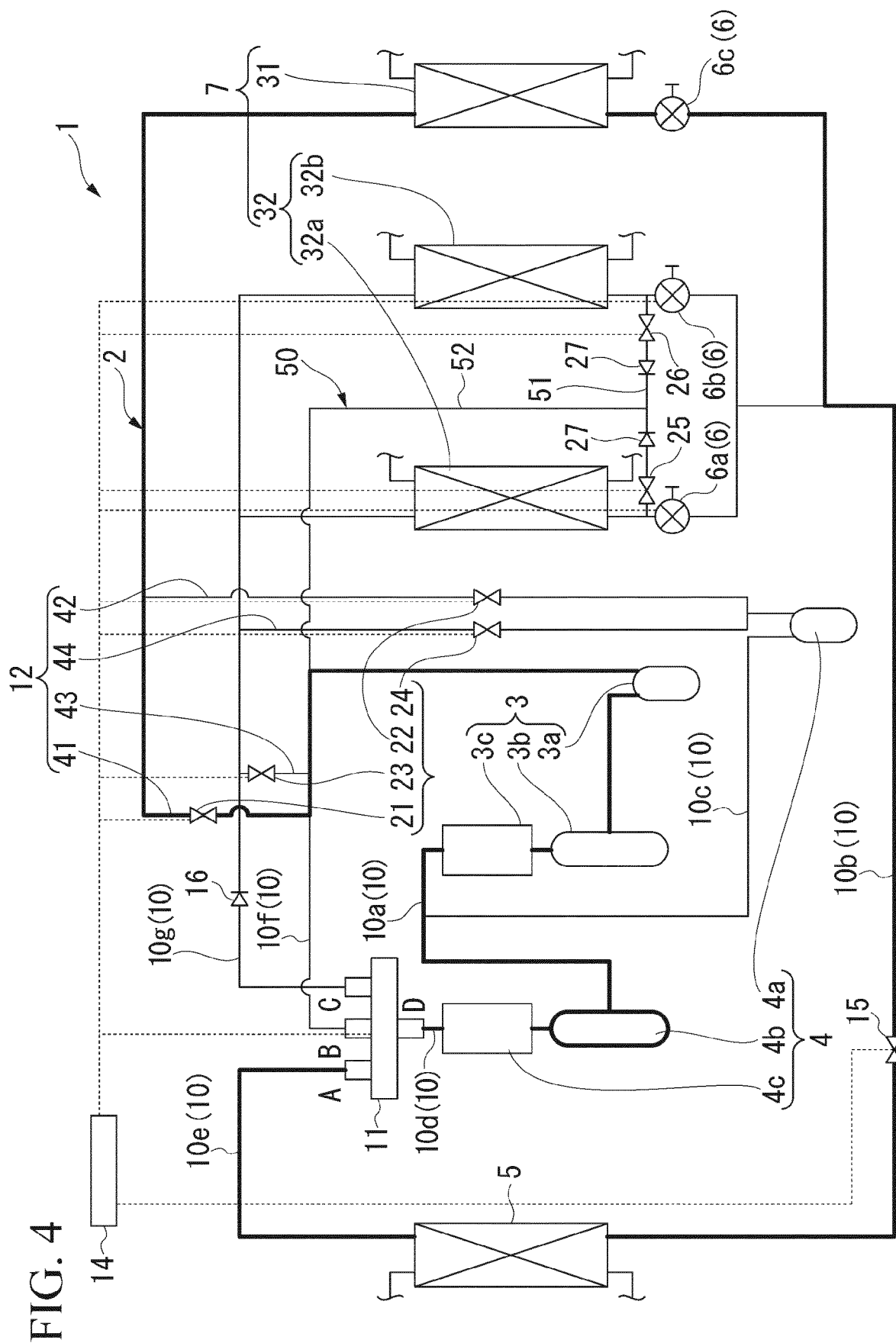
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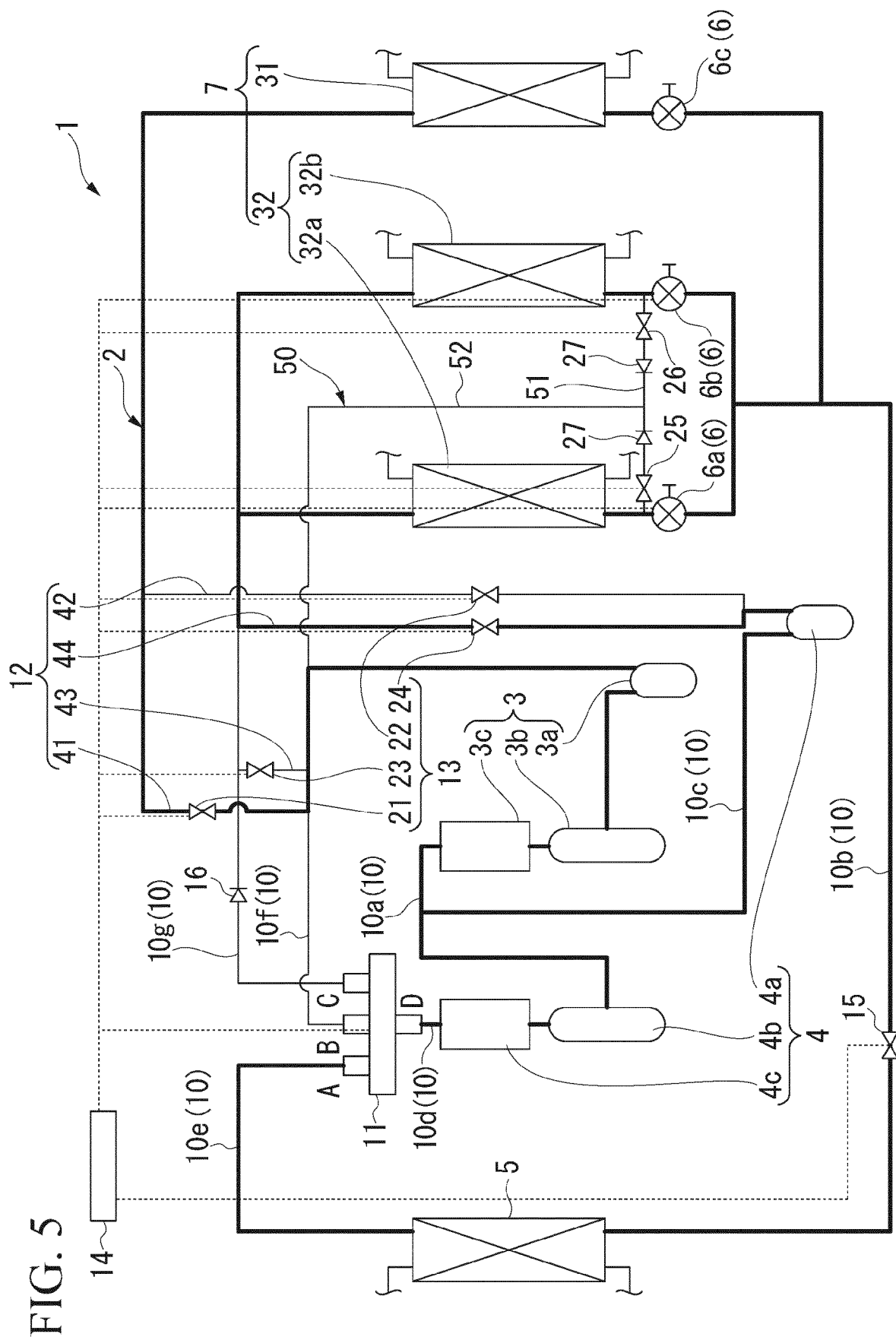
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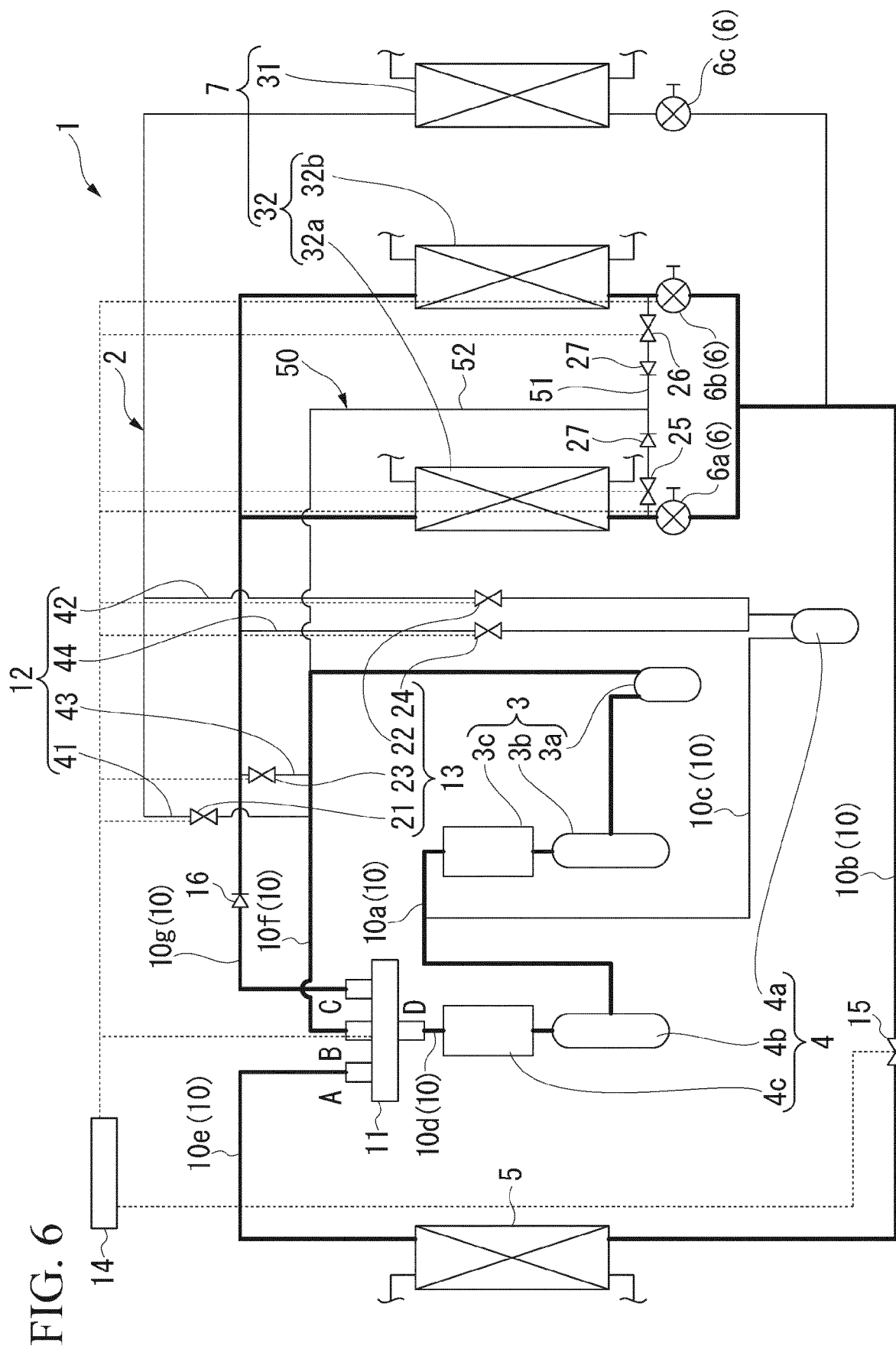


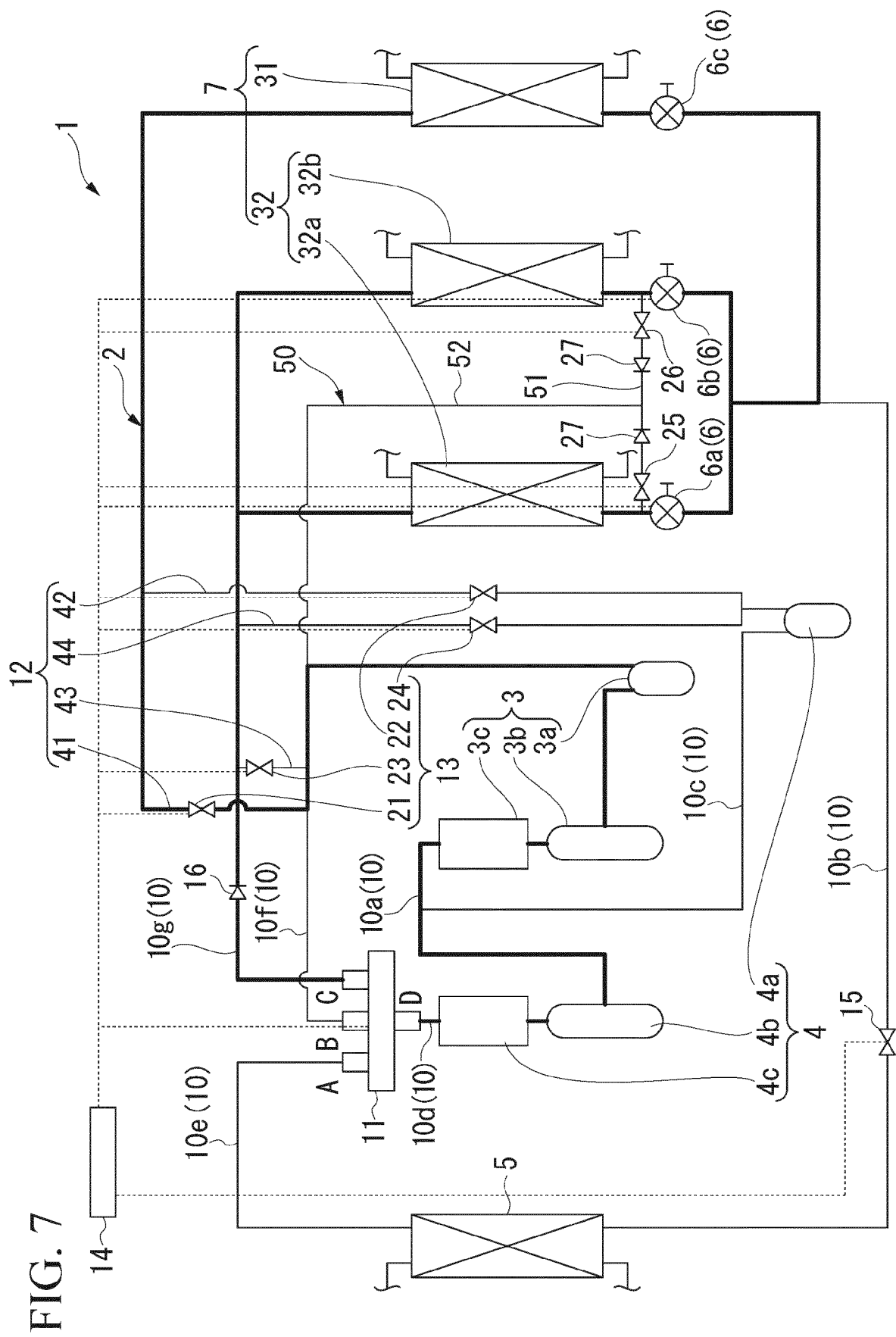


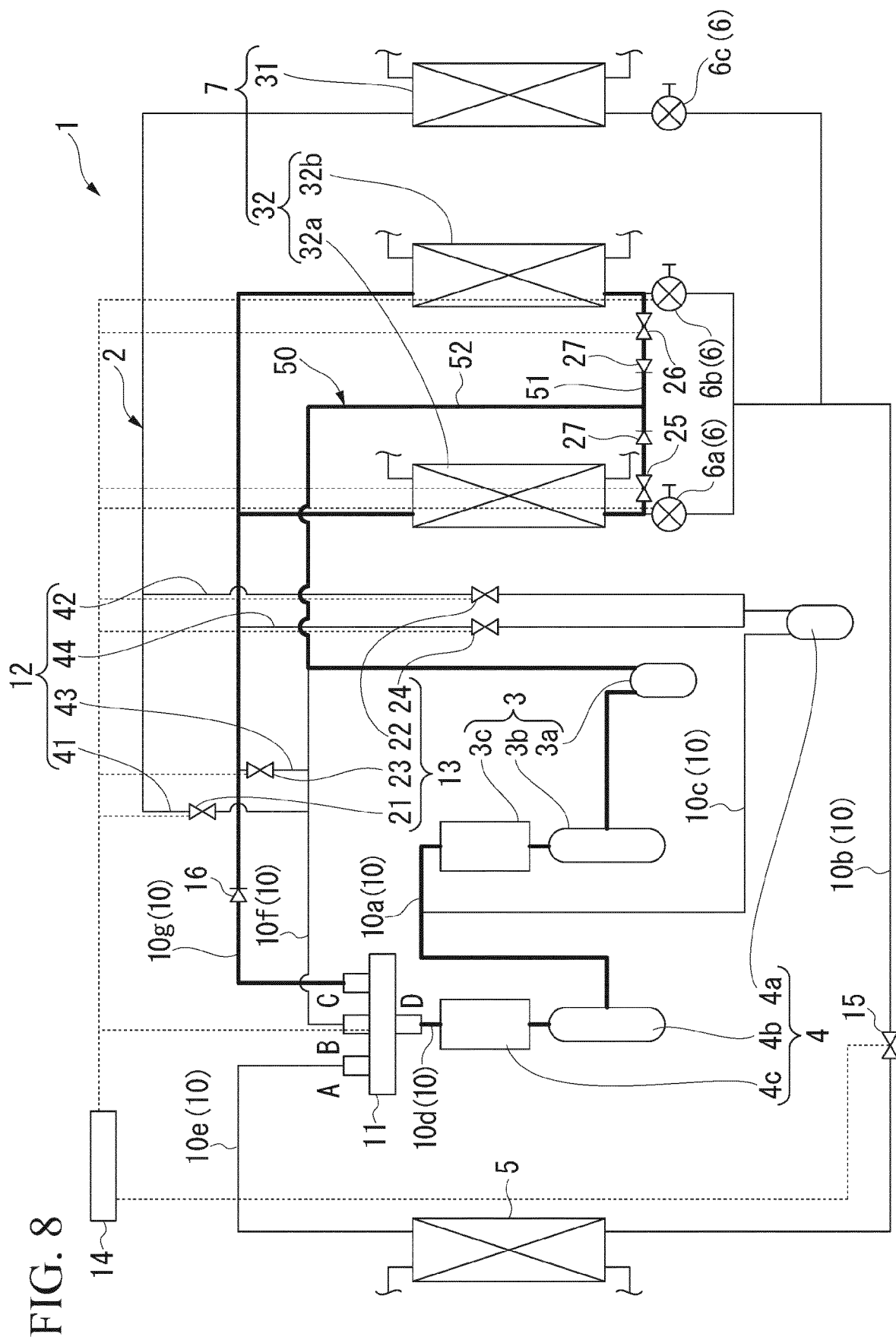














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