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

(11) **EP 3 228 951 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
27.01.2021 Bulletin 2021/04

(21) Application number: **14907314.0**

(22) Date of filing: **05.12.2014**

(51) Int Cl.:
F25B 1/00 *(2006.01)* ***F25B 13/00*** *(2006.01)*
F25B 49/02 *(2006.01)* ***F25B 47/02*** *(2006.01)*

(86) International application number:
PCT/JP2014/082295

(87) International publication number:
WO 2016/088262 (09.06.2016 Gazette 2016/23)

(54) REFRIGERATION CYCLE APPARATUS

KÄLTEKREISLAUFVORRICHTUNG

APPAREIL À CYCLE DE RÉFRIGÉRATION

(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 RS SE SI SK SM TR

(43) Date of publication of application:
11.10.2017 Bulletin 2017/41

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(56) References cited:
WO-A1-2013/021762
JP-A- H07 127 954
JP-A- H09 196 490
JP-A- 2002 048 359
JP-A- 2002 195 609
WO-A1-2013/021762
JP-A- H07 332 817
JP-A- H10 267 494
JP-A- 2002 048 359
JP-A- 2013 036 683

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Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus.

Background Art

[0002] Traditionally, techniques for anti-freezing of water refrigerant have been proposed for a heat exchanger connected to multiple refrigerant circuits. One such apparatus of this technique is configured as follows, for example. Temperatures of a medium to be cooled, such as water refrigerant, circulating in a plate heat exchanger detected at the entry and exit and operation capacities of individual refrigeration circuits are used as data inputs. By being provided with a temperature estimating unit that calculates the temperature of water refrigerant at the exit of a water refrigerant passage in each use-side heat exchanging unit connected to the refrigerant circuit, the refrigeration apparatus prevents freezing of water refrigerant (see Patent Literature 1).

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2007-187353 (Claim 1) JP 2002 048359 A; WO213/021762 A1 and JP 2013 036683 disclose related refrigeration apparatus Moreover, JP 2013 036683 A discloses a refrigeration cycle apparatus comprising: a plurality of refrigeration cycles allowing refrigerant to circulate therein, each of the refrigeration cycles comprising a compressor, a refrigerant flow switching device, an air-side heat exchanger, a pressure reducing device, and a heat medium-side heat exchanger connected in sequence with refrigerant pipes, the heat medium-side heat exchangers allowing a heat medium and the refrigerant to exchange heat with each other; a heat medium outlet of a first heat medium-side heat exchanger and a heat medium inlet of a third heat medium-side heat exchanger being connected in series with a first heat medium passage, a heat medium outlet of a second heat medium-side heat exchanger and a heat medium inlet of a fourth heat medium-side heat exchanger being connected in series with a second heat medium passage, the first heat medium passage and the second heat medium passage being connected in parallel, wherein heat medium inlets of the first heat medium-side heat exchanger and the second heat medium-side heat exchanger being connected in parallel with a first pipe and wherein heat medium outlets of the third heat medium-side heat exchanger and the fourth heat medium-side heat exchanger being connected in parallel with a second pipe, the first pipe having a first bifurcation from which the first pipe branches into the first heat medium-side heat exchanger and the second heat medium-side heat exchanger, the second pipe having a second bifurcation from which the second pipe branches into the third heat medium-side heat exchanger and the fourth heat medium-side heat exchanger.

Summary of Invention

Technical Problem

[0004] Unfortunately, in the apparatus disclosed in Patent Literature 1 that includes the multiple refrigerant circuits connected to the single plate heat exchanger, failure of any refrigerant circuit causes stop of operation of the other normal refrigerant circuits.

[0005] An object of the invention is to overcome the above problem, and is to provide a refrigeration cycle apparatus that can continue the operation regardless of failure of any of multiple refrigerant circuits.

Solution to Problem

[0006] A refrigeration cycle apparatus according to an embodiment of the invention is provided in claim 1.

Advantageous Effects of Invention

[0007] The refrigeration cycle apparatus according to an embodiment of the invention includes multiple refrigeration cycles connected in series and in parallel and thus can continue the operation regardless of failure of any of the refrigerant circuits. Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a schematic diagram illustrating the configuration of a refrigeration cycle apparatus according to Embodiment 1 not forming part of the invention, as defined in the appended claims.

[Fig. 2] Fig. 2 is a flowchart illustrating an operation of a heat source controller in a defrosting mode according to Embodiment 1.

[Fig. 3] Fig. 3 is a schematic diagram illustrating an example variation in the circuit configuration of a refrigeration cycle apparatus according to Embodiment 1.

[Fig. 4] Fig. 4 is a schematic diagram illustrating the configuration of a refrigeration cycle apparatus according to Embodiment 2 not forming part of the invention, as defined in appended claims.

[Fig. 5] Fig. 5 is a schematic diagram illustrating the configuration of a refrigeration cycle apparatus according to Embodiment 3 according to the invention.

Description of Embodiments

[0009] The refrigeration cycle apparatus according to the above mentioned embodiments will now be described with reference to the accompanying drawings. The embodiments illustrated in the drawings are mere examples and should not be construed to limit the invention. The components having the same reference signs in the drawings are same or correspond to each other throughout the specification. The relative sizes of the components in the drawings may differ from the actual relative sizes.

Embodiment 1

[Configuration of Heat Source Device 1]

[0010] Fig. 1 is a schematic diagram illustrating an example partial configuration of a refrigeration cycle apparatus according to Embodiment 1 not forming part of the invention, as defined in the appended claims. With reference to Fig. 1, a heat source device 1, which constitutes a part of the refrigeration cycle apparatus, includes refrigeration cycles 2a, 2b, 2c, and 2d having a same circuit configuration and a same specification and a heat source controller 11. The refrigeration cycles 2a, 2b, 2c, and 2d having an identical configuration may be collectively referred to as "refrigeration cycles 2."

[0011] The refrigeration cycle 2a includes a compressor 3a, a refrigerant flow switching device 4a (e.g., a four-way valve), an air-side heat exchanger 5a, a main expansion valve 7a, and a water-side heat exchanger 8a, which are connected in an annular manner with refrigerant pipes. The refrigeration cycle 2a is further provided with an air-side heat exchanger fan 6a (air-sending device 6a for the air-side heat exchanger 5a) in the vicinity of the air-side heat exchanger 5a. The refrigeration cycles 2b, 2c, and 2d each have the same configuration as that of the refrigeration cycle 2a.

[0012] The compressors 3a, 3b, 3c, and 3d suck low-temperature low-pressure refrigerant and generate high-temperature high-pressure refrigerant through compression. Atypical example of the compressors 3a, 3b, 3c, and 3d is an inverter compressor having a controllable capacity. The compressors 3a, 3b, 3c, and 3d having an identical configuration may be collectively referred to as "compressors 3."

[0013] The refrigerant flow switching devices 4a, 4b, 4c, and 4d switch the flow of refrigerant upon the switching between a cooling mode and a heating mode. As the refrigerant flow switching devices 4a, 4b, 4c, and 4d, elements having an identical configuration may be collectively referred to as, in this case, "refrigerant flow switching devices 4."

[0014] The air-side heat exchangers 5a, 5b, 5c, and 5d function as condensers in the cooling mode and as evaporators in the heating mode. The air-side heat exchangers 5a, 5b, 5c, and 5d allow the refrigerant and the air supplied by the air-side heat exchanger fans 6a, 6b, 6c, and 6d to exchange heat with each other, for example. As the air-side heat exchangers 5a, 5b, 5c, and 5d, elements having an identical configuration may be collectively referred to as "air-side heat exchangers 5." Also, as the air-side heat exchanger fans 6a, 6b, 6c, and 6d, elements having an identical configuration may be collectively referred to as "air-side heat exchanger fans 6."

[0015] The main expansion valves 7a, 7b, 7c, and 7d serve as pressure reducing valves or expansion valves, and decompress to expand the refrigerant. A typical example of the main expansion valves 7a, 7b, 7c, and 7d is an electronic expansion valve having a controllable opening degree. The main expansion valves 7a, 7b, 7c, and 7d having an identical configuration may be collectively referred to as "main expansion valves 7."

[0016] The heat source controller 11 receives data on the pressures and temperatures of refrigerant in the refrigeration cycles 2 and the temperatures of water (heat medium) from various sensors (not shown). The heat source controller 11 then controls individual actuators based on operational information on the heat source device 1 and instructions about an operation from a user of the refrigeration cycle apparatus, i.e., activates or inactivates the compressors 3 or controls the rotation speeds of the compressors 3, controls the opening degrees of the main expansion valves 7, and controls the rotation of the air-side heat exchanger fans 6.

[Configuration of Water Pipes 9]

[0017] The water-side heat exchangers 8a, 8b, 8c, and 8d allow the refrigerant flowing in the respective refrigeration cycles 2 and the water (heat medium) to exchange heat with each other. The water inlets of the water-side heat exchanger 8a and the water-side heat exchanger 8b are connected in parallel with a water pipe 9a. The water outlets of the water-side heat exchanger 8c and the water-side heat exchanger 8d are connected in parallel with a water pipe 9b. The water outlet of the water-side heat exchanger 8a and the water inlet of the water-side heat exchanger 8c are connected in series with a water pipe 9c. The water outlet of the water-side heat exchanger 8b and the water inlet of the water-side heat exchanger 8d are connected in series with a water pipe 9d. The water-side heat exchangers 8a, 8b, 8c, and 8d correspond to the "heat medium-side heat exchangers" in the present invention. The water pipes 9c and 9d correspond to the "first heat medium passage" and "second heat medium passage," respectively, in the present invention. As the water-side heat exchangers 8a, 8b, 8c, and 8d, elements having an same configuration may be collectively referred to as "water-side heat exchangers 8."

[0018] The flow of water (heat medium) will now be described. The part of the water pipe 9a outside the heat source device 1 is provided with a cold water pump 10. As indicated by the broken arrow in Fig. 1, the cold water

pump 10 transfers water (heat medium) such that the water flows through the water pipe 9a and branches into the water-side heat exchanger 8a and the water-side heat exchanger 8b. The water introduced in the water-side heat exchanger 8a flows through the water pipe 9c and enters the water-side heat exchanger 8c. The water introduced in the water-side heat exchanger 8b flows through the water pipe 9d and enters the water-side heat exchanger 8d. The water from the water-side heat exchanger 8c and the water from the water-side heat exchanger 8d join each other in the water pipe 9b and the joined water is discharged from the heat source device 1. The illustrated configuration of Embodiment 1, in which the cold water pump 10 is disposed outside the heat source device 1, should not be construed to limit the invention. The cold water pump 10 may also be disposed inside the heat source device 1.

[Cooling Operation of Refrigeration Cycle Apparatus]

[0019] The cooling operation of the refrigeration cycle apparatus will now be explained. In the refrigeration cycle 2a, the high-temperature high-pressure gas refrigerant generated through compression in the compressor 3a exits the compressor 3a, enters the air-side heat exchanger 5a, and then exchanges heat with the air supplied by the air-side heat exchanger fan 6a to condense into liquid. This high-pressure liquid refrigerant exits the air-side heat exchanger 5a, and is then decompressed in the main expansion valve 7a into two-phase gas-liquid refrigerant. The refrigerant then evaporates in the water-side heat exchanger 8a serving as an evaporator and thus removes heat from water (heat medium) to generate cooled water. The low-temperature low-pressure refrigerant exits the water-side heat exchanger 8a and then enters the compressor 3a.

[0020] Although the above explanation focuses on the cooling operation of the refrigeration cycle 2a, the refrigeration cycles 2b, 2c, and 2d perform the cooling operation same as that of the refrigeration cycle 2a. The same holds for a defrosting operation and a heating operation described below.

[Heating Operation of Refrigeration Cycle Apparatus]

[0021] The heating operation of the refrigeration cycle apparatus will now be explained. In the heating mode, the refrigerant flow switching device 4a switches the flow of the refrigerant from that in the cooling mode. In the refrigeration cycle 2a, the high-temperature high-pressure gas refrigerant generated through compression in the compressor 3a exits the compressor 3a, enters the water-side heat exchanger 8a, and then exchanges heat with water (heat medium) to condense into liquid. The water (heat medium) is thereby heated to a higher temperature. The high-pressure liquid refrigerant exiting the water-side heat exchanger 8a is then decompressed in the main expansion valve 7a into two-phase gas-liquid refrigerant. The refrigerant then evaporates in the air-side heat exchanger 5a serving as an evaporator and thus removes heat from the surrounding air to be turned into low-temperature low-pressure refrigerant. The low-temperature low-pressure refrigerant exiting the air-side heat exchanger 5a then enters the compressor 3a.

[0022] In the refrigeration cycle apparatus in the heating mode, a high humidity of the air and a low temperature equal to or lower than 0 degrees C at the heat transferring surfaces of the air-side heat exchangers 5 cause the water vapor in the air to condense and freeze and thus generate frost on the heat transferring surfaces. The frost on the air-side heat exchangers 5 increases the wind resistance thereof, resulting in insufficient performance of the air-side heat exchangers 5. This problem requires a defrosting operation for melting the frost on the air-side heat exchangers 5, which needs a heat source for melting the frost.

[0023] A typical defrosting technique involves switching of the flow of refrigerant to the direction in the cooling mode with the refrigerant flow switching devices 4, operating the compressors 3, and then removing the frost from the air-side heat exchangers 5 by the heat of the water flowing through the water-side heat exchangers 8. In this case, if one or more refrigeration cycles 2 conduct the defrosting operation while the other refrigeration cycles 2 perform the heating operation, the water (heat medium) heated by the heating operation is cooled again by the defrosting operation. In Embodiment 1, such a decrease in the temperature of water (heat medium) can be reduced by the following measure.

[Defrosting Operation of Refrigeration Cycle Apparatus]

[0024] The defrosting operation of the refrigeration cycle apparatus will now be explained. The defrosting operation differs from the cooling operation in that the operation of the air-side heat exchanger fan 6a is halted in the defrosting mode. In the refrigeration cycle 2a, the high-temperature high-pressure gas refrigerant generated through compression in the compressor 3a exits the compressor 3a, enters the air-side heat exchanger 5a, and then transfers its heat to the frost on the air-side heat exchanger 5a to condense into liquid. This high-pressure liquid refrigerant exiting the air-side heat exchanger 5a is then decompressed in the main expansion valve 7a into two-phase gas-liquid refrigerant. The refrigerant then evaporates in the water-side heat exchanger 8a serving as an evaporator and thus removes heat from water (heat medium) to generate cooled water. The low-temperature low-pressure refrigerant exiting the water-side heat exchanger 8a then enters the compressor 3a.

[Control of Heat Source Controller 11]

[0025] The heat source device 1 according to Embodiment 1 is equipped with the four refrigeration cycles 2a, 2b, 2c, and 2d. The heat source controller 11 can sup-

press a decrease in water temperature by controlling these independent four refrigeration cycles 2a, 2b, 2c, and 2d so as not to simultaneously perform defrosting operations. In another situation, the heat source controller 11 can reduce the decreasing time of the temperature of water (heat medium), rather than suppression of a decrease in the temperature of the water (heat medium), by conducting simultaneous defrosting operations of the four refrigeration cycles 2a, 2b, 2c, and 2d. The heat source controller 11 can select either of these controls preset in the heat source controller 11.

[0026] Fig. 2 is a flowchart illustrating an operation of the heat source controller 11 in the defrosting mode according to Embodiment 1 of the invention. The steps of control of the heat source controller 11 illustrated in Fig. 2 will now be explained with reference to Fig. 1.

(Step S1)

[0027] The heat source controller 11 determines whether simultaneous defrosting operations of the four refrigeration cycles 2a, 2b, 2c, and 2d are available in the preliminary setting. If the simultaneous defrosting operations of the four refrigeration cycles 2a, 2b, 2c, and 2d are available; then the process goes to Step S2; otherwise the process goes to Step S4.

(Step S2)

[0028] The heat source controller 11 determines whether any one or more of the four refrigeration cycles 2a, 2b, 2c, and 2d is to conduct the defrosting operation. If any one or more of the refrigeration cycles are to conduct the defrosting operation; then the process goes to Step S3; otherwise the process goes to Step S1.

(Step S3)

[0029] The heat source controller 11 conducts the simultaneous defrosting operations of the four refrigeration cycles 2a, 2b, 2c, and 2d. The process then goes to Step S1.

(Step S4)

[0030] The heat source controller 11 determines whether any one of the four refrigeration cycles 2a, 2b, 2c, and 2d is to conduct the defrosting operation. If any one of the refrigeration cycles is to conduct the defrosting operation; then the process goes to Step S5; otherwise the process goes to Step S1.

(Step S5)

[0031] The heat source controller 11 determines whether only at least one refrigeration cycle 2 is in the defrosting mode. If only the at least one refrigeration cycle 2 is in the defrosting mode; then the process goes to Step S6; otherwise the process goes to Step S1.

(Step S6)

[0032] The heat source controller 11 conducts the defrosting operation of the refrigeration cycle 2 being a target. The process then goes to Step S1.

[0033] As described above, even if any water-side heat exchanger 8 is punctured by freezing of water, for example, the other refrigeration cycles 2 can continue the operation for the moment because of the independence of water-side heat exchangers 8 in the refrigeration cycles 2.

[0034] In a traditional apparatus including a single water-side heat exchanger 8 connected to two refrigeration cycles 2 in the heating mode, the defrosting operation of one of the refrigeration cycles 2 varies the water temperature in the water-side heat exchanger 8. This variation affects the operational state of the other refrigeration cycle 2 performing the heating mode, resulting in an unstable water temperature. In contrast, the water-side heat exchangers 8 according to Embodiment 1 are independent from each other disposed in the respective refrigeration cycles 2a, 2b, 2c, and 2d. This configuration can reduce the effects of the refrigeration cycle 2 in the defrosting mode on the other refrigeration cycles 2 performing the heating mode, and thus can stabilize the heating operations.

[0035] The configuration according to Embodiment 1 that includes the heat source device 1 equipped with the four refrigeration cycles 2 should not be construed to limit the present invention. The configuration only requires at least three refrigeration cycles 2. The same holds for Embodiments 3 and 4 described below.

[0036] Fig. 3 is a schematic diagram illustrating an example variation in the circuit configuration of the refrigeration cycle apparatus according to Embodiment 1 of the present invention. In the refrigeration cycle apparatus according to Embodiment 1, the water pipes 9 can be rearranged. The following description focuses on an example configuration of the water pipes 9 after rearrangement in the refrigeration cycle apparatus.

[Configuration of Water Pipes 9]

[0037] With reference to Fig. 3, the water inlet of the water-side heat exchanger 8a is connected with a water pipe 9h. The water outlet of the water-side heat exchanger 8a and the water inlet of the water-side heat exchanger 8b are connected in series with a water pipe 9i. The water outlet of the water-side heat exchanger 8b and the water inlet of the water-side heat exchanger 8d are connected in series with a water pipe 9j. The water outlet of the water-side heat exchanger 8d and the water inlet of the water-side heat exchanger 8c are connected in series with a water pipe 9k. The water outlet of the water-side heat exchanger 8c is connected with a water pipe 91. The water-side heat exchangers 8a, 8b, 8c, and 8d are

thus sequentially connected in series.

[0038] The flow of water (heat medium) will now be described. As indicated by the broken arrow in Fig. 3, the cold water pump 10 transfers water (heat medium) such that the water flows through the water pipe 9h into the water-side heat exchanger 8a. The water from the water-side heat exchanger 8a flows through the water pipe 9i and enters the water-side heat exchanger 8b. The water from the water-side heat exchanger 8b flows through the water pipe 9j and enters the water-side heat exchanger 8d. The water from the water-side heat exchanger 8d flows through the water pipe 9k and enters the water-side heat exchanger 8c. The water from the water-side heat exchanger 8c flows through the water pipe 9l and is discharged from the heat source device 1.

[0039] The range of the flow rate of water in the heat source device 1 is defined by the conditions such as the freezing, a decrease in performance, or the restriction of oscillation due to pulsation in the water-side heat exchangers 8. In comparison of the heat source devices 1 between Embodiments 1 and 3, the heat source device 1 according to Embodiment 1 has higher maximum and minimum flow rates of water because of the bifurcation in the water pipe 9a (see Fig. 1), whereas the heat source device 1 according to Embodiment 3 has lower maximum and minimum flow rates of water because of no bifurcation in the water pipe 9h (see Fig. 3).

[0040] In general, the work of refrigerant pipes after the installation of a heat source device 1 accompanies the reconstruction of the high-pressure gas circuits, and thus requires large tasks, such as collection of refrigerant and other reconstructing works and procedures. To solve this problem, the water-side heat exchangers 8 are individually disposed in the respective refrigeration cycles 2. Accordingly, the configuration of the water pipes 9 in the heat source device 1 according to Embodiment 1 can be changed into the configuration of the water pipes 9 in the heat source device 1 according to Embodiment 3 and vice versa, for example, by only the rearrangement of the water pipes 9. That is, only the rearrangement of the water pipes 9 can vary the maximum and minimum flow rates of water in the water pipes 9.

[0041] As described above, in the heat source device 1, the maximum and minimum flow rates of water in the water pipes 9 can be readily varied by only the rearrangement of the water pipes 9 without work of the refrigerant pipes in the heat source device 1.

Embodiment 2

[0042] Fig. 4 is a schematic diagram illustrating the configuration of the refrigeration cycle apparatus according to Embodiment not forming part of the invention, as defined in the appended claims. The basic configuration of the heat source device 1 according to Embodiment 2 is same as that of the heat source device 1 according to Embodiment 1. The following description of Embodiment 2 thus focuses on the difference from Embodiment 1, i.e., the configuration of the water pipes 9.

[Configuration of Water Pipes 9]

[0043] With reference to Fig. 4, the water inlets of the water-side heat exchanger 8a and the water-side heat exchanger 8b are connected in parallel with a water pipe 9e. The water outlets of the water-side heat exchanger 8c and the water-side heat exchanger 8d are connected in parallel with a water pipe 9f. The water outlets of the water-side heat exchanger 8a and the water-side heat exchanger 8b are connected in parallel with a water pipe 9g. The water outlets of the water-side heat exchanger 8c and the water-side heat exchanger 8d are connected in parallel with the water pipe 9g. The water-side heat exchanger 8a and the water-side heat exchanger 8b, which are connected in parallel, are connected in series to the water-side heat exchanger 8c and the water-side heat exchanger 8d, which are connected in parallel, with the water pipe 9g. The water pipes 9e, 9f, and 9g correspond to the "heat medium passages" in the present invention.

[0044] The flow of water (heat medium) will now be described. As indicated by the broken arrow in Fig. 4, the cold water pump 10 transfers water (heat medium) such that the water flows through the water pipe 9e and branches into the water-side heat exchanger 8a and the water-side heat exchanger 8b. The water introduced in the water-side heat exchanger 8a and the water introduced in the water-side heat exchanger 8b join each other in the water pipe 9g. The joined water then branches in the downstream part of the water pipe 9g into the water-side heat exchanger 8c and the water-side heat exchanger 8d. The water from the water-side heat exchanger 8c and the water from the water-side heat exchanger 8d join each other in the water pipe 9f and the joined water is discharged from the heat source device 1.

[0045] As described above, the water-side heat exchangers 8 according to Embodiment 2 are individually disposed in the respective refrigeration cycles 2a, 2b, 2c, and 2d. Even if any water-side heat exchanger 8 is punctured by freezing of water, for example, the other refrigeration cycles 2 can continue the operation for the moment because of the independent water-side heat exchangers 8.

[0046] The configuration can also reduce the effects of the refrigeration cycle 2 in the defrosting mode on the other refrigeration cycles 2 in the heating mode, and thus can stabilize the heating operations.

[0047] In the case of the defrosting operation of the refrigeration cycle 2a or the refrigeration cycle 2b, the water from the refrigeration cycle 2a and the water from the refrigeration cycle 2b join each other in the water pipe 9g. This configuration can suppress a decrease in the temperature of the water entering the refrigeration cycle 2c and the refrigeration cycle 2d and thus can stabilize the heating operations of the refrigeration cycle 2c and the refrigeration cycle 2d.

[0048] The configuration according to Embodiment 2 that includes the heat source device 1 equipped with the four refrigeration cycles 2 should not be construed to limit the invention. The configuration only requires at least four refrigeration cycles 2.

Embodiment 3

[0049] Fig. 5 is a schematic diagram illustrating the configuration of the refrigeration cycle apparatus according to Embodiment 3 of the invention. The basic configuration of the heat source device 1 according to Embodiment 4 is same as that of the heat source device 1 according to Embodiment 1. The following description of Embodiment 3 thus focuses on the difference from Embodiment 1, i.e., the configuration of the water pipes 9 and additional valves 12 in the water pipes 9.

[Configuration of Water Pipes 9]

[0050] With reference to Fig. 5, the water inlets of the water-side heat exchanger 8a and the water-side heat exchanger 8b are connected in parallel with a water pipe 9m. The water outlets of the water-side heat exchanger 8c and the water-side heat exchanger 8d are connected in parallel with a water pipe 9n. The water outlet of the water-side heat exchanger 8a and the water inlet of the water-side heat exchanger 8c are connected in series with a water pipe 9o. The water outlet of the water-side heat exchanger 8b and the water inlet of the water-side heat exchanger 8d are connected in series with a water pipe 9p. The water outlet of the water-side heat exchanger 8a and the water inlet of the water-side heat exchanger 8b are connected in series with a water pipe 9q. The water outlet of the water-side heat exchanger 8d and the water inlet of the water-side heat exchanger 8c are connected in series with a water pipe 9r.

[0051] The valves 12 provided in the water pipes 9 will now be described. With reference to Fig. 5, the water pipe 9m has a bifurcation 13a from which the water pipe 9m branches into the water-side heat exchanger 8a and the water-side heat exchanger 8b. Similarly, the water pipe 9m is provided with a valve 12a between the bifurcation 13a and the water inlet of the water-side heat exchanger 8b. The water pipe 9n has a bifurcation 13b from which the water pipe 9n branches into the water-side heat exchanger 8c and the water-side heat exchanger 8d. The water pipe 9n is provided with a valve 12b between the bifurcation 13b and the water outlet of the water-side heat exchanger 8d. The water pipes 9q, 9r, and 9o are provided with valves 12c, 12d, and 12e, respectively. Examples of each valve 12 include a solenoid valve capable of blocking the flow of water and a flow control valve having a controllable opening degree.

[0052] This heat source controller 11 can vary the combination of the water pipes 9 in which water flows by switching the valves 12 depending on the operational mode of the heat source device 1. The heat source controller 11 can also vary the range of the flow rate of water in the heat source device 1.

[0053] As described above, the heat source controller 11 can vary the combination of the water pipes 9 in which water flows and also vary the range of the flow rate of water in the heat source device 1 by switching the valves 12. That is, the range of the flow rate of water in the heat source device 1 can be varied by on-site operations of the heat source controller 11 to transmit signals to the valves 12 for switching the valves 12, without reconstruction of the water pipes 9.

Reference Signs List

[0054]

1 heat source device 2 refrigeration cycle 2a-2d refrigeration cycle 3 compressor 3a-3d compressor 4 refrigerant flow switching device 4a-4d refrigerant flow switching device
5 air-side heat exchanger 5a-5d air-side heat exchanger
6 air-side heat exchanger fan 6a-6d air-side heat exchanger fan
7 main expansion valve 7a-7d main expansion valve
8 water-side heat exchanger 8a-8d water-side heat exchanger 9 water pipe 9a-9r water pipe 10 cold water pump 11 heat source controller 12 valve 12a-12d valve 13a bifurcation 13b bifurcation

Claims

1. A refrigeration cycle apparatus comprising:

a plurality of refrigeration cycles (2a-2d) allowing refrigerant to circulate therein, each of the refrigeration cycles (2a-2d) comprising a compressor (3a-3d), a refrigerant flow switching device (4a-4d), an air-side heat exchanger (5a-5d), a pressure reducing device (7a-7d), and a heat medium-side heat exchanger (8a-8d) connected in sequence with refrigerant pipes, the heat medium-side heat exchangers (8a-8d) allowing a heat medium and the refrigerant to exchange heat with each other;
a heat medium of a first heat medium-side heat exchanger (8a) and a heat medium inlet of a third heat medium-side heat exchanger (8c) being connected in series with a first heat medium passage (9o),
a heat medium of a second heat medium-side heat exchanger (8b) and a heat medium inlet of a fourth heat medium-side heat exchanger (8d) being connected in series with a second heat medium passage (9p),
the first heat medium passage (9o) and the second heat medium passage (9p) being connected

in parallel, wherein heat medium inlets of the first heat medium-side heat exchanger (8a) and the second heat medium-side heat exchanger (8b) being connected in parallel with a first pipe (9m) and wherein heat medium outlets of the third heat medium-side heat exchanger (8c) and the fourth heat medium-side heat exchanger (8d) being connected in parallel with a second pipe (9n),
a heat medium outlet of the first heat medium-side heat exchanger (8a) and the heat medium inlet of the second heat medium-side heat exchanger (8b) being connected in series with a third pipe (9q),
the heat medium outlet of the fourth heat medium-side heat exchanger (8d) and a heat medium inlet of the third heat medium-side heat exchanger (8c) being connected in series with a fourth pipe (9r),
the first pipe (9m) having a first bifurcation (13a) from which the first pipe (9m) branches into the first heat medium-side heat exchanger (8a) and the second heat medium-side heat exchanger (8b),
the first pipe (9m) being provided with a first valve (12a) between the first bifurcation (13a) and the heat medium inlet of the second heat medium-side heat exchanger (8b),
the second pipe (9n) having a second bifurcation (13b) from which the second pipe (9n) branches into the third heat medium-side heat exchanger (8c) and the fourth heat medium-side heat exchanger (8d),
the second pipe (9n) being provided with a second valve (12b) between the second bifurcation 13b and the heat medium outlet of the fourth heat medium-side heat exchanger (8d), and
the third pipe (9q), the fourth pipe (9r), and the first heat medium passages (9o) being provided with a third valve (12c), a fourth valve (12d), and a fifth valve (12e), respectively.

2. The refrigeration cycle apparatus of claim 1, further comprising fans (6a-6d) for the air-side heat exchangers (5a-5d) and a heat source controller (11) configured to control the compressors (3a-3d), the refrigerant flow switching devices (4a-4d), the pressure reducing devices (7a-7d), and the fans (6a-6d) for the air-side heat exchangers (5a-5d),
the heat source controller (11) being configured to determine whether the refrigeration cycles (2a-2d) conducts defrosting operations

3. The refrigeration cycle apparatus of claim 2, wherein the heat source controller (11) is configured to, if simultaneous defrosting operations of the refrigeration cycles (2a-2d) can be conducted, then conduct defrosting operations of all the refrigeration cycles (2a-2d), or otherwise conduct a defrosting operation of a refrigeration cycle (2a-2d) being a target of defrosting from among the refrigeration cycles (2a-2d).

4. The refrigeration cycle apparatus of claim 1, further comprising fans (6a-6d) for the air-side heat exchangers (5a-5d) and a heatsource controller (11) configured to control the compressor (3a-3d), the refrigerant flow switching device (4a-4d), the pressure reducing device (7a-7d), and the fans (6a-6d) for the air-side heat exchangers (5a-5d),
the heat source controller (11) being configured to execute

a first step (S1) of determining whether simultaneous defrosting operations of the plurality of refrigeration cycles (2a-2d) can be conducted,
a second step (S2, S4) of determining whether any of the refrigeration cycles (2a-2d) conducts a defrosting operation,

conduct the defrosting operations of all of the refrigeration cycles when determining in the first step that the simultaneous defrosting operations of the plurality of refrigeration cycles (2a-2d) can be conducted and determining in the second step that any of the refrigeration cycles (2a-2d) conducts a defrosting operation, while,
when determining in the first step that the simultaneous defrosting operations of the plurality of refrigeration cycles (2a-2d) cannot be conducted and determining in the second step that any of the refrigeration cycles (2a-2d) conducts a defrosting operation, execute a third step (S5) of determining whether at least one of the refrigeration cycles (2a-2d) other than the refrigeration cycles to conduct the defrosting operations is conducting the defrosting operation, and
conduct the defrosting operation of the at least one of the refrigeration cycles being the refrigeration cycles to conduct the defrosting operations when determining in the third step (S5) that the refrigeration cycles (2a-2d) other than the refrigeration cycles to conduct the defrosting operations are not conducting the defrosting operation.

5. The refrigeration cycle apparatus of any one of claims 1 to 4, wherein the first heat medium passage (9o) and the second heat medium passage (9p) are capable of being rearranged.

Patentansprüche

1. Kältekreislaufvorrichtung, umfassend:

eine Vielzahl von Kältekreisläufen (2a-2d), die es einem Kältemittel erlaubt, darin zu zirkulie-

ren, wobei jeder der Kältekreisläufe (2a-2d) einen Kompressor (3a-3d), eine Kältemittelstrom-Schaltvorrichtung (4a-4d), einen luftseitigen Wärmetauscher (5a-5d), eine Druckverringerungsvorrichtung (7a-7d) und einen wärmemediumseitigen Wärmetauscher (8a-8d) umfasst, die in Reihe mit Kältemittelrohren verbunden sind, wobei die wärmemediumseitigen Wärmetauscher (8a-8d) es einem Wärmemedium und dem Kältemittel ermöglichen, Wärme miteinander auszutauschen;
einen Wärmemediumauslass eines ersten wärmemediumseitigen Wärmetauschers (8a) und einen Wärmemediumeinlass eines dritten wärmemediumseitigen Wärmetauschers (8c), die in Reihe mit einem ersten Wärmemediumdurchlass (9o) verbunden sind,
einen Wärmemediumauslass eines zweiten wärmemediumseitigen Wärmetauschers (8b) und einen Wärmemediumeinlass eines vierten wärmemediumseitigen Wärmetauschers (8d), die in Reihe mit einem zweiten Wärmemediumdurchlass (9p) verbunden sind,
wobei der erste Wärmemediumdurchlass (9o) und der zweite Wärmemediumdurchlass (9p) parallel miteinander verbunden sind, wobei die Wärmemediumeinlässe des ersten wärmeseitigen Wärmetauschers (8a) und des zweiten wärmemediumseitigen Wärmetauschers (8b) parallel mit einem ersten Rohr (9m) verbunden sind und wobei die Wärmemediumauslässe des dritten wärmemediumseitigen Wärmetauschers (8c) und des vierten wärmemediumseitigen Wärmetauschers (8d) parallel mit einem zweiten Rohr (9n) verbunden sind,
ein Wärmemediumauslass des ersten wärmemediumseitigen Wärmetauschers (8a) und der Wärmemediumeinlass des zweiten wärmemediumseitigen Wärmetauschers (8b) in Reihe mit einem dritten Rohr (9q) verbunden sind,
der Wärmemediumauslass des vierten wärmemediumseitigen Wärmetauschers (8d) und ein Wärmemediumeinlass des dritten wärmemediumseitigen Wärmetauschers (8c) in Reihe mit einem vierten Rohr (9r) verbunden sind,
das erste Rohr (9m) eine erste Verzweigung (13a) aufweist, von der aus sich das erste Rohr (9m) in den ersten wärmemediumseitigen Wärmetauscher (8a) und den zweiten wärmemediumseitigen Wärmetauscher (8b) verzweigt,
das erste Rohr (9m) ein erstes Ventil (12a) zwischen der ersten Verzweigung (13a) und dem Wärmemediumeinlass des zweiten wärmemediumseitigen Wärmetauschers (8b) aufweist,
das zweite Rohr (9n) eine zweite Verzweigung (13b) aufweist, von der aus sich das zweite Rohr (9n) in den dritten wärmemediumseitigen Wärmetauscher (8c) und den vierten wärmemediumseitigen Wärmetauscher (8d) verzweigt,
das zweite Rohr (9n) ein zweites Ventil (12b) zwischen der zweiten Verzweigung (13b) und dem Wärmemediumauslass des vierten wärmemediumseitigen Wärmetauschers (8d) aufweist, und
das dritte Rohr (9q), das vierte Rohr (9r) und die ersten Wärmemediumdurchlässe (9o) ein drittes Ventil (12c), ein viertes Ventil (12d) bzw. ein fünftes Ventil (12e) aufweisen.

2. Kältekreislaufvorrichtung nach Anspruch 1, ferner umfassend Gebläse (6a-6d) für die luftseitigen Wärmetauscher (5a-5d) und eine Wärmequellen-Steuervorrichtung (11), die ausgelegt ist, die Kompressoren (3a-3d), die Kältemittelstrom-Schaltvorrichtungen (4a-4d), die Druckverringerungsvorrichtungen (7a-7d) und die Gebläse (6a-6d) für die luftseitigen Wärmetauscher (5a-5d) zu steuern,
wobei die Wärmequellen-Steuervorrichtung (11) ausgelegt ist, um zu bestimmen, ob die Kältekreisläufe (2a-2d) Abtauvorgänge durchführen.

3. Kältekreislaufvorrichtung nach Anspruch 2, wobei die Wärmequellen-Steuervorrichtung (11) ausgelegt ist, um, wenn gleichzeitige Abtauvorgänge der Kältekreisläufe (2a-2d) durchgeführt werden können, die Abtauvorgänge aller Kältekreisläufe (2a-2d) durchzuführen, oder andernfalls einen Abtauvorgang eines Kältekreislaufes (2a-2d) durchzuführen, der ein Abtauziel unter den Kältekreisläufen (2a-2d) ist.

4. Kältekreislaufvorrichtung nach Anspruch 1, ferner umfassend Gebläse (6a-6d) für die luftseitigen Wärmetauscher (5a-5d) und eine Wärmequellen-Steuervorrichtung (11), die ausgelegt ist, um den Kompressor (3a-3d), die Kältemittelstrom-Schaltvorrichtung (4a-4d), die Druckverringerungsvorrichtung (7a-7d) und die Gebläse (6a-6d) für die luftseitigen Wärmetauscher (5a-5d) zu steuern,
wobei die Wärmequellen-Steuervorrichtung (11) ausgelegt ist, um einen ersten Schritt (S1) des Bestimmens, ob gleichzeitige Abtauvorgänge der Vielzahl von Kältekreisläufen (2a-2d) durchgeführt werden können, und
einen zweiten Schritt (S2, S4) des Bestimmens, ob einer der Kältekreisläufe (2a-2d) einen Abtauvorgang durchführt,
auszuführen, und
wenn in dem ersten Schritt bestimmt wird, dass die gleichzeitigen Abtauvorgänge der Vielzahl von Kältekreisläufen (2a-2d) durchgeführt werden können, und wenn in dem zweiten Schritt bestimmt wird, dass einer der Kältekreisläufe (2a-2d) einen Abtauvorgang durchführt, die Abtauvorgänge aller Kältekreisläufe durchzuführen, während
wenn in dem ersten Schritt bestimmt wird, dass die

gleichzeitigen Abtauvorgänge der Vielzahl von Kältekreisläufen (2a-2d) nicht durchgeführt werden können, und in dem zweiten Schritt bestimmt wird, dass einer der Kältekreisläufe (2a-2d) einen Abtauvorgang durchführt, einen dritten Schritt (S5) des Bestimmens, ob zumindest einer der Kältekreisläufe (2a-2d), der keiner der Kältekreisläufe ist, die die Abtauvorgänge durchführen, den Abtauvorgang durchführt, auszuführen, und
den Abtauvorgang von zumindest einem der Kältekreisläufe, die die Kältekreisläufe sind, die die Abtauvorgänge durchführen, durchzuführen, wenn in dem dritten Schritt (S5) bestimmt wird, dass die Kältekreisläufe (2a-2d), die nicht die Kältekreisläufe sind, die die Abtauvorgänge durchführen, nicht die Abtauvorgänge durchführen.

5. Kältekreislaufvorrichtung nach einem der Ansprüche 1 bis 4, wobei der erste Wärmemediumdurchlass (9o) und der zweite Wärmemediumdurchlass (9p) in der Lage sind, neu angeordnet zu werden.

Revendications

1. Appareil à cycles de réfrigération comprenant :

une pluralité de cycles de réfrigération (2a-2d) permettant à du frigorigène d'y circuler, chacun des cycles de réfrigération (2a-2d) comprenant un compresseur (3a-3d), un dispositif de commutation d'écoulement de frigorigène (4a-4d), un échangeur de chaleur côté air (5a-5d), un dispositif de réduction de pression (7a-7d) et un échangeur de chaleur côté milieu caloporteur (8a-8d) connectés en séquence avec des tuyaux de frigorigène, les échangeurs de chaleur côté milieu caloporteur (8a-8d) permettre à un milieu caloporteur et au frigorigène d'échanger de la chaleur l'un avec l'autre ;
une sortie de milieu caloporteur d'un premier échangeur de chaleur côté milieu caloporteur (8a) et une entrée de milieu caloporteur d'un troisième échangeur de chaleur côté milieu caloporteur (8c) étant connectées en série avec un premier passage de milieu caloporteur (9o),
une sortie de milieu caloporteur d'un deuxième échangeur de chaleur côté milieu caloporteur (8b) et une entrée de milieu caloporteur d'un quatrième échangeur de chaleur côté milieu caloporteur (8d) étant connectées en série avec un second passage de milieu caloporteur (9p),
le premier passage de milieu caloporteur (9o) et le second passage de milieu caloporteur (9p) étant connectés en parallèle, dans lequel des entrées de milieu caloporteur du premier échangeur de chaleur côté milieu caloporteur (8a) et du deuxième échangeur de chaleur côté milieu caloporteur (8b) étant connectées en parallèle avec un premier tuyau (9m) et dans lequel des sorties de milieu caloporteur du troisième échangeur de chaleur côté milieu caloporteur (8c) et du quatrième échangeur de chaleur côté milieu caloporteur (8d) étant connectées en parallèle avec un deuxième tuyau (9n),
une sortie de milieu caloporteur du premier échangeur de chaleur côté milieu caloporteur (8a) et l'entrée de milieu caloporteur du deuxième échangeur de chaleur côté milieu caloporteur (8b) étant connectées en série avec un troisième tuyau (9q),
la sortie de milieu caloporteur du quatrième échangeur de chaleur côté milieu caloporteur (8d) et une entrée de milieu caloporteur du troisième échangeur de chaleur côté milieu caloporteur (8c) étant connectées en série avec un quatrième tuyau (9r),
le premier tuyau (9m) ayant une première bifurcation (13a) à partir de laquelle le premier tuyau (9m) se ramifie dans le premier échangeur de chaleur côté milieu caloporteur (8a) et le deuxième échangeur de chaleur côté milieu caloporteur (8b),
le premier tuyau (9m) étant pourvu d'une première vanne (12a) entre la première bifurcation (13a) et l'entrée de milieu caloporteur du deuxième échangeur de chaleur côté milieu caloporteur (8b),
le deuxième tuyau (9n) ayant une seconde bifurcation (13b) à partir de laquelle le deuxième tuyau (9n) se ramifie dans le troisième échangeur de chaleur côté milieu caloporteur (8c) et le quatrième échangeur de chaleur côté milieu caloporteur (8d),
le deuxième tuyau (9n) étant pourvu d'une deuxième valve (12b) entre la seconde bifurcation (13b) et la sortie de milieu caloporteur du quatrième échangeur de chaleur côté milieu caloporteur (8d), et
le troisième tuyau (9q), le quatrième tuyau (9r) et les premiers passages de milieu caloporteur (9o) étant pourvus respectivement d'une troisième vanne (12c), d'une quatrième vanne (12d) et d'une cinquième vanne (12e).

2. Appareil à cycles de réfrigération selon la revendication 1, comprenant en outre des ventilateurs (6a-6d) pour les échangeurs de chaleur côté air (5a-5d) et un dispositif de commande de source de chaleur (11) configuré pour commander les compresseurs (3a-3d), les dispositifs de commutation d'écoulement de frigorigène (4a-4d), les dispositifs de réduction de pression (7a-7d) et les ventilateurs (6a-6d) pour les échangeurs de chaleur côté air (5a-5d),
le dispositif de source de chaleur (11) étant configuré pour déterminer si les cycles de réfrigération (2a-2d)

effectuent des opérations de dégivrage.

3. Appareil à cycles de réfrigération selon la revendication 2, dans lequel
le dispositif de source de chaleur (11) est configuré pour, si des opérations de dégivrage simultanées des cycles de réfrigération (2a-2d) peuvent être effectuées, effectuer alors des opérations de dégivrage de tous les cycles de réfrigération (2a-2d), ou effectuer sinon une opération de dégivrage d'un cycle de réfrigération (2a-2d) étant une cible de dégivrage parmi les cycles de réfrigération (2a-2d).

4. Appareil à cycles de réfrigération selon la revendication 1, comprenant en outre des ventilateurs (6a-6d) pour les échangeurs de chaleur côté air (5a-5d) et un dispositif de commande de source de chaleur (11) configuré pour commander le compresseur (3a-3d), le dispositif de commutation d'écoulement de frigorigène (4a-4d), le dispositif de réduction de pression (7a-7d) et les ventilateurs (6a-6d) pour les échangeurs de chaleur côté air (5a-5d),
le dispositif de commande de source de chaleur (11) étant configuré pour exécuter

> une première étape (S1) consistant à déterminer si des opérations de dégivrage simultanées de la pluralité de cycles de réfrigération (2a-2d) peuvent être effectuées,
> une seconde étape (S2, S4) pour déterminer si l'un quelconque des cycles de réfrigération (2a-2d) effectue une opération de dégivrage,

effectuer les opérations de dégivrage de tous les cycles de réfrigération lors d'une détermination dans la première étape que les opérations de dégivrage simultanées de la pluralité de cycles de réfrigération (2a-2d) peuvent être effectuées et d'une détermination dans la deuxième étape que l'un quelconque des cycles de réfrigération (2a-2d) effectue une opération de dégivrage, et dans le même temps,
lors d'une détermination dans la première étape que les opérations de dégivrage simultanées de la pluralité de cycles de réfrigération (2a-2d) ne peuvent pas être effectuées et d'une détermination dans la deuxième étape que l'un quelconque des cycles de réfrigération (2a-2d) effectue une opération de dégivrage, exécuter une troisième l'étape (S5) consistant à déterminer si au moins un des cycles de réfrigération (2a-2d) autre que les cycles de réfrigération pour effectuer les opérations de dégivrage effectue l'opération de dégivrage, et
effectuer l'opération de dégivrage du au moins un des cycles de réfrigération étant les cycles de réfrigération pour effectuer les opérations de dégivrage lors d'une détermination dans la troisième étape (S5) que les cycles de réfrigération (2a-2d) autres que les cycles de réfrigération pour effectuer les opérations de dégivrage n'effectuent pas l'opération de dégivrage.

5. Appareil à cycles de réfrigération selon l'une quelconque des revendications 1 à 4, dans lequel le premier passage de milieu caloporteur (9o) et le second passage de milieu caloporteur (9p) peuvent être réarrangés.

FIG. 1

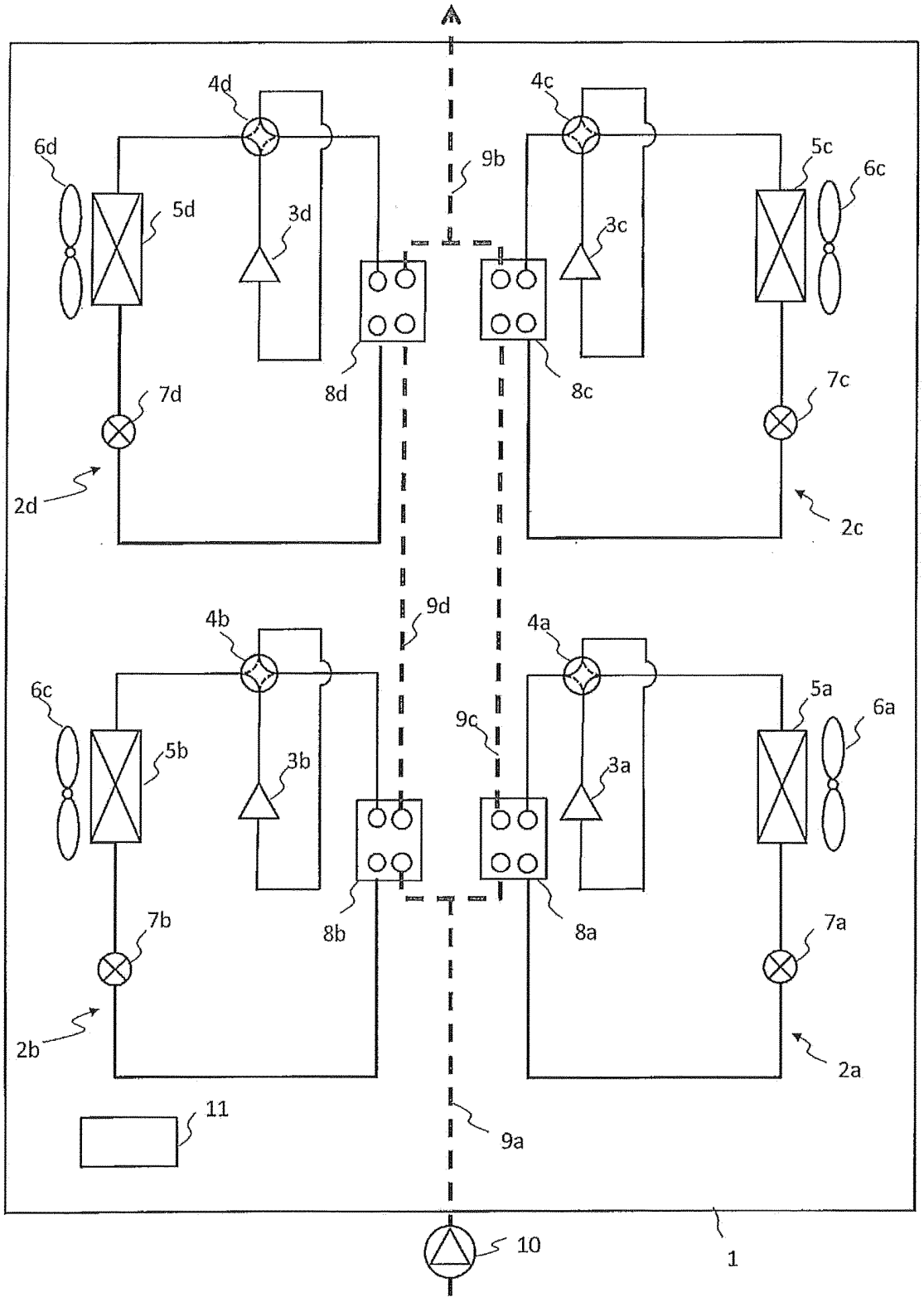

4d
4c
6d
9b
5c
6c
5d
3d
3c
8d
8c
7d
7c
2d
2c
4b
9d
4a
6c
5a
6a
9c
5b
3b
3a
8b
8a
7b
7a
2b
2a
11
9a
10
1

FIG. 2

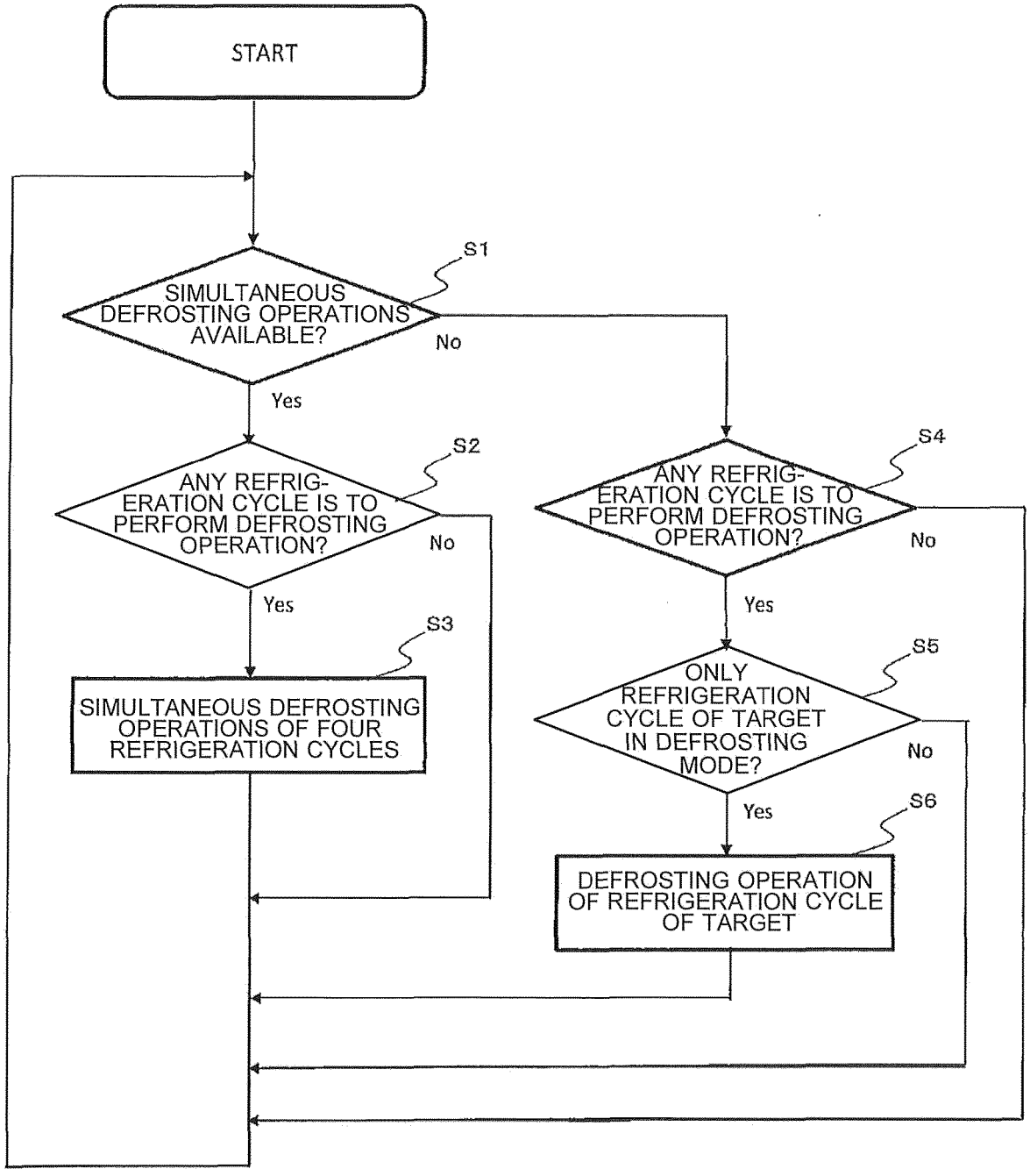

START
S1
SIMULTANEOUS DEFROSTING OPERATIONS AVAILABLE?
No
Yes
S2
ANY REFRIG-ERATION CYCLE IS TO PERFORM DEFROSTING OPERATION?
No
Yes
S3
SIMULTANEOUS DEFROSTING OPERATIONS OF FOUR REFRIGERATION CYCLES
S4
ANY REFRIG-ERATION CYCLE IS TO PERFORM DEFROSTING OPERATION?
No
Yes
S5
ONLY REFRIGERATION CYCLE OF TARGET IN DEFROSTING MODE?
No
Yes
S6
DEFROSTING OPERATION OF REFRIGERATION CYCLE OF TARGET

FIG. 3

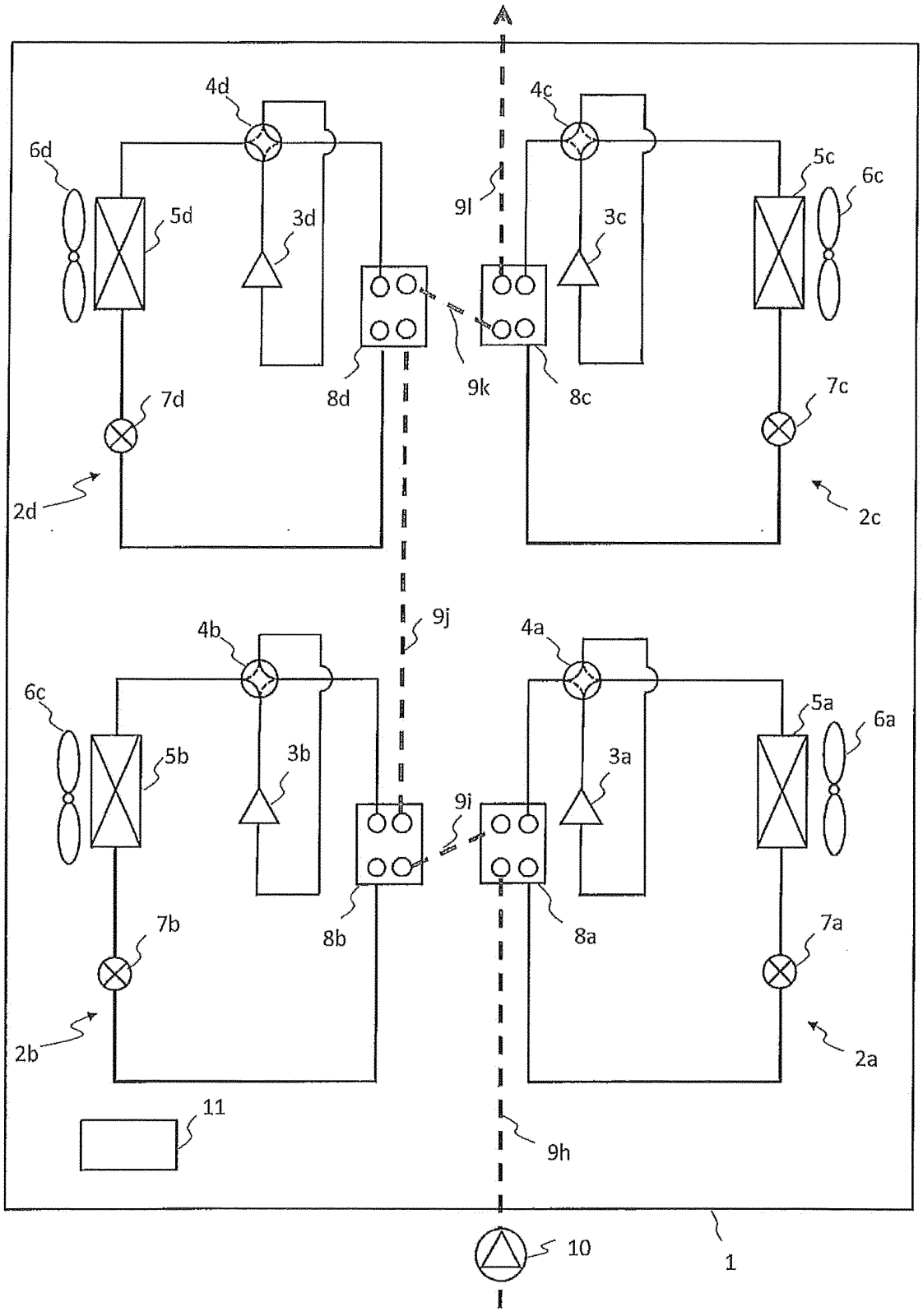

4d
4c
6d
5d
3d
9l
3c
5c
6c
9k
8d
8c
7d
7c
2d
2c
9j
4b
4a
6c
5b
3b
9j
3a
5a
6a
8b
8a
7b
7a
2b
2a
11
9h
10
1

FIG. 4

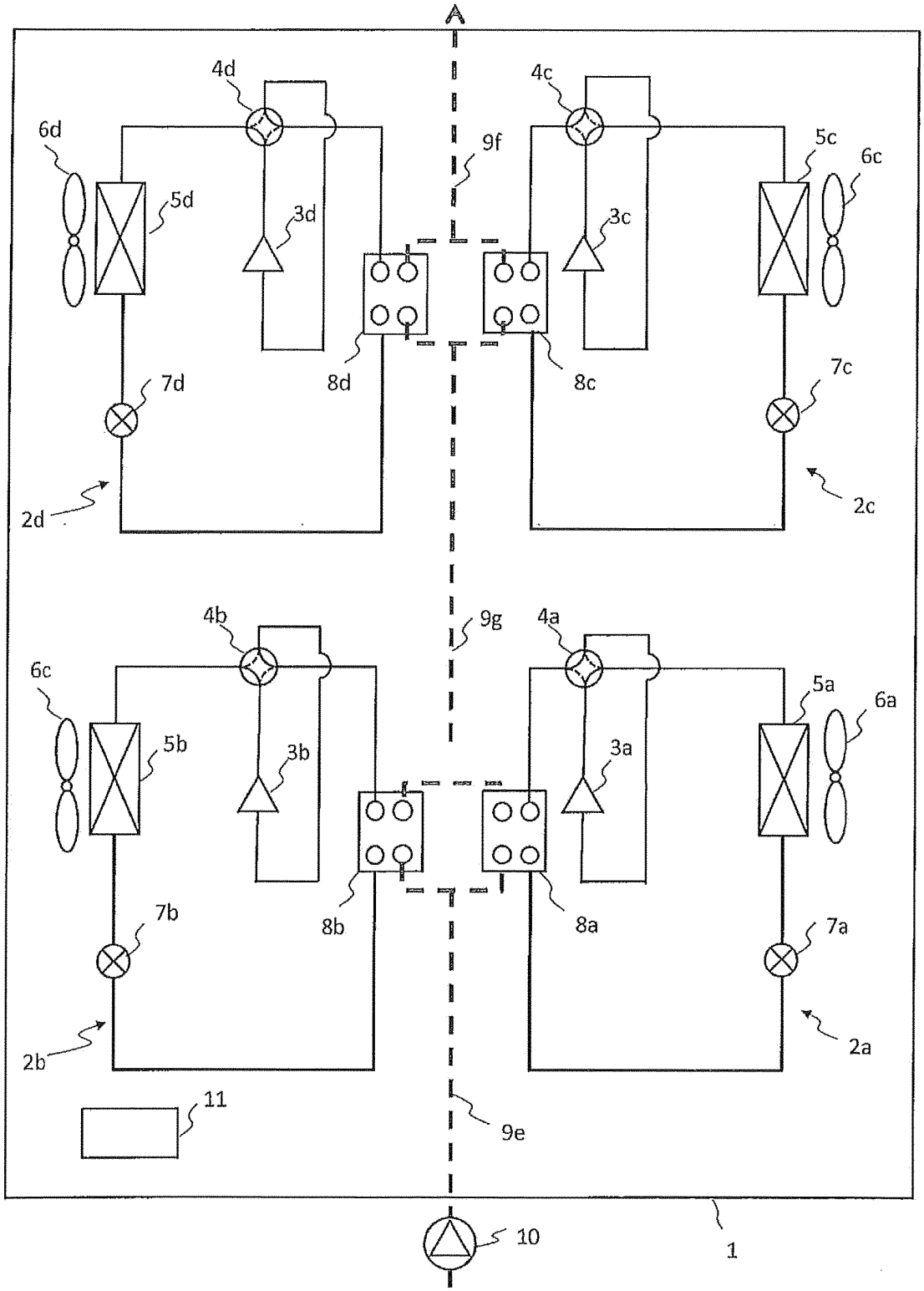
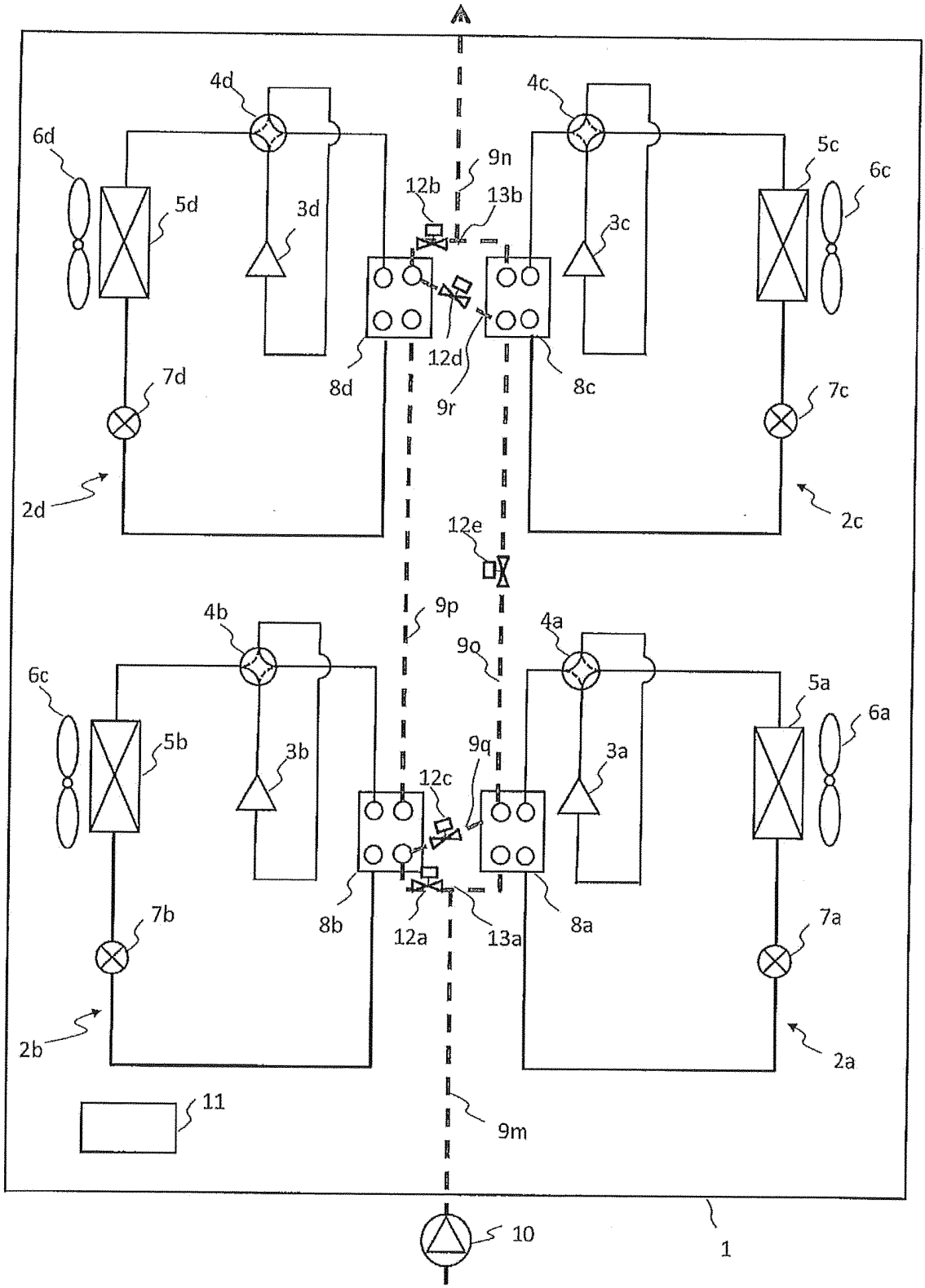

A
4d
4c
6d
9f
5c
6c
5d
3d
3c
8d
8c
7d
7c
2d
2c
4b
9g
4a
6c
5a
6a
5b
3b
3a
8b
8a
7b
7a
2b
2a
11
9e
10
1

FIG. 5


4d
4c
6d
5d
3d
9n
12b
13b
3c
5c
6c
12d
8d
9r
8c
7d
7c
2d
2c
12e
9p
4b
4a
9o
6c
5b
3b
9q
3a
5a
6a
12c
8b
12a
13a
8a
7b
7a
2b
2a
11
9m
10
1

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007187353 A **[0003]**
- JP 2002048359 A **[0003]**
- WO 213021762 A1 **[0003]**
- JP 2013036683 A **[0003]**